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Barth.w Mosse

Dublin. Hodges & Smith

Rec'd 12th July 1870.

BIOGRAPHICAL MEMOIR

OF

BARTHOLOMEW MOSSE, M.D.

FELLOW AND LICENTIATE OF SURGEONS, AND FOUNDER OF THE DUBLIN LYING-IN HOSPITAL.

DUBLIN:

HODGES AND SMITH, GRAFTON-STREET.

1858.

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SURGEON AND LICENTIATE IN MIDWIFERY, AND FOUNDER OF THE DUBLIN LYING-IN HOSPITAL.

EXTRACTED FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR NOVEMBER, 1846.

DUBLIN:
HODGES AND SMITH, GRAFTON-STREET.
1846.

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DUBLIN:
PRINTED AT THE UNIVERSITY PRESS,
BY M. H. GILL.

BIOGRAPHICAL MEMOIR.

In our last Number we alluded to the establishment of that noble institution, The Dublin Lying-in Hospital, as one proof of the high estimation in which the science of medicine and surgery has been held by those engaged in the practice of it in this country. We may add, further, that it is an evidence of energy and benevolence such as have rarely been exhibited. Men will labour diligently for their own advancement, either directly or indirectly, and will even contribute liberally to the relief of distress; but how seldom do we see an individual devoting his time, his talents, bodily and mental labour, and his wealth, to the sole purpose of raising up an asylum for the relief of suffering, and, at the same time, for the improvement of his own profession, without the prospect,—nay, we may say, without the possibility,—of an adequate reward? And yet this was what was done, simply and without display, and, as will appear by the following memoir, under circumstances of unparalleled difficulty, by the founder and builder of the Lying-in Hospital in this city. If the College of Physicians may justly glory in such a man as Sir Patrick Dun, the Surgeons have no less reason to be proud of Dr. Mosse.

As a sketch of the life of such a man may afford encouragement and support to those who are engaged in the actual strife of life, and cannot but interest all who are occupied with similar pursuits, we now present to the profession, and to the city of Dublin, for which he achieved so much, such details as we have been able to collect(*a*).

(*a*) In the memoirs which shall appear in this our Gallery of "Illustrious Physicians and Surgeons in Ireland," we shall in every instance acknowledge our obligations to the various authors, and also state the sources from which we or they have drawn the materials of such. It is strange that up to the present date, no Life or Sketch of the noble philanthropist who forms the subject of this memoir should have appeared in print. The corporation of the Lying-in Hospital should certainly have done some such honour to his memory. In the second volume of Whitelaw and Walsh's History of Dublin, published in 1818, we find some brief notice of the benevolent founder of the Lying-in Hospital, but the scale of that work forbade any extended biography. "The case of Mosse," presented to the Irish Parliament, printed bills of the various "schemes" invented by him for the purpose of raising money to build and support the Hospital, and such like means of information, occasionally crossed the path of the literary antiquary; but no effort was made, either by the corporation or the medical staff of the hospital, to collect and arrange these materials, till a few years ago, when his descendant, William Monck Mason, Esq., author of the History of St. Patrick's Cathedral, &c., made some searches after the papers of Mosse, and commenced to collect information, with the intention, we understand, of publishing his Life; but this, if ever completed, has never seen the light. This circumstance, however, may have prevented those immediately connected with the institution from engaging in

BARTHOLOMEW MOSSE, son of the Rev. Thomas Mosse, rector of Maryborough, Queen's County, was born in the year 1712. After receiving a "genteel education," he was sent to Dublin, and bound apprentice to Mr. John Stone, surgeon. We know no-

the matter. To our esteemed friend and contributor, Dr. Fleetwood Churchill, the profession is mainly indebted for reviving the history of Mosse. With great labour and research he procured and condensed all that was known about Mosse (chiefly, however, in a medical point of view), and read it at one of the meetings of the Obstetrical Society, in the year 1842. Dr. Churchill kindly placed his MS. in our hands some weeks ago, and we had it at once put into print. On reading it over, however, we found references made to an unknown biographer, and to an original document, of which the following is the history, and which we consider of such value in an historical and archæological point of view, and moreover, so unlikely again to meet the public eye, that we have stopped the press, abstracted the Ophthalmological Report which was promised in our last, and have printed this most interesting record almost entire, and without alteration, in its stead.

This document is a manuscript "Account of the Rise and Progress of the Lying-in Hospital in Dublin, with an Attempt towards the Life and Character of Doctor Bartholomew Mosse, the Founder thereof, by B. H———," which is now in the possession of Dr. Collins, ex-Master of the hospital, who received it from the late Dr. Joseph Clarke (with whose memoir we hope one day to present our readers); and Dr. Collins kindly placed it at our disposal. Upon searching the records of the Hospital, we find that the author, Benjamin Higgins, was first secretary to the board, and afterwards the registrar of the Hospital in 1760,—and must, therefore, have been personally acquainted with Mosse, and an eye-witness of much of what he wrote about. Moreover, Dr. Collins has, in a note to us, borne the following testimony to this gentleman: "Mr. Higgins was one of the most correct men that ever filled any public office, as well as a man of most exemplary character. I have often and often heard Dr. Clarke speak of him in the highest terms, and it always appeared to me to give him much pleasure to do so." This account is drawn up in a clear, simple style; is a plain statement of facts, and a transcript of several documents, the originals of which do not, in all probability, now exist, but to which several references are made in the archives of the Institution. With the exception of a few transpositions, we have made no alteration in the text, and have marked as quotations, and printed as they were written, all those portions extracted from Higgins's "Account."

Mr. Strickland, the present registrar, has with laudable zeal and industry lately collected into a large volume several most interesting documents, consisting of various original letters, petitions, deeds, statements, accounts, receipts, and agreements, &c., relating to the founding of the Hospital. To this volume, together with the minute book of the Hospital, we have been kindly permitted access by our friend, Dr. Johnson, the present Master, who has also presented us with a copy of a manuscript history of the Institution, written by the late Dr. Cleghorn. To Dr. Churchill, however, we owe the great bulk of our obligations.

We are happy to inform our friends, that the portrait which accompanies this biography is entirely a work of Irish art. The original picture, which now decorates the board-room of the Hospital, was presented to the institution by W. M. Mason, Esq., in November, 1833, but by whom painted we have not been able to discover; the sketch was made by Mr. James Forde, and engraved by Mr. Duncan. There is also a plaster bust of Mosse, standing on a bracket in the hall, with this inscription underneath:

BART. MOSSE, M. D.
MISERIS SOLAMEN
INSTITUIT.
MDCCLVII.

It seems to have been modelled from a mask taken after death, and was probably the work of Van Nost. We offer no apology for, but rather congratulate our readers and the public on this lengthened biography of our distinguished countryman.—EDITOR.

thing of his pursuits or habits of life as a student, but that they were creditable to him, and that he availed himself of such opportunities as offered, may be presumed from the following certificate, which was found among his papers after his decease:

"I do hereby certify that Mr. Bartholomew Mosse hath faithfully and diligently served his apprenticeship to me; and I do hereby believe him well qualified to practise surgery.

(Signed), "JOHN STONE."

Dublin, 12*th July*, 1733.

The Royal College of Surgeons of Ireland was not incorporated until 1784, and it appears that, previous to this event, the Surgeon-General possessed the power of examining and granting licenses to practise surgery. Thus we read:

"I do certify that I have examined Mr. Bartholomew Mosse, who served his apprenticeship to Mr. Stone, in Dublin, and find him very well qualified to practise the art of surgery.

"Dated in Dublin, this 12th day of July, 1733.

"JOHN NICHOLS."

There is a discrepancy here which we are not able to explain, except by supposing that Mr. Nichols acted as a substitute for the then Surgeon-General, as he himself was only appointed to that office by letters patent dated April 3, 1761.

Sometime after receiving this qualification or license (probably about 1737 or 1738, but the exact date is uncertain), Mosse was employed by the Government to take charge of the men drafted from Ireland to complete the regiments in Minorca; and that he performed the duty satisfactorily is shewn by the following certificate.

"We do hereby certify that Mr. Mosse, one of the surgeons appointed by Government to take charge of the men draughted from Ireland to compleat the regiments in Minorca, has performed his duty in taking care of those men that were under his charge, and likewise has greatly recovered those who came on board diseased.

"Given under our hands, at St. Phillip's, October 4, 1738.

"WILLIAM CONGREVE,
"CHAS. WHITEFOORD,
"ROBT. COTTER."

We here quote from the manuscript memoir of Mr. Higgins, referred to in the foregoing note, and from which we have gleaned many of the previous particulars.—"Dr. Mosse, both before and after the above appointment, practised surgery and midwifery with great success; but this did not prevent his seeking to add to his information, by intercourse with the practitioners of other countries, for in a paper which he afterwards published, he states, that, 'intending to perfect himself in surgery and midwifery, he travelled into England, France, and Holland, and several other parts of Europe; and that from his first entrance into such study and profession he became convinced of the great usefulness, if not necessity, of having an hospital for lying-in women in the city of Dublin, and

resolved as far as in his power to have such an hospital established; and for that purpose laid himself out particularly to inquire into and to observe the hospitals in the countries through which he travelled."

The conviction thus early entertained, and the plans thus carefully matured, were not likely to remain inoperative in a mind so energetic in its benevolence as Dr. Mosse's: indeed, had he been less prompt, an adequate stimulus would have been offered by the misery and want of the poor, witnessed by him in the course of his practice. Even in the present day, when the means of relief for the distressed have been so muliplied, there are few of us who have not met with cases of melancholy destitution at a time when there is more than usual need of kindness and comfort. The necessity of an institution for poor lying-in women thus rendered apparent by his daily experience, Dr. Mosse determined upon putting his plans into speedy execution. "Having," says his biographer, "settled in Dublin, he married the daughter of the Venerable Dr. Whittingham, Arch-Deacon of Dublin, and having obtained a license in midwifery he quit the practice of surgery."

"In the course of his practice charity often demanded his assistance; and he hath often declared, that the misery of the poor women of the city of Dublin, at the time of their lying-in, would scarcely be conceived by any one who had not been an eye witness of their wretched circumstances; that their lodgings were generally in cold garrets open to every wind, or in damp cellars, subject to floods from excessive rains; destitute of attendance, medicines, and often of proper food, by which hundreds perished with their little infants.—*State of the Hospital, published November*, 1750.

"These distresses excited his compassion, and he resolved no longer to delay his endeavours to establish an hospital for poor lying-in women. Having communicated this humane and charitable intention to a few particular friends, who highly approved of his schemes, he took a large house in George's-lane, which he furnished with beds and other necessaries, and opened the same on the 15th of March, 1745, continuing to support it chiefly at his own expense, and constantly attending it in person until the apparent usefulness of it induced several well-disposed persons to encourage the undertaking by benefactions and yearly subscriptions, which encouraged him to enlarge his plan.

"He belonged to a society called 'The Union,' consisting of a number of persons of different occupations, most of whom subscribed four shillings and four pence yearly, to be paid quarterly, for the support of the intended hospital; and this is supposed to have been the first assistance he received."

It is quite clear that this would go but a very little way towards defraying its expences, nor have we any information as to its other sources of revenue, but Dr. Mosse seems to have confidently anticipated that an institution so valuable would not be allowed to fail for want of funds. Perhaps he thought, as we heard a well-known

charitable individual of our day declare, that the "best way of getting money is to get into debt." The house which he purchased in George's-lane is at present No. 59, South Great George's-street, opposite Fade-street; it stands back from the street, and is now approached by a narrow alley; the first building contains twelve rooms, with closets for nurses; and at the rere of this is a second, containing one large and two small wards, with out-offices. In front of it there was originally a court-yard, which may still be seen on some of the old maps of the city(*a*), but this space has long since been filled up with buildings; the whole is now in a most dilapidated condition, and tenanted by a number of poor families. The accompanying sketch of this most interesting building, even in its present state of decay, may not be without its interest.



So far, then, we may consider the original hospital founded and established by the enterprize of one man; and in our estimate of the credit due to him we ought not to forget that the institution was the first of the kind in the British dominions, and may therefore be truly regarded as the parent of all those in the capital of the sister country(*b*).

(*a*) See the charts published with Wilson's Dublin Directory about that period; see also Pool and Cashe's Views of the City of Dublin, 1780. In the lower part of the old hospital in George's-lane originally resided the father of the late Archbishop Magee; and in the small building behind it (now an envelope manufactory), was, some years ago, the well-known "Daly's Academy."

(*b*) In consequence of applications then made to Dr. Mosse for information as to

In *Faulkner's Journal* for March, 1745, we find an account of the opening of the Hospital in George's-lane, and at the conclusion of it the following notice, from which it would appear that the founder received but little sympathy from his professional brethren, although he offered them advantages that few would now be slow in accepting. It is as follows:—"Constant attendance will be given at the said Hospital by Mr. Bartholomew Mosse, until assisted by the rest of the gentlemen of the faculty."(*a*)

As the hospital became more known, its friends and supporters increased; and besides ordinary subscriptions, Dr. Mosse, who was essentially a "man of many projects," had recourse for its support to plays, lottery schemes, concerts, oratorios, &c.; and we may mention that he brought over Castrucci, the last pupil of Corelli, as an attraction to these concerts. These various resources had produced, since 1745, about £3649 altogether at the time (1750) when he published his first Report.

Reports of the Institution were published annually, giving the number of females relieved and children born, with a statement of the receipts and expenses; and from one we give the following extract, shewing the care taken in the economical disbursements of the funds, when compared with similar institutions: "The supporting of 2307 women in the British Lying-in Hospital, London, as appears from the printed state of the said hospital, cost £7313 16*s.* 10½*d.*, which is more than £3 3*s.* 5½*d.* each; whereas the supporting of 3975 women in the Lying-in Hospital in George's-lane, Dublin, including all expenses, came to but £3913 13*s.* 0¾*d.*, which is very little more than 19*s.* 8½*d.* each. By which the manager of the last named charity saved to the public no less a sum than £8696 12*s.* 5½*d.*; for had the above 3975 women cost £3 3*s.* 6½*d.* each, the whole amount would have been £12,610 5*s.* 6*d.*"

"This hospital, besides the relief of the distresed, was intended as a school for young surgeons intending to practise midwifery, as it might render it unnecessary for such to resort to France and other foreign parts for instruction; and also as a nursery to raise and transplant into the several parts of the kingdom, women, who, being duly qualified, might settle in such parts as most stand in need of them. The Doctor was, at the time of opening the hospital about thirty-three years of age, in full health and vigour, of a clear understanding, affable and agreeable in his conversation and behaviour, and beloved and esteemed by all his acquaintances; and the great advantage of it being soon observed, as well abroad as at home, application was made to Dr. Mosse, in the year 1747, by several persons in London (particularly Dr. Layard), for his plan, scheme, and regulations, which he transmitted to them; and an hospital was erected in London the year following on the same plan, with the same regulations, which soon met with so great encouragement from the public, that before the year 1751 two more hospitals for lying-in women were opened in the said city."

We have now arrived at the second grand epoch of Dr. Mosse's undertaking. Finding that the applications for admission exceeded the accommodation of the house in George's-lane, and also that there were many inconveniences which he could not remedy, he determined to erect an hospital which should combine extent with suitable convenience. Promptitude in executing that which he deemed advisable appears to have been a remarkable feature in Dr. Mosse's character, and in the present instance was displayed as usual: for on August 25, 1748, three years after the opening of the old house, he took the piece of ground in Great Britain-street, consisting of 4A. 1R. 9P., at present occupied by the hospital gardens and Rutland-square. By the lease, dated as above, W. Naper, Esq. made over the ground to Dr. Mosse, his heirs and assigns, for lives renewable for ever, at the yearly rent of £70.

This was of course a considerable addition to the limited finances of the original hospital, but it was a trifle comparatively. The new hospital had to be built, and on no limited scale, and meanwhile the old establishment had to be kept up; and yet we find no hesitation in the mind of this large-hearted man about the personal difficulties in which he might be involved by his benevolent undertaking. He seems to have embarked his whole interest and heart, as well as his money, in the institution, from which, it is evident, he could have little hope of remuneration. No sooner was the ground taken than

the plan and method of conducting his hospital, the Broumlow-street Hospital in London was established in 1747; and in the year 1748 or 1749, the British Lying-in Hospital, Long Acre; followed in 1750 by the City of London Lying-in Hospital, Aldersgate-street; in 1752 by Queen Charlotte's Lying-in Hospital, Paddington; and in 1765 by the Westminster Lying-in Hospital, Lambeth, "on the same plan and with similar regulations."

(*a*) We copy the following from *Faulkner's Journal*, No. 1884, from March 23 to 26, 1745:

"On Friday, the 15th instant, was opened an hospital for poor lying-in women, in George's-lane, facing Fade-street; and the same evening Judith Rochford was received into the said hospital, recommended by the minister, churchwardens, and a great number of the principal parishioners of St. Andrew's parish, as a very great object of charity; and on Wednesday last she was safely delivered of a son.

"As this hospital is solely designed for the use of such poor and distressed women as are not in circumstances to provide themselves at such a time with a convenient place to lye in, or with the common necessaries for persons in such a condition, by which means many poor though honest and industrious women perish, and leave their helpless orphans a burthen to the public (notwithstanding they may at any hour have the best assistance in the physical way that this city affords), therefore, the directors of this hospital request that the public recommend none but such as truly merit the benefit of this most useful charity.

"The beds hitherto erected are few, but the directors in a short time hope to be able to fill the house, which will conveniently contain twenty-four beds. This number, they apprehend, will be sufficient to relieve all the poor objects, in such a way, in this city. Every woman is to have a warm, decent bed to herself, and shall be provided with all manner of necessaries, and the greatest care imaginable will be taken of her and the new-born infant from the time she is received until well able to leave the hospital without danger; and all this without the least expense to her.

"N.B.—Those who are inclined to contribute to the support and encouragement of this so useful and charitable an undertaking may send their subscriptions or benefactions to the Rev. Dr. Wynne, Dr. Blashford, Sir Arthur Gore, Bart., Thomas Prior, and Ralph Sampson, Esqrs.; or any of the clergy in and about Dublin."

he set about devising how it might be rendered available to the funds. "And in order," says his biographer, "to secure a probability of maintaining such hospital, he first, at the risk of his whole fortune, laid out and furnished a garden, with an orchestra, coffee-room, and decorations, for the entertainment of the public in the manner of Vauxhall, near London, whereon he expended about £2000. He then employed a band of music, and soon found his expectations fulfilled by a constant resort of company during the summer season which produced nearly £400 annually. The Doctor was so much delighted with the beauty of the garden, that he employed a painter (M. Grezoni), and had a perspective view of it painted on canvass, with the company, music, &c., which cost him an hundred guineas. This picture was accounted a great masterpiece, and was so true a representation, that the Doctor intended to have it engraved the size of a large sheet of paper, and to be sold at three half-crowns each, for which he actually received subscriptions from several persons. He sent the original picture to France to be engraved, but it was seized, upon being landed there, and could never since be recovered.

"About the year 1749 there were many reports propagated reflecting on the character of Dr. Mosse, which it is supposed were occasioned through envy of his great talents and success, as several gentlemen of the professions of physic, surgery, and midwifery, were his chief enemies, and made use of all their endeavours to blast his reputation and overturn his scheme. Amongst many reports to his disadvantage, one of the chief was, that he had taken the lease in his own name, and for the use of himself and family, without any intention of building an hospital; and that, under the specious pretence of public charity, he was then extorting large sums of money, with which he meant to quit the kingdom. To obviate all suspicions of that nature, and to satisfy the public of the rectitude of his intentions, he executed a declaration of trust, endorsed on the lease, whereby he made over the same to three gentlemen of note, in trust for the use and support of the said charity. This declaration was dated the 1st of January, 1749, and was duly registered."

We know not whether Dr. Mosse expected that the public would give him credit for disinterested benevolence in these varied schemes —perhaps he never thought about it; but in the present day, at least, we do not believe that any evidence could convince some persons that a man who founded an hospital that flourished, gave concerts, bought ground, laid out gardens, &c., &c., was not making a very large fortune by it; and that simply, because they know of no other motive which would tempt themselves to do likewise. We need not, therefore, be surprised that, notwithstanding his enormous personal risk, and the actual outlay of money, and in the teeth of a yearly authentic statement of accounts, that these prudent speculators suspected a good per centage somehow, and reported that he intended "to quit the kingdom."

"Having now purchased timber, and many other materials

towards erecting the new hospital, he thought proper," (says the manuscript memoir from which we quote), "to distinguish the city of Dublin, for the relief of whose poor the Hospital was chiefly intended, by giving to the Lord Mayor the honour of laying the first foundation stone. And, accordingly, on June 4, 1751 (May 24, 1751, old style), being the birth-day of His Majesty King George III., then Prince of Wales, the first stone was laid by the Right Honourable Thomas Taylor, Lord Mayor; Thomas Morgan, Esq., Recorder; Thomas White and George Reynolds, Esqrs., Sheriffs; who came for that purpose, attended by the Aldermen, Commons Council, and the Masters and Wardens of the several corporations of the city, with their proper insignia." The first stone was laid at the west corner of the front of the hospital, and under it Dr. Mosse placed an engraved plate of copper, giving a brief account of the particulars already mentioned, with gold, silver, and copper coins of that year. The building, as it now stands, was designed, and also built, by Mr. Cassels, a distinguished architect of this city.

The following anecdote is so characteristic of the energy and hopefulness of the subject of it, and told with so much *naivetè*, that we give it in the words of his biographer: "It is worthy of remarking what the doctor assured an intimate friend, that on the morning of the 24th of May, whereon the first stone was laid, he was *barely worth* £500; and although he knew the hospital would cost him above £20,000, yet he never despaired of seeing it finished." And he rather quaintly adds: "As a further proof of his resolution and perseverance, he gave the Lord Mayor and his attendants a genteel and liberal entertainment, to which he had formally invited them; so that he seemed to be possessed of many thousands, while no man, besides himself, knew his real circumstances, having before been obliged to expend almost his whole personal fortune, and to mortgage his estate for near its value."

The building, thus commenced, was carried on with spirit as far as the funds permitted; the Doctor raised all the money he could on his own credit, and then unfortunately had recourse to lottery schemes, at that time much in vogue. We say unfortunately, for although at first he succeeded in raising about £8000, yet they ultimately failed, and involved him in debt and difficulties.

"In the year 1752 the Doctor projected a scheme of a lottery, and as a sanition, offered to give the city of Dublin two-thirds of the profits towards rebuilding Essex-bridge, the other third to be divided between the hospitals following: Inns'-quay Infirmary, Mercer's, The Incurables, and Lying-in Hospitals. But £500 was to be given to the Lying-in Hospital out of the two-thirds allotted towards the bridge, and the like sum out of the dividends of the other hospitals, in the consideration that the Doctor had projected the scheme, &c. On this occasion a great number of the chief citizens, with all the physicians and surgeons belonging to the several hospitals, formed themselves into a society, and had many meetings. This lottery was intended to be drawn in Dublin, and Dr. Mosse

provided wheels, &c., at a great expense. But, after the tickets were all sold, the Lords Justices would not allow the drawing. Thereupon the Doctor went to London, to the Duke of Athol, to endeavour to obtain his leave to draw it in the Isle of Man, and offered the Duchess £1000: but such leave could not be procured, so that all the money received for tickets was returned, and the whole expense fell on the Doctor; the several others who were to have had share of the profits absolutely refusing to bear any share of the loss, which amounted to a very considerable sum. Notwithstanding this discouraging prospect, he continued to carry on the building, and raised money for that purpose (but soon planned another scheme) on his credit; but upon his going to London to forward a scheme in 1753, his enemies raised many scandalous and fresh reports, giving out that he had absconded for debt, and could never return; that he had deceived the town by attempting to work miracles, but that no man of common sense had ever looked upon him in any other light than that of a madman, or a builder of castles in the air.

"Whilst his character was thus roughly handled at home, he met with many difficulties abroad by his lottery schemes, for which he and many others were prosecuted. But, being of an undaunted resolution, he surmounted every obstacle, and continued to carry on the building to the surprise of his friends and the mortification of his enemies. The Doctor being in London in December, 1753, an intimate friend in Dublin wrote him a letter, which has been found amongst his papers, dated 11th December, 1753, from which the following is an extract: 'I assure you that your success in London cannot give you more pleasure than it does me. Mr. N——tt wrote a private letter to Mr. M——ll, which he was pleased to communicate to me, and in this he gives him to understand that Dr. Mosse hath done wonders, that his traffic in the mercantile way *hath lowered the exchange, and that he hath supported the credit of poor Ireland at a very critical time.*' In the year 1754 he founded a scheme on a Dutch lottery which would have enabled him to finish the hospital had it met with success. But meeting with many obstacles and unforeseen misfortunes in the progress of that scheme, and finding his character likely to suffer on that occasion more than ever, he thought proper the year following to lay a state of his whole proceedings in that affair before the public; which he accordingly published, and many hundreds of them were dispersed as well in London as in Dublin."

As this public manifesto, which was published in 1755, has reference chiefly to matters of accounts in this lottery scheme, and insurance, and to a subject long since universally acknowledged,—the clearing of Dr. Mosse's character and reputation,—we do not think it necessary to insert it here. It was originally intended that the hospital should have £10,000 from the scheme, but from losses and unfortunate chances it received but £2450.

In order to effect an insurance on this lottery, and to save all parties, Dr. Mosse proceeded to London. "This was readily procured by

the temptation of a premium of thirteen and a half per cent. The insurance was full immediately, and many gentlemen offered themselves for underwriters, for whom there was no room. Several merchants, of great note and fortune, were bound in a policy of insurance to secure the charity against the hazards of the wheel. The scheme was deemed very advantageous by every person, as the insuring adventurers had five per cent. above par. Still the success was far from answering their expectations, as will appear by the following state of the account and dealings between them and the managers, and a balance of £2320 4*s.* 6*d. still due to the charity remains in their hands.*"

[Here follows, in Mr. Higgin's narrative, the statement of the accounts].

"It is mentioned in the foregoing narrative," says Mr. Higgins, in commenting upon this public statement of the accounts, "that the managers had paid the fortunate chances, until they had reduced the demand under £2000, which sum it was not in their power to discharge, as the insurers were upwards of that sum in their debt, and as they had expended on the building, out of the profits of that scheme, the sum of £2450, as appears by a state of the hospital published in the year 1757; so that they were obliged to stop payment, which was the occasion of great exultation to their enemies, and lessened the number of their friends, or, at least, such of them as would not be at the trouble of a nice examination of facts.

"Sometime after this the Doctor filed a bill against the insurers, to bring them to a fair account, to which they filed an answer, and therein acknowledged a debt of £2130. But the Doctor's death put an end to the suit, and the same debt remains due by the insurers, and about the like sum is still due to the fortunate adventurers."

The following romantic adventure occurred to him while returning to Dublin, after effecting the insurance just alluded to. "Amongst the many difficulties and distresses which the Doctor underwent in the last-mentioned scheme, the following is somewhat singular. Having been in London, paying off the fortunate chances, he left that city the latter end of 1755, in order to come to Dublin; and having arrived at Holyhead, as he was there going on shipboard, he was arrested by a person who had followed him from London, at the suit of a person who had been employed by him there, for an alleged debt of about £200. He was taken to Beaumaris, and there confined; but before his friends had notice of his situation he made his escape by night out of a back window which hung over the sea, and prevailed on two boatmen to carry him over an arm of the sea to a considerable distance, where, perhaps, no boat had before ventured, and he remained in a poor cabin on the wild mountains of Wales for some weeks before he would venture home."

All this time, however, the old hospital in George's-lane continued in active operation, dispensing its blessings among the poor, and educating a class of practitioners who were to carry the prac-

tical advantages which its instruction afforded, not only throughout our own, but to every civilized country on the globe. Up to this period (the end of 1755) Mosse had contrived to collect or otherwise procure no less than £11,694, chiefly by means of plays, oratorios, and "schemes" of various kinds. Of this sum, £3531 was laid out upon the support and maintenance of the hospital in George's-lane, and £8163 expended on the new building in Great Britain-street. At this period all his resources appear to have been exhausted; yet notwithstanding the ill success of his previous venture, he attempted another scheme, but his character was so much depreciated by the last that it did not succeed, and he found himself under a necessity of dropping that method of raising money. He was, moreover, involved in debt, and hourly subject to arrest and imprisonment, having sold or mortgaged almost every thing he was worth. In this distressed condition he communicated his unhappy situation to some persons of the first rank, and was encouraged to make an application to the House of Commons, and to pray their aid to pay off the debts he had contracted on account of the hospital, and to enable him to finish the same.

A copy of this document, to which we have already referred, and which was very widely circulated at the time, now lies before us. It is styled, "The Case of Bartholemew Mosse, Esq., of the City of Dublin, Surgeon, and Licentiate in Midwifery, 1755," and sets forth the erection of, and benefits derived from, the hospital in George's-lane; and, among other items, sheweth, "That the said hospital has been a means of stopping or lessening that most unnatural, though formerly frequent, practice of abandoning, or perhaps murdering, new-born infants; for since the first opening of the said hospital there have been few or no instances of a child exposed or murdered within the city or suburbs of Dublin. That such hospital being established in this city makes it unnecessary for such gentlemen as intend to practise midwifery to resort to France or other foreign parts for instruction and experience in this branch, several such having already been instructed in said hospital, and applications are daily made by others for the same purpose. * * * That the said Bartholomew Mosse hath laboured under many and great difficulties in the support of the said charitable institution, and in carrying on the building of the said new hospital, and cannot finish the same without the aid of the honourable House of Commons, having already been obliged to expend thereon a considerable sum of money out of his own private fortune."

Attached to this document are the whole accounts, receipts, and disbursements of the old hospital in George's-lane, as well as the sums expended on the erection of the new; by which it appears that during the ten years and a half ending the 30th September, 1755, there had been received £11,694, of which sum £10,548 was obtained from plays, oratorios, and various "schemes" in lotteries, devised by Dr. Mosse, the remainder only being donations and subscriptions. The sum of £3531 was expended upon the hospital in

George's-lane, and the fitting up of the gardens in Great Britain-street, leaving the Doctor and his work in debt £5830. As a claim or set-off against the country and the institution, the Doctor adopted a form of debtor and creditor account, not quite unknown in the present day. It runs thus at the top of the third page of his memorial:

"To the said Bartholomew Mosse's trouble in superintending the hospital in George's-lane ten years and a half, ... — — —

"To ditto's trouble in superintending the new building in Great Britain-street seven years and a half, — — —

"To ditto's five journeys to London and other parts of England, to further several schemes for the benefit of the hospital, ... — — —

"To interest of money borrowed to carry on the building at such times as money could not be raised any other way," . . . . . — — —

Then follows "An Account of the Women admitted into the Hospital in George's-lane, from its first opening on the 25th March, 1745, to the 30th September, 1755, with their different Ages," the parishes in Dublin and the other parts of the kingdom from which they came, the class of society to which they belonged, the number of deliveries, results, and sex of births, and the mortalities of mothers and children, together with the number of twins, &c., forming altogether one of the most interesting as well as the earliest statistical tables of this description on record, and shewing that the registry of this hospital a hundred years ago was better kept than many of the present day. Finally, to this case of Mosse was appended a recommendation from the Protestant clergy and churchwardens of the various parishes in Dublin.

"We observe," say these latter, "that generally the habitation of the working poor in this city is only one room, and a family, or perhaps more, therein, where, when the wife is in labour, and sometimes before and after, the work of that room must be suspended, whereby not only the ordinary expenses must be continued, but even extraordinary must accrue for the use of the lying-in woman; and yet no work is carried on to support them, for fear of disturbing the woman, which frequently throws poor families, as objects of distress, on the parish, and the handicraft for the time is totally lost; therefore this hospital, besides the humanity of relief, may continue workmen at their employment, for the service of the public, and remove one common excuse for idleness. We further observe, that the condition of the wives of soldiers, menial servants, and labourers, more especially when they are left widows with child, is so deplorable, that they frequently have either no lodging for their reception in their distress, or are obliged to lie in ruinous untenanted houses, destitute of all conveniences of clothes, fire, &c., to the manifest danger of themselves and children."

This petition was presented in his own name in the session of

1755, and on the "23rd March, 1756, the House addressed His Majesty to grant a sum of £6000 to be 'expended in paying such debts as were then due, for materials and work done, at the said hospital, and in finishing the same,' and this sum His Majesty was graciously pleased to grant."

Before this time, so early as the 16th June, 1752, Dr. Mosse had applied for a charter to incorporate a number of noblemen and gentlemen as governors and guardians of the hospital; and in the year 1755 he succeeded in obtaining it. It is dated December 2, 1756, and in the preamble sets forth that, "in answer to a petition addressed to the Duke of Dorset, stating the number of poor women distressed at their lyings-in, and of children lost, especially the wives of soldiers and sailors; and that as a considerable sum has been collected and legacies bequeathed, and in order to prevent gentlemen going abroad for instruction," &c. &c., for these reasons it appoints the Lord Lieutenant, the Lord Primate, the Lord Archbishop of Dublin, the Lord Chancellor, the Right Honourable the Speaker of the House of Commons, the Lord Mayor, the Lord Bishop of Kildare, the Commander-in-chief, the Dean of St. Patrick's, the Archdeacon of Dublin, the High Sheriffs, the Earls of Kildare and Shelburn (afterwards Duke of Leinster, and Earl of Arran), the Lord Bishops of Clogher, Cork, Ross, and Raphoe, the Right Honourable Sir A. Gore, Right Honourable J. Ponsonby, Dr. Mosse, and others, to be a body corporate, under the name of the "Governors and Guardians of the Hospital for the Relief of poor Lying-in Women in Dublin," with the necessary powers and liabilities as such; with one President, six Vice-Presidents, a Treasurer, Secretary, and Master, with a Committee to manage the affairs of the hospital, &c. &c.

By it, the master is to be elected or re-elected annually, and certain rules are laid down for the election of other officers, and their salaries, &c.; and each master is now *ex officio* a governor, after his term of seven years has expired.

The following extract has reference to the medical appointments, and to the pupils:

"And we do further authorize and direct, that the master of the Lying-in Hospital for the time being be always some experienced practitioner in midwifery, and that he shall have two assistants, men-midwives, to be proposed by him; the said master to be appointed by the then sitting committee. And that all students in physic, surgeons, or apprentices to surgeons, and all such others, whether men or women, as intend to practise midwifery, and shall be approved of by the said master, shall and may have full liberty to attend the hospital, and be instructed under the said master and his two assistants. And that from and after the death, resignation, or removal for reasonable cause, of the said Bartholemew Mosse, whom we hereby appoint first master of the said hospital, and to continue in the said office for and during the term of his natural life, unless he shall sooner resign, or be removed for a reasonable cause, no

one person, however deserving, shall be capable of being elected master of said hospital, who has been master for seven years, either successively or at different times, but amounting in the whole term to seven years.

"And our further will is, that in all future elections of master of the hospital, regard be always had, and preference given, to such as have been assistants to the former or any master of the hospital; and that on proposing or appointing all future assistants, regard be always had and preference given to such as have been instructed in the said hospital. And we do hereby authorize and direct that no one person shall be continued assistant to the master longer than for the space of three years.

"And our further will and pleasure is, that these our letters patent, and every thing therein contained and specified in the enrolment thereof, shall be in all and every thing firm, valid, and effective in law, according to the perfect tenor of these our letters patent, &c. &c.

(Signed) "Domville."

The topographical relations of the locality which was chosen for the site of the hospital in Great Britain-street, and the "New Gardens," as they then, and even up to a very recent period were denominated, may not be uninteresting. Let us follow the route which must have been taken from George's-lane to the upper end of Sackville-street. We suppose the passenger could with facility find his way under the creaking signs which projected from the narrow, gable-fronted houses of Dame-street, by "King William," if not better known, more reverenced a century ago; by the Old Post Office, afterwards the site of Daly's Club House; by Turnstile-alley, and the Old Parliament House, to the College; and, turning through a collection of wretched sheds and thatched cabins, which then surrounded the river side of Alma Mater, into the narrow passage of Fleet-lane and Fleet-alley, which occupied the site of the present Westmoreland-street; by the Lazar House, through the barbers' shops, lime-kilns, and saw-pits(*a*), to "the Ferry," where he took boat to the northern side of the Liffey, nearly at the place where Carlisle-bridge now stands. There were no proper quays on any part of the river at that time; but a dirty strand occupied its banks, with the ends and backs of the houses presenting an irregular and broken line of dark, gloomy buildings along it, the lanes and alleys of which were unsafe to walk through, even in the day-light; while the shipping passed up to the Custom House, which stood a little below the southern end of Essex-bridge. Having reached the opposite bank, he might choose one of the two narrow streets and lanes, called the Dutch Lots, and Bachelor's-lane, which ran up-

(*a*) One of the oldest inhabitants of Dublin lately told us, that once passing through that lane to the river, in the open day, he no sooner entered its gloomy and polluted precincts, than a man called out, "There's a rat in the trap;" on which he was attacked by a ruffian who rushed out of an open door, and from whom he only escaped by defending himself with his cane-sword, without which few gentlemen ever then went abroad.

wards into Drogheda-street(*a*), now Lower Sackville-street, as far as the "Barracks," which occupied the locality of the present Post Office, to "The Mall," a large open space, with an oval enclosure, which occupied the site of the present Upper Sackville-street, then the almost suburban residence of many of the Irish nobility and gentry. Here a double row of tall elms shaded the Dublin belles and macaronies of 1750; and the loungers of the north side of the city vied with those of the south, who strutted within the sunk fence and dirty ditches of St. Stephen's-green. Beyond Great Britain-street it was almost "the country." The sloping ascent of what is now Rutland-square led to the Barley Fields; and an open space of waste ground opposite Britain-street, on which there were a few small thatched cabins, a pool of stagnant water, a "noddy stand," and "the bowling green"(*b*)—the whole being a locality memorable as a spot on which the Irish and the inhabitants of Dublin once overthrew the Danes in a fierce combat,—was chosen as the site of the present Hospital and Rotunda.

"It has often been regretted," say Whitelaw and Walsh, in their History of the City of Dublin, "that this fine edifice did not face Sackville-street, to which it would have formed a noble termination; and such, we are told, was the founder's wish, but a refusal on the part of the proprietor of that street to accede to the proposed exchange of some ground necessary for this purpose, obliged him to relinquish a plan which none but a man devoid of taste and judgment could reject."

The building was continued under the patronage of the governors and guardians of the new corporation; although in point of fact the management was very properly left in the hands of the founder, and, as we shall presently find, it was prosecuted with his usual energy. In the course of the session of 1757, the new corporation, at his instance, again petitioned parliament for a further supply for carrying on the work, and besides "recommended Dr. Mosse to the consideration of the House, setting forth 'that he had solely attended to the hospital in George's-lane twelve years, and superintended the building of the new hospital in Great Britain-street,

(*a*) The ground on this side of the water belonged to the Earl of Drogheda, from whom all the streets in this locality were named, thus—Henry, Moore, Earl, Off, Drogheda; Mellifont-lane, now called Elephant-lane, was likewise named after a well-known locality on his property. Why do not some of our young antiquaries collect materials for preserving some record of Old Dublin, the topography, legends, and history of which, a hundred years ago, would, we are sure, make a most entertaining volume, and supply some future chronicler or novelist with materials which, in a few years more, it will be impossible to grasp?

(*b*) The Bowling Green, which was in use after the enclosure of the Rutland-square Gardens, is the piece of level ground still forming the lower part of this space. On the 14th of February, 1767, a number of gentlemen, residing in Rutland-square and its vicinity, petitioned the Board of Guardians to have it still kept up and put into proper order. In this petition they say: "We, therefore, presume when you know that we and many of the subscribers are entertained with that diversion (bowling) during the summer, you will give your directions for having the bowling-green put into proper order against the approaching season. This will much oblige us and several others, whom we apprehend will not subscribe unless they have the pleasure of such amusement in a better manner than heretofore."

and the making of the garden thereto, nine years and a half, with the utmost diligence, and that thereby the same were done in the most effectual and cheapest manner. That by such attendance and superintendence, and advancing and borrowing money to carry on the work, he had injured himself greatly in his profession, and hurt himself and his family in their circumstances.' In consequence of this petition, the Honourable House, on the 11th November, 1757, were pleased to grant a sum of £6000 for the use of the hospital, and £2000 to Dr. Mosse, as a reward for his exertions."

At the close of the same year, 1757 (six years from the laying of the first stone), the hospital being nearly finished, and the upper floor furnished with fifty beds and all other requisites, the Doctor determined to open it immediately for the reception of patients, which was accordingly done, December 8, 1757, by His Grace the Duke of Bedford, then Lord Lieutenant, who, with Her Grace the Duchess, and a great number of the nobility and gentry, was entertained at breakfast at the hospital; after which, says the manuscript memoir, "fifty-two poor women, great with child, who attended in the hall with proper certificates for admission, and were all decently clothed in uniform at the expense of the hospital, each in a blue calimanco gown and petticoat, shift, handerchief, cap, and apron; and thus they appeared before His Grace as President of the hospital, the Duchess, and the rest of the Governors and Guardians, with many of the nobility and gentry, who all expressed the highest satisfaction. During the whole time of breakfast and the ceremony of opening the hospital, their Graces and the company were entertained with a concert of vocal and instrumental music, and every thing was conducted in the most regular, easy, and genteel manner.

"Thus we see a public building, useful in its design, and beautiful in the execution, begun and carried on by the address and resolution of a single person, without either the security of fortune or patronage of the great; and yet, no application to Parliament until facts had silenced malice and extorted a general approbation(*a*)."

The hospital in George's-lane was now closed; and in one of the Annual Reports of Dr. Mosse, to which we have already alluded, it is stated, that "in the space of twelve years previous to the opening of the new hospital, 3975 women were delivered in the old one, of 2101 boys, and 1948 girls,—in all 4049 children, 74 women having had twins; and at an expense of £3913 13*s.*, or about 19*s.* 8½*d.* for each woman and her child." Of the entire number Dr. Mosse observes, that the

"Proportion of males to females was as		12	to 11
,,	Women having twins ,,	1	,, 53½
,,	Women dying ,,	1	,, 90⅔
,,	Children dying in the first month ,,	1	,, 17
,,	Children still-born ,,	1	,, 34

(*a*) See Wilson's Dublin Magazine for April, 1763.

"OF THE AGES OF THE WOMEN:

409	were from	15 to 20
2452	"	21 „ 31
935	"	31 „ 41
89	"	41 „ 53"

"The Doctor being a native of the Queen's County, was looked upon by the grand jury and gentlemen of that county as an honour to it: and they at an assizes made a collection towards erecting and supporting a bed in the hospital, which they supported for some years, and it was called the Queen's County bed. Whereupon he intended to apply to the Grand Jury of every other county in the kingdom, and endeavour to induce each of them to erect and support a bed. He had a petition prepared for that purpose, which he had intended to have printed or engraved with proper blanks; but by his sickness and death this scheme, with many others, proved abortive.

"Doctor Mosse had also formed a scheme (which in fact was partly executed) for nursing, clothing, and maintaining all the children who should be born in the Lying-in-Hospital, whom their parents should consent to intrust to his care. A school was to be opened, provided with able Protestant masters in the most useful trades and manufactures. Into this school the children, at a proper age, were to be received; there to be instructed in the principles of the Christian religion, in honesty and industry, and to be taught some such trade as their genius most strongly inclined them to; (but his chief intention was to establish a hardware manufacture as at Birmingham in England); and it is a fact, that with a view of this kind he, at his own private expense, had put out some children to be nursed, who, after his death, were returned to their parents."

Among the various means resorted to by Mosse to support the hospital were the entertainments at the "New Gardens," as we already stated. What the exact condition of those gardens was on their first opening we are unable to say, as the picture which was painted of them was lost in Paris; but from some of the bills and private papers of Mosse we learn that a low wall originally surrounded the gardens, within which were planted rows of elm trees. Bands of music, and public singers, &c., were employed, and the gardens were occasionally handsomely illuminated, and the trees covered with coloured lamps. They were illuminated on all festivals and days of rejoicing. Thus we read in an account between George Falkner, the celebrated printer and editor of the Journal which bears his name, the following item: "This present evening, being the anniversary of the battle of Dettingen, the New Garden will be illuminated;" and again we find a similar advertisement inserted on account of the taking of Belleisle. Occasional illuminations were ordered "by special command of the Lords Justices." We may here remark that the first play given for the benefit of the Lying-in Hospital was "The Conscious Lovers." Among the accounts for exhibitions we find a tinman's bill "for the erection of Pluto's palace;" and we find under the item of "payments to musicians," during one summer, no less a sum than £1240.

Among the decorations and attractions got up by Dr. Mosse for the benefit of the Gardens was a picture of Charity (probably a transparency), painted by an artist named Tudor, who likewise "received £140 for painting the orchestra."

Mr. Higgins gives the following account of the Doctor's intention in decorating the Gardens:—"There is a part of the Garden wall on the east side, next Cavendish-street, which on the Garden side is built or lined with brick; there, he intended to build a pavilion, which would stand in the county of Dublin (all the rest of the Garden being in the city). For this pavilion he had actually provided hewn stone, and other materials. He also intended erecting a magnificent statue of Juno Lucina (the heathen goddess presiding over women in labour), and to call the garden Lucina's Garden. He had also agreed with the celebrated Mr. Van Nost for several statues which were actually fixed on pedestals, but as none of them were paid for in his life-time (one excepted), they were returned after his death."

Most of the bills and accounts which passed between Dr. Mosse and Van Nost for these statues being still preserved, and now lying before us, we are able to rectify this error of Mr. Higgins, who, probably, had not access to Van Nost's receipts, and we think the following list may not be uninteresting to the lovers of art. Some of those works were in marble, but the great majority were castings in metal. We find receipts for at least ten of these busts, only two of which are now forthcoming; some of the work was retained by the artist for non-payment of agreement after Dr. Mosse's death; but we have a positive receipt for the following:

"*To Statues delivered at the Lying-in Hospital by John Van Nost.*

"To a statue of Antinous, always sold for eighteen guineas, but agreed with Dr. Mosse to remit eight guineas in each of the six statues, ...	£11	7	6
"To a Venus de Medici, ...	11	7	6
"To a Mercury, ...	11	7	6
"To an Apollo, ...	11	7	6
"To a Faunus, ...	11	7	6
"To a sitting Venus, ...	11	7	6
"To a marble bust of Lord Sudley, ...	39	16	3
"To a marble bust of Lord Shannon, ...	39	16	3
	£147	17	6

Of which sum we find £97 7*s.* 3*d.* was paid by Dr. Mosse, through

the hands of Mr. Murray; and at foot of the account we find the following notice in the handwriting of the artist:

"The intention of Dr. Mosse was by agreement with John Van Nost to have had several more marble busts, and two large statues, one of his present Majesty, the other of the Prince of Wales, to be fixed on each pavilion in the front of the building."

We quote the following from a letter of Van Nost's, drawn up by him in 1759, after Dr. Mosse's decease, for the information of the Governors and Guardians of the hospital:

"At first he talked of twelve marble busts for the three long rooms, but concluded to make a beginning with four, namely, the Earl of Kildare, Bishop of Clogher, Lord Shannon, and Sir Arthur Gore. Three of these gentlemen sat for their likenesses to Mr. Van Nost, who, by directions of Dr. Mosse waited on the Earl of Kildare above three years ago, to beg the favour of a sitting for his Lordship's likeness. The Earl of Kildare refused it, but Dr. Mosse intended to use all the interest he could for that honour. Meanwhile Van Nost went on with the other three, two of which are finished, and the third boasted out. There were intended six statues in metal for the gardens, four of those are finished long ago, and they would all have been fixed up in the garden last summer had Mr. Darley completed the pedestals in time. The pedestals are now done in the garden, and one of the statues is fixed on. It was also agreed that John Van Nost should also execute two large statues in lead, and to be bronzed in gold; the one was to be King George the Second, the other the Prince of Wales, to be fixed on each pavilion in the front, as Van Nost has proportioned the plinths now set on the pavilion for that purpose. On agreeing for this business Dr. Mosse was pleased to tell Mr. Van Nost that he would not tie him down to any particular price, but desired that he would execute the work in the best manner, and from the good opinion he had of John Van Nost he would abide by his demands."

The public may fairly ask what has become of this fine collection, of which, with the exception of two busts,—probably those of the Bishop of Clogher and Lord Shannon, which stand on short pillars, in the entrance hall,—no vestige now remains. The following letter, addressed by the artist to the board of governors, shortly after the decease of Mosse, may, however, throw some light upon the subject.

"I have several days past done myself the honour of attending this Board, concerning my statues, to beg to know if you will be pleased to purchase them, or if they are to be returned to me. Counsellor Whittingham was pleased some time ago to tell me to bring them, and fix them on the pedestals in the garden, as was intended by Dr. Mosse, telling me that if the gentlemen of this honourable board approved, I should be paid for them; if not, he promised they should be returned to me. According to his directions I fixed them on their pedestals with some expense. I have been a long time past collecting and making these six statues, on

purpose for this garden; four of them I could have sold the other day, but was not permitted to take them away." Mr. Higgins, however, informs us that they were all returned to the artist.

We have thus far entered into a detail of the foregoing circumstances, as affording an instance not only of the intense energy and perseverance of Mosse, but of his acquaintance with, and cultivation of the Fine Arts, and of his enlarged views and grand intentions with respect to the structure which he had designed, and, had he lived, would, no doubt, have completed. The gardens, as they must then have appeared, with their statues, pavilions, ornamental walks, fountains, water-works, and shrubberies, together with the entertainments given there, with bands, concerts, and pyrotechnic displays, and their constant and tasteful illuminations, must have formed a novelty most attractive in our city at that period; and indeed we believe this public promenade, which generally presented "a numerous and brilliant assemblage of the first people in the city," was one of the earliest places of public out-door amusement in the Irish metropolis.

The hospital was now completed from the design of Mr. Cassels, and formed one of the greatest architectural ornaments of our city; and we may here remark, that Dr. Mosse was not only the founder, but that the building was carried on under his immediate superintendence, and all the details of the expenditure passed through his hands: several of the audited accounts of which now lie before us. The following correspondence shews Dr. Mosse to have been possessed of a most cultivated and refined taste, and, as we already stated, to have paid no small attention to the arts.

"Hitherto no mention hath been made," says Mr. Higgins, "of the chapel in the hospital, which the Doctor intended should excel anything of that size in Europe, which, had he lived a little longer, it certainly would have done, the decorations of stucco figures and other beautiful ornaments being finished at a great expense by the ingenious Mr. Cramillion, and the pews made of the best mahogany. The Doctor intended to have the large place in the centre, and the four shields in the ceiling, painted, and the stucco cornices and mouldings round the shields, as well as the iron scroll-work round the gallery, gilt. And here it may afford satisfaction to give some account of the intended paintings in the ceiling. Mr. Cipriani, a painter, then in London, was applied to for this purpose, and a plan of the chapel, with the shields to be painted, was transmitted to him by the Doctor; and several letters passed between them on that occasion, which are looked upon as curious, and are therefore given *verbatim*.

"DOCTOR MOSSE TO MR. CIPRIANI.

"'*Dublin, August* 1, 1758.

"'SIR,—Agreeable to Mr. R—y's desire, you will receive with this a plan of the ceiling of the chapel in the Lying-in Hospital.

The room is eighty-six feet square and thirty feet high. The centre of the ceiling is prepared for painting in oil colours. The subject at present thought of is the Nativity of our Saviour; and those for the shields, such as Abraham offering up his son Isaac; Pharaoh's daughter taking Moses out of the bulrushes, &c. &c. You will observe that the ceiling is now properly plastered for painting thereon, prepared in a fit manner by the gentleman who executed the rest of the work. However, I am entirely of Mr. R—y's opinion, that the best and surest way will be for you to come over to Dublin and view the place. Then we can fix the price and subjects much easier; and if we should not then agree, you shall be paid all reasonable charges for your time and trouble that Mr. R—y shall approve of.'

"MR. CIPRIANI TO DR. MOSSE.

"'*London, October* 4, 1758.

"'SIR,—You will excuse my not answering sooner your's of the first of August; the country and business have taken up so much of my time that I could not do it sooner. By the measure and description you were pleased to send me of the place to be painted in the hospital, I see that something fine may be done. These, therefore, are my demands: I shall, if you will agree to it, make a finished sketch, or, as we call it in the Italian, *un modello finito* of the whole; that is, a picture of a small size, that will give you an idea, and a very full idea, of the grand picture to be made according to your wishes. Whether my sketch is approved of or not, I will have forty guineas for it. If you should approve of it, we shall then treat about the sum that I shall expect for my coming to Dublin and painting the thing according to my sketch; and then you will give me leave to be so explicit as to tell you, with honest freedom, that I shall insist upon having the money to be agreed upon insured here in London. Was I a great and rich man I should not be so scrupulous; but as I must live by my pencil, I must make sure of my merchandize, and sell it in a clear, mercantile manner. I forewarn you, likewise, that I will have no superintendent to my work, and will not be under the least control.

"'You, Sir, and whoever is concerned in this affair, must prepare yourselves to be satisfied that I shall strive to do my best, and be content that an honest artist will do his utmost to gain fame and the good-will of his employers. This winter, then, if you agree to it, I shall make the sketch, and after having been paid for it, one-half before I begin, and the other half when I shall be done, I shall send it to you; and in case it give satisfaction, and the sum be agreed upon for the whole work, I shall set out next spring for Ireland to do it.

"'Whether we agree or not, I am very much obliged to you for the good opinion you seem to entertain of my abilities, and am, with the greatest regard,' &c.

"DR. MOSSE TO MR. CIPRIANI.

"'*Dublin, October* 20, 1758.

"'SIR,—I received your's of the 4th instant, and am satisfied to give you forty guineas for the sketch you mentioned, twenty guineas of which shall be immediately lodged with Messrs. Colley and Nixon, in Little St. Helen's, Bishopsgate-street, to be paid to you on beginning the picture, and the remaining twenty guineas to be paid by the same gentlemen on your delivering the picture to them completely finished.'(*a*)

"'The device for the centre is to be the Nativity of our Saviour, and the devices for the four shields shall be sent to you in a week or ten days; and all those devices I would have painted into one piece.

"'The bearer, Signor Riccardelli, can describe the ceiling of the chapel in a plainer manner than can be done by letter, and can also tell you that there are no windows but on one side of the chapel, which are south-east, where the altar is to be placed. As this chapel is intended only for Protestant worship, I would have the painting entirely free from any superstitious or Popish representation. The sooner you finish the sketch the better it will answer the intended purpose. I send by Signor Riccardelli another draught of the moulding round the centre or grand piece, and also of the mouldings round the shields. I am, &c.'

"MR. CIPRIANI TO DR. MOSSE.

"'*London, November* 12, 1758.

"'SIR,—Signor Riccardelli, in delivering me your's of the 20th of October, has been so good as to give me a very clear and distinct idea of the situation and light of the chapel; and in consequence of your and his instructions, I hope I shall make such a sketch as to give satisfaction. I was much pleased in hearing from him that you understand what we call in Italian '*il sotto in su*,' or, as I think you call it in English, 'the foreshortened painting.' It is always a great encouragement to an artist to have to do with people that have a clear conception of the powers of his art. Signor Riccardelli hinted to me that you appear a little surprised at my fair and open expressions in my last; and yet I hope my picturesque freedom was favourably construed, considering that I am a foreigner, that I have some business, in London, and that I cannot venture into a new country without being morally certain of succeeding.

"'I shall immediately set about the sketch, and be assured that my utmost skill and diligence shall be bestowed upon it. The sooner you send me the other devices the better; though, in my opinion, the middle and grand one would do better in a sketch by itself. Nevertheless, I shall comprise them all five in one, and take

(*a*) This sketch was finished, and after the Doctor's death his executors, for the honour or his memory, wrote to Mr. Cipriani for it, and offered to pay the remaining twenty guineas; but the painter did not choose to part with it.

these additional pains to remove all objections. I beg you will consider me as being, with the greatest esteem, &c.

"'P.S.—I forgot almost to tell you that you shall have no other Popery in the picture than the Nativity of our Saviour; and, as I am pretty sure that the Pope shall never set foot in Ireland, so you may be confident that my picture will never contribute to the enlargement of His Holiness's jurisdiction.'

"MR. CIPRIANI TO DR. MOSSE.

"'*London, November* 20, 1758.

"'SIR,—I forgot to tell you in my former that Signor Riccardelli has apprized me of what you told him, that you were not yet entirely resolved in regard of the main subject, and whether it should be the Nativity of our Saviour or His Ascension. My inclination tends rather to the Nativity, as more susceptible of poetical images, at least in my opinion; yet the subject is to please you and the beholders, rather than the painter. Therefore, please do me the honour to acquaint me with your final determination, that I may go about it in good earnest. Meanwhile I shall go on drawing thoughts fit for either subject, and shall be very impatient to have them fixed by the knowledge of your pleasure."

"DR. MOSSE TO MR. CIPRIANI.

"*Dublin, December* 2, 1758.

"'SIR,—I received both your letters of the 12th and 20th of November, and have considered the subjects, and think that the following devices will be very proper for the chapel of the Lying-in Hospital:

"'As you approve of the Nativity of our Lord for the centre, I am well pleased it should be the subject. In the second chapter of St. Luke's Gospel you behold a multitude of the heavenly host, appearing amid the gloom of night to poor affrighted shepherds, proclaiming the happy birth of the great Redeemer of mankind; and in the second chapter of St. Matthew's Gospel a star leadeth the wise men to the place of our Lord's nativity. They behold him in his mother's arms; in raptures they adore him, and present gifts, &c. May not the star leading the wise men have a fine effect? Their prostration also before the babe? If you should happen to alter your opinion, and choose the Ascension instead of the Nativity, you will find it described in the first chapter of the Acts of the Apostles, and I leave it to your choice which of these two subjects to make use of.

"'And for the four shields: First, in the tenth chapter of St. Mark we behold little children crowding about our Lord, some attempting to walk, others in their mothers' arms, the disciples rebuking those that brought them, our Lord ordering them to be permitted to come to him, expressing his great love for them

in the most endearing manner, taking them up in his arms, embracing them, blessing them. All these figures are most strong and striking. Second: Look into the twenty-first chapter of Genesis, fifteenth and sixteenth verses, Hagar weeping over her expiring child, and calling upon God for relief; God sendeth his angel, &c. Are not these striking figures? Remark that God sendeth help to the mother and child, both forlorn and disconsolate, wearied with their journey through the inhospitable wilderness of Beersheba. Remark further, that she cannot bear to see the child die. May she not be represented with her hands lifted up to heaven, taking the last look at her beloved? Third; In the first chapter of Exodus we read of Pharaoh's barbarous purpose of putting an end to the whole Hebrew race (verse 15). The King of Egypt spake to the Hebrew midwives, and said: 'When ye do the office of a midwife to the Hebrew women, and see them upon the stools, if it be a son then shall ye kill him, but if it be a daughter then shall she live. But the midwives feared God, and did not as the King of Egypt commanded them, but saved the men-children alive. And the King of Egypt called for the midwives, and said unto them, Why have ye done this thing, and saved the men-children alive?' May not Pharaoh be represented rising from his throne, his hands raised up, his eyes furious, and his whole visage overspread with rage; the affrighted women bending before him pleading their excuse. This story seems to afford full scope for the genius of a painter to exercise itself. Fourth; In the second chapter of Exodus you behold Pharaoh's daughter at the bank of a river, looking with eyes of tenderness, surprize, and compassion, upon Moses, a beautiful infant, weeping in the ark. May she not be further represented as affording immediate succour, agreeing with a nurse who happens to be the child's mother, and will not the astonished, delighted mother make a beautiful part of the picture? Although I have here mentioned four devices which I think would be proper for the shields, yet if you should find any of them, in your judgment, not convenient for the size or compass of those shields, or should think of any other subject more proper, or which you think would have a better effect, be pleased to let me hear from you, that we may endeavour to please each other. I am, &c., &c.'

"The Doctor," continues the manuscript, "had bespoke an organ for the chapel, which was not finished in his life-time, but hath since been received, and being thought too large and too loud for the size of the chapel, hath been erected in the new music room, or large Rotundo. He had also bespoke a chiming clock and a ring of small bells for the steeple of the Hospital, but some ladies who lived in the neighbourhood insisted that neither bells nor clock should be fixed there, as they might disturb them on mornings; which he (though with great reluctance) complied with. He also intended to fit out an observatory in the steeple, and had provided a telescope for it; but the telescope, through some mistake in landing it, was seized by a revenue officer, and afterwards sold by auc-

tion at the Custom House while the Doctor was absent in England, and that part of the steeple remains still unfinished.

"While the chapel was finishing with all possible expedition, the Doctor applied to the late Rev. Dr. Lawson, and requested him to preach the first sermon therein, which he readily agreed to, and wrote a sermon for that purpose, which he privately lent to the Doctor, who had a copy made of it, and returned the original at the time appointed. This copy being found amongst the Doctor's papers after his death, hath been published by his executors, and by that means escaped the fate which all the sermons of that great preacher met with, being burned by directions of his last will. As some persons, to this day, object to this hospital as being an encouragement to idleness and to vice, and as being too grand in the building, the sermon above-mentioned answers these objections in the following manner:

"'But may not this institution, after all, be an encouragement to idleness? Women bred to work, finding here unbought, unearned provision, will cease from labour. Surely they must be very bad, and would be idle at any rate, whom the prospect of an aid so limited and transitory can make idle. Say, rather, the industrious will be induced by this comfortable help in their greatest exigencies, to redouble their industry, will work more cheerfully, and return to labour with better health. Well, but is not this institution an encouragement to vice and licentious manners? Is vice indeed so provident? Doth it foresee with such deliberation, and is it deterred by future difficulties and dangers? Surely not; it braves the greatest every day. At least the good wrought here is certain, the evil, if any, doubtful; besides, all due care is taken to prevent such supposed abuse. The admitted, their state, character, circumstances, are inquired into, and proper testimonials demanded; or if, after all deserving objects that offer have been taken care of, an unworthy should by stealth slide in, would not piety, would not humanity forgive? At worst, one sinless soul is preserved, the unoffending infant. Well, but, granting all this, why such grandeur? To relieve these poor objects 'tis right, but why in a palace? You will agree that such building should be large for convenience, strong for lasting, neat and warm for health. Now, allow fully for these conditions; ornament occasions a much less additional expense than is imagined; neither is it useless; it gives pleasure to a beneficent mind to behold the seat of the bounty clean, fair, even elegant; it draws attention and inquiry to a scheme so reasonable and benefactions. Virtue should be beautiful as well as beneficial."

The hospital now being open for the reception of patients, its character and that of its founder established beyond the reach of calumny, the Government of the country in some degree pledged to its support, and many individuals of the highest rank and greatest influence interested in its prosperity, Dr. Mosse may well have surveyed the result of his labours with complacency, and have contemplated spending the remainder of his life less laboriously,

though not less usefully, in extending the benefits of this great work to the poor, and in training up a body of well-educated, intelligent practitioners, to spread throughout the country the benefits received at his hands. We say, he might not unreasonably have anticipated this, but such was not his appointed lot; it pleased God to spare his life, just to witness the perfect success of his exertions in the establishment of the hospital, but no more.

"Having greatly impaired his health by intense study and application of mind, by his close attention to the business of the hospital, by constantly superintending the building, and by several fatiguing journeys to London, to forward his schemes, he did not long enjoy the pleasure arising from the success of his labours, for he grew so ill in the beginning of the winter of 1758, that he was obliged for the most part to confine himself to his chamber. Several physicians attended him, but, finding all their endeavours ineffectual, they advised him to return into the country. On this occasion Alderman Peter Barre made him the kind offer of his house at Cullenswood (about a mile from town), which the Doctor readily accepted; and there, on the 16th of February following, he departed this life in the 47th year of his age, and was interred at Donnybrook(*a*), leaving the new hospital a monument to posterity of his surprising perseverence, diligence, and ingenuity, and indeed one of the most superb architectural ornaments of the great and elegant city of Dublin. He left but two children."

Thus died this great and good man, in the prime of life and usefulness, possessing great energy and high benevolence of character, which he so employed as to have conferred immeasurable benefit upon his own and subsequent generations. His eulogy is to be found in his acts. Without fortune, without influence, without patronage, without precedent, he conceived the project of affording relief to a certain class of the community, and with extraordinary energy, prudence, and perseverance, by never relaxing, never despairing, he carried it into execution, at an expense of character, station, and pecuniary independence. By the earnestness of his benevolence he interested persons of all classes, and finally secured for his good work the patronage of Government, and the protection of the throne. For this one great object, of providing an asylum and a refuge for woman in her greatest hour of trial, he lived,—for this he may be said to have died,—died poor as to wealth, but rich in the blessings of the needy, and of those who were ready to perish.

The following extract from the Doctor's Will provides that the object for which he sacrificed so much during his lifetime should be secured to the poor after his death. "Whereas William Naper, Esq., did, by indenture bearing date the 15th day of August, in the year of our Lord 1748, demise and grant all that lot or piece of ground on the north side of Great Britain-street, described at large in such indenture and the maps thereto annexed, unto me, my heirs and as-

(*a*) We have made diligent but unsuccessful search for the tomb of Mosse at Donnybrook.

signs, during the lives in such indenture named, with a covenant of renewal for ever, at the yearly rent of £70 sterling, after the first two years of said demise; and by a deed bearing date the first day of January, 1749, and endorsed upon the said indenture of lease, I have declared that the said indenture of lease, and the ground thereby demised, were taken by me in trust for the hospital for poor distressed lying-in women; and I did thereby covenant with the trustees or persons in such endorsed deed named, to make and execute such further grant and conveyance of the said premises as should be thought necessary for assuring the same to the use and benefit of the said hospital, as in and by said indenture of lease, and the said deed, endorsed thereupon more fully appears.

"And it hath pleased Almighty God to bless my intention and endeavour so far, that, notwithstanding the many difficulties I have struggled with, I have lived to see an hospital for the said charitable use built upon the said ground, and now almost completed; His Majesty's most gracious charter obtained, erecting a corporation by the name of 'The Governors and Guardians of the Hospital for the Relief of poor Lying-in Women in Dublin;' and the said charity and hospital encouraged and supported by the benefactions of many well-disposed persons, but, above all, by the Honourable House of Commons of this kingdom, in their several votes and addresses in favour of the same.

"I think it my duty, in the first place, with regard to worldly affairs, to confirm, as far as in me lies, my said declaration of trust; and I do hereby, for me, my heirs, and assigns, grant, confirm, give, and devise all the said lot or piece of ground, with the said indenture of lease, and all benefit of the covenant for renewal, and all and singular the premises demised and granted by the said indenture, together with all buildings and improvements whatsoever erected or made thereupon, and all my right, title, or interest of, in, or to the same, subject, however, to the rent, covenants, or reservations on the tenants or lessees' part, in the said indenture contained, to be paid, done, or performed, to the Right Honourable James Earl of Kildare, and the Right Honourable Sir Arthur Grove, Lord Viscount Sudley, of Castle Grove, and their heirs for ever, to the only use and behoof of the said corporation or body politic, and their successors for ever."

Immediately after Dr. Mosse's death, the Governors held several meetings for the purpose of investigating into the state of the hospital, and the works then carrying on; and finding themselves in debt, and several parts of the building unfinished, they petitioned the House of Commons, in November, 1759, for a further grant of money, and also recommended to the consideration of Parliament the Doctor's family. This petition was accompanied by one from Mrs. Jane Mosse, the Doctor's widow; and in consequence of a favourable report from the Committee of Inquiry, the House was pleased to grant £3000 to the hospital, and £1000 to Mrs. Mosse, for the use of herself and her children.

Similar petitions were presented in November, 1761, and November, 1763, and grants were made, to the amount of £4000 to the hospital, and £1500 to Mrs. Mosse.

Soon after this last grant the Governors undertook the erection of the Rotundo, which is 100 feet in diameter, and capable of accommodating upwards of 2000 persons; and having expended thereupon £1800, they again petitioned Parliament for aid, as upwards of £2000 more were required to complete it. In reply to this petition the House gave an additional grant of £2000.

It may not be uninteresting to insert here a debtor and creditor account between Dr. Mosse and the public, which is given in the manuscript memoir, with the following observations:

"From what has been said it may give some satisfaction to consider how far the public are obliged or indebted to Dr. Mosse on account of this hospital. This can only be shewn in a general way, leaving every reader at liberty to criticise, alter, or object to the form, to the whole, or a part, as he shall think proper. But the following sketch is submitted to the impartial and the candid.

THE PUBLIC TO DR. MOSSE

"*Dr.*	£	*Cr.*	£
To fitting up, furnishing, and maintaining twelve years, the hospital in George's-lane (printed statement)	3913	By two Parliamentary Grants in Sessions 1755–7, £6000 each, net, deducting fees, ...	11,640
To laying out and making the garden in Great Britain-street, building coffee-room, orchestra, &c., finding wood, iron work, globes, &c., ...	4000	By ten years' profits of the garden,	4000
To value of said garden (now capable of producing, at least, £500 per annum), ...	10,000	By lottery schemes, about . . .	9595
To building and furnishing the new hospital as it stood at his death, by a gross calculation of skilful persons, ...	25,000	By several benefactions, about .	2108
To maintainance of said hospital from its opening until his death, about	800	By Parliamentary Grant to himself in 1757, net, ...	1940
To his attendance, labour, and trouble for fifteen years, . .	5000	By cash from Governors of hospital to his executors, ...	1000
		By Parliamentary Grants to his widow and children 1759, 1761, and 1762, £2500, net . . .	2425
	48,713		32,708
		Balance due by the public which, at least, deserves gratitude to his memory, ...	16,005
			48,713

"N.B.—It is submitted to the consideration of the public whether credit should be given in the above sketch for the first £6000 obtained from Parliament by the Doctor's own unwearied industry and application (being net £5820), or for the money raised by his own schemes, being £9595, making together £15,415, which being added to the said balance of £16,005, would make the balance due by the public £31,420, without considering his many journeys, troubles, and anxieties, which few men, if any, in this age would have undergone without some view of profit(*a*)."

(*a*) Thus ends the memoir of Mr. Higgins, from which we have derived most

But, though the good thus effected be great and unparalleled in these kingdoms, we think it inferior in point of value to the benefit conferred upon the profession, and, through it, upon the public in general, by the extensive opportunities of observation and experience afforded to both masters and students. It is to be regretted that no regular registry of the pupils who attended this institution was preserved until the days of the late Dr. Clarke. Were such in existence, it would now be a pleasing task to state the exact numbers, of the many thousand students, from the different countries of the British isles, and from the Continent, who have profited by this splendid establishment. The majority of the students attend for six months, but many for a much longer period, and six are accommodated with apartments in the hospital: all receiving practical instruction, at the bed-side and in the lecture room, from the master and his assistants.

From among these pupils, fifty-six assistants have been elected, two at a time, for a period of three years, having during that period the supervision of the hospital in turn, under the superintendence of the master, and enjoying opportunities of performing the more serious operations under his eye.

From among the assistants, fourteen masters have been appointed, each for a period of seven years, having during that time the undivided management and responsibility of the patients.

Dr. Mosse's successor in the mastership was the celebrated Sir Fielding Ould.

If now we recollect that for some years past more than 2000 females have been delivered annually in the hospital, we shall see that a man who has successively been pupil, assistant, and master, must have had such experience as falls to the lot of no other obstetrician in the empire. We may safely assert that nearly all the correct practical knowledge of midwifery, diffused through this country, has had its origin in the benevolent enterprize of Dr. Mosse.

As a school of midwifery we are proud to claim for it an unrivalled superiority, not only in the British isles, but (and we speak advisedly, having visited all the others of note upon the Continent) in Europe also. The writings of Ould, Jebb, Clarke, Labatt, Collins, and Kennedy, who have been successively masters of this hospital, and of Douglass, Murphy, and others, who have been assistants, evidence the amount of information which it affords. Dr. Collins, in his truly practical and honest report of his seven years' mastership, has set an example which we sincerely hope to see imitated; and we trust our present master and his assistants will shortly give us the result of their experience.

There are some subjects connected with the Lying-in Hospital on which we would, in all good friendship, make a few observations. It has been now nearly ninety years in existence in Britain-street. There have been upwards of 155,000 deliveries, and with all this, no public obstetric museum has yet been created in this hospital. It is true that individual masters have, for the benefit of their pupils, made collections; but these are their private property, either to be removed from the institution, or disposed of to the incoming masters, on the occasion of a change of officers. Look at the splendid collection which Dr. Montgomery(*a*), from his own private resources, almost, we may say, with his own hands, has created for the benefit of his lectures at the School of Physic; and why should not the Lying-in Hospital, with its ample means and most extensive resources, be supplied with this most necessary appliance to any school of practical medical science.

There is a library within the walls of the hospital, but it also is private property(*b*). Again, there are, as in every well-regulated hospital, accurate notes taken of all, or at least of most of the cases of interest, and we know that a volume of most important *material* is thus collected by each of the masters and their assistants, but this is private property. Why not, as in other hospitals, provide a proper clinical clerk to note, and proper books to preserve this valuable information, reserving to the medical officers, for the time being, the right of making use of it?

From 1757 to the beginning of the present year, the number of patients admitted has been 159,625; sent out undelivered, 7015; delivered in hospital 152,395; of 154,630 children, the sexes being in the proportion of about twelve males to eleven females. The number of women having twins, or more, has been one in sixty; having three or four children, about 1 in 5000 (there was only one instance of four at a birth); children still-born, about one to seventeen; mortality of mothers, one in eighty-nine; children dying in the hospital, one in twenty-one.

of the previous information. Since the foregoing sheets were put to press we have received the following notices of this gentleman from the minute books of the hospital. Benjamin Higgins was ordered (as clerk) to prepare a report of the tradesmen's bills on the 15th of October, 1759; appointed register 2nd May, 1760; Nov. 1st, 1771, petitions to be excused from attendance at concerts on account of his health; received at this time an additional salary of £20 per annum; appointed deputy treasurer in 1790; again, in 1796, a memorial was presented to the Lord Lieutenant in behalf of the widow of Benjamin Higgins. On the 14th May, 1796, "The Board, taking into consideration the faithful services of B. Higgins, who has since the foundation of this charity been a diligent and unwearied supporter of the same for forty years and upwards, and having considered the narrow circumstances of his widow, Resolved, that in case the funds of this institution shall exceed its annual expenditure, the annual sum of £30 sterling be paid to the widow of the said Benjamin Higgins." "Resolved, that this Board will place a tombstone in the churchyard of Donnybrook, over the grave of the said Benjamin Higgins, as a lasting testimony of their regret at his loss, and of their grateful sense of his unremitting zeal for this institution."

(*a*) This Museum of Dr. Montgomery's contains about 700 preparations. It is his own private property, but the College of Physicians have provided a room for it at their Hall in Sir Patrick Dun's Hospital. In our last biography, p. 292, this circumstance of the Museum being the Doctor's private property was inadvertently, and most unintentionally omitted.

(*b*) We have just learned that the Commissioners for Inquiry into the State of the Public Charities of Dublin have recommended the purchase of both these by the Government.

Neither our time nor space permit us to enter into the history of the Dublin Lying-in Hospital subsequent to the time of Mosse; we may mention, however, that as it now stands, it contains 140 beds, of which number fifteen are appropriated to chronic diseases. Subsequent to the building of the Rotundo, in 1765, the hospital was in a great measure supported by means of the income derived from it, and the subscriptions of the Governors. The average receipts of the Gardens, Rotundo, and public Assembly-rooms, from 1789 to 1796, amounted to four thousand pounds per annum; but after this period this income became greatly diminished. A large portion of the produce of the entertainments, amounting to about £1000 yearly, arose from Sunday evening promenades; but in 1796, representations having been made to the Governors, that these entertainments were prejudicial to religion and morality, they were relinquished. During the year 1798, and for some years afterwards, the public rooms were occupied as a barrack by the Government, during which time the supplies arising from entertainments were greatly diminished; and the tax on sedan chairs(*a*), which the Governor were empowered to levy by an Act of 25 Geo. III.—and which for many years made a very considerable item in the resources of the institution, amounting in 1798 to £547,—having gradually diminished every year, in 1803 the British Parliament granted £2619, and from that period large annual grants were made up to the year 1835, when the Government reduced this source of income to £1000 a year. In 1790 debentures were issued for a loan of £11,000 to complete the Rotundo rooms, the interest of which has ever since been paid at 4 per cent., Irish; and this £400 a year is still a heavy drag upon the resources of the institution.

(*a*) During the period when this tax was levied, the hospital published "A List of the Proprietors of Licenses for Sedan Chairs," &c., together with "A Scheme for Card Assemblies," &c. From one of these curious little books now lying before us, and in which are likewise given the coats of arms of all the benefactors of the institution (some of which armorial bearings are still preserved in the wards of the institution), we learn that there were 257 *private* sedan chairs in Dublin in 1787, belonging, besides the ordinary resident gentry, to one Duke, one Duchess, twelve Earls, sixteen Countesses, eleven Viscounts, nine Viscountesses, thirty-seven titled Ladies, one Archbishop, three Bishops, five Lords, ten Baronets, forty-two Honourables, male and female, &c.

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Engraved by W.H.Lizars, Edin.r

D M B

Dublin, Hodges & Smith, 1847.

ILLUSTRIOUS PHYSICIANS AND SURGEONS IN IRELAND.

No. III.

DAVID MACBRIDE, M. D.,

With a Portrait.

It is much to be regretted that very scanty memorials of the many eminent physicians and surgeons who practised in Ireland, in the latter part of the seventeenth and during the eighteenth century, have been preserved; yet, being desirous to promote the object which has been already set forth in the memoirs of Sir Patrick Dun and Dr. Bartholomew Mosse, we have been induced to attempt the compilation of the following memoir of one of the most eminent practitioners in Dublin during the last century, and whose published works contributed in no small degree to extend the fame of Irish scientific literature both in England and on the Continent(*a*).

David Macbride was descended from an ancient family of that name in the shire of Galloway, in Scotland; his grandfather came to Ireland about the end of the seventeenth century, and officiated at Belfast to a congregation of Presbyterians. His father was also a Presbyterian clergyman, and married the daughter of Mr. Boyd, of Killabeg, in the county of Down; he was minister of Ballymoney, near Coleraine, in the county of Antrim, where David was born on the 26th of April, 1726.

He was educated at the public school of Ballymoney, and, after serving an apprenticeship to a surgeon in that place, he entered the Royal Navy; where having served for some time as mate in an hospital-ship, he was subsequently advanced to the rank of surgeon, in which capacity he remained until the peace of Aix-la-Chapelle in 1748.

A seafaring life having afforded him many opportunities of observing scurvy in all its stages, it was about this time he first turned his attention towards the discovery of a remedy for that disease, the investigation of which he carried on for several years, and made many ingenious experiments, which resulted in the publication of his Essays, to be noticed presently.

Subsequent to the treaty of Aix-la-Chapelle, Mr. Macbride went to Edinburgh, where he studied anatomy under Monro, and afterwards to London, where he studied midwifery under Doctors Hunter and Smellie; he also attended the lectures of other distinguished teachers on the different branches of medicine, but did not take a medical degree.

(*a*) For the materials of this memoir we are indebted to our esteemed friend and learned contributor, Dr. Aquilla Smith, who has already thrown so much light upon the history of medicine in Ireland.

In the year 1749 he settled in Ballymoney, and in 1751 he removed from thence to Dublin, and commenced practice as a surgeon and accoucheur in the twenty-sixth year of his age; but, being young and remarkably bashful, his practice for several years was very limited. His abilities were then only known to his family connexions and a circle of select friends. These, however, were captivated with his company, not only from his being possessed of agreeable manners and a pleasing disposition, but for his general knowledge in painting, music, and of many of the branches of polite literature.

Mr. Macbride was a member of the Medico-Philosophical Society, established in Dublin in 1756 (an account of which was given in the preface to the first volume of the present series of our periodical(*a*)), and filled the office of secretary after the death of Dr. Charles Smith, in 1762.

To this "little society(*b*)." which, at its first institution, consisted of only seven members, who met "once a fortnight for their mutual improvement," he first communicated his ideas respecting the treatment of scurvy, and many of the experiments detailed in his "Experimental Essays,—I. on the Fermentation of Alimentary Mixtures,—II. on the Nature and Properties of Fixed Air,—III. on the respective Powers, and Manner of acting, of the different Kinds of Antiseptics,—IV. on the Scurvy; with a Proposal for trying new Methods to prevent or cure the same, at Sea,—V. on the dissolvent Power of Quick-Lime,"—which were first published in London in 1764, 8vo. pp. 267.

These soon attracted the attention of philosophers and physicians, and were shortly after translated into different languages; and on

(*a*) See preface to the first Number of this Journal, p. xxix.

(*b*) It appears that it was customary, at the meetings of the Medico-Philosophical Society, for the members not only to read original papers, but also to make communications in the form of reviews of new or rare books, and reports on recent discoveries, &c. Thus we find among the papers of this body contained in "The Repository," now in the Library of the Royal Irish Academy, a notice of Dr. Macbride's, detailing the contents of "Gooch's Practical Remarks on Surgery," in 1758, and giving therein some short commentary of his own on each section; likewise extracts and translations from the Memoirs of the Parisian Academy of Surgery, on M. Rocolin's essay on the utility of uterine injections, and Leveret's treatise on the method of delivering the placenta, and others of a like nature. In the same year he made a most interesting communication to the Society, shewing that Hippocrates recommended the use of emetics in the treatment of uterine discharges. As this paper is one not only of interest, but of practical value, even in the present day, we shall, at some future period, publish it entire in our Medical Miscellany, as well as other communications from the pages of the manuscript work just referred to. In 1761 he gave an account of Astruc's theory of menstruation.

At the meeting of this Society on the 16th of October, 1764, Dr. Rutty gave a general analysis and commentary upon the first four of Dr. Macbride's Experimental Essays, and spoke in highly commendatory terms of their universal influence on practical medicine.

the 27th of November, 1764, the University of Glasgow testified their approval of the work, by conferring the degree of Doctor of Physic on the author.

A "second edition, enlarged and corrected," was published in London, in 1767, 8vo. pp. 296, and in the same year a tract of thirty-eight pages, giving "an historical Account of a new Method of treating the Scurvy at Sea, containing ten Cases, which shew that this destructive Disease may be easily and effectually cured without the aid of fresh vegetable Diet."

In the first three essays, which are preliminary to the fourth, we do not find any thing which calls for particular notice. In forming our estimate of the value of chemical experiments made about the middle of the last century, we should endeavour to forget the more exact knowledge of our own times, and place ourselves in the position of a contemporary with the author; for, though instances might be quoted in which the inferences drawn from the experiments are erroneous, yet the facts detailed in the experiments will ever remain as evidences of the ability and patience with which the investigations were pursued.

The following extracts from the fourth essay, will put the reader in possession of Dr. Macbride's theory, and the mode of treatment proposed by him for the cure of scurvy:

"For some time, even before I engaged in the course of experiments which have been set forth in the three preceding essays, I was firmly of opinion, that the cure of the *sea scurvy* depended chiefly, if not altogether, on the *fermentative quality* of the *fresh* vegetables; which are found, by experience, to be the only things that, with certainty, conquer this destructive disease. And in consequence of this persuasion, it occurred to me, that as there are vegetable substances, which, though not perfectly recent, are yet capable of fermentation, such in particular as *common malt;* that this, if taken in the way of medicine, would, in all probability, produce effects similar to those produced by green vegetables, and consequently cure the scurvy; and as *malt* can be preserved sound, for a considerable length of time, it might be carried to sea, and there kept, in order to make *wort* occasionally as it might be wanted; and thus prove a remedy, always in readiness, against that fatal disease."—*Second Ed.* p. 167.

"The method in which it is proposed to prepare the *wort*, is, to take *one* measure of the *ground malt*, and pour on it *three* measures of boiling water; stir them well, and let the mixture stand, close covered up for three or four hours, after which strain off the liquor."—*Ibid.* p. 194.

The mode of administration proposed, is, to boil the *wort* "into a *panado*, with sea biscuit, and some of the dried fruits that are usually carried to sea; the patient to make at least two meals a day on this palatable mess, and to drink a quart or more of the *fresh infusion*, in the course of the twenty-four hours."—*Ibid.* p. 189.

About the beginning of the year 1762 Dr. Macbride communicated his views on the treatment of scurvy, in the form of a letter,

to his friend, Dr. George Cleghorn, Professor of Anatomy in the University of Dublin, by whom copies were transmitted to Dr. Wm. Hunter, and to Henry Tom, Esq., one of the Commissioners for taking care of Sick and Wounded Seamen. Through their influence, the Lords of the Admiralty, in May, 1762, gave orders to have the *wort* tried in the naval hospitals at Portsmouth and Plymouth. The Doctor also acknowledges his obligations to Vice-admiral Sir Charles Saunders, by dedicating to him the second edition of the Essays, published in 1767.

Notwithstanding all this powerful influence, Dr. Macbride, writing on the 12th of December, 1766, is compelled to say: "I take it for granted that nothing has been done in consequence of that order, nor any report ever made."—*Second Edit.* p. 171, *note.*

In a postscript appended to the second edition of the Essays, there is "An extract from a medical journal kept by Mr. Alexander Young, surgeon to His Majesty's ship Jason," of which Captain *John Macbride*, only brother to the Doctor, was commander, in which journal is given an account of the successful treatment of four cases of scurvy by wort, which, with the cases detailed in the "Historical Account" published in 1767, and some particulars in the chapter on scurvy in Macbride's "Practice of Medicine," comprise all the evidence collected by the author, who, in 1777, intimated his intention to publish all the letters and reports which had been communicated to him, but he did not live to carry his intention into effect.

The fifth essay, the title of which is, "On the Dissolvent Power of Quick-Lime," contains a number of miscellaneous experiments and observations, all tending to a further proof of what had been advanced in the four preceeding essays.

After giving a summary of Dr. Black's theory of the constitution of calcareous earth, Dr. Macbride adds: "But it occurred to me, that it might possibly be still further proved, and that in a way which would afford an ocular demonstration;" and with this object the first experiment was devised. Into a filtered solution of lime-water fixed air (carbonic acid gas) was passed by means of an ingeniously-contrived apparatus, of which a figure is given; "and it was highly pleasing to see the particles of quick-lime, which, but two or three minutes before, were quite invisible, and dissolved in the water, all running together and falling to the bottom:" the precipitate, when collected, "effervesced violently with spirits of vitriol (sulphuric acid), and thus was the theory of Dr. Black placed beyond the reach of contradiction."—*Second Ed.* p. 229.

Having determined, "in three different instances, that the lime is precipitated from lime-water by restoring to it the fixed air," he adds, "may not lime-water, therefore, upon this principle, be used as a *test* to try whether or not bodies contain *fixed air?*"

In the seventeenth experiment, he proved the truth of his conjecture, by shewing that the "*perspirable matter*," as emitted from the lungs, contains fixed air or carbonic acid. "Three ounces of filtered lime-water being put into a phial, and a funnel fixed close into the neck of it," he says, "I blew in my breath through the funnel; and

by the time I continued so doing for ten or twelve minutes, I found the water growing turbid, and the lime becoming visible." He also determined the existence of carbonic acid in the sweat and in the atmosphere, and states that when carbonic acid is evolved in the stomach, from effervescent mixtures, "it often operates like a charm in restraining vomitings."

He also proved that saliva does not contain fixed air, but that it absorbs it rapidly.

The solvent power of lime-water on vegetable matter was the subject of many of his experiments; and, of Peruvian bark infused in it, he says: "I can venture to assure the reader, from repeated experience, that the bark, given in this manner, will scarce ever fail; particularly with regard to the uterine discharges, when they proceed from mere relaxation or weakness."(*a*)

From the success of the first experiment, Dr. Macbride began to think that the sulphur in the natural sulphureous waters might also be rendered visible as well as lime. He therefore instituted experiments, the result of which was that they "pointed out a method of making a pure solution of sulphur, which, being diluted to the proper degree, gives an artificial sulphureous water, perfectly resembling the natural as to taste, smell, transparency, and want of colour, and not liable to grow turbid on the addition of acids, which all other artificial solutions of sulphur, hitherto known, constantly do."

Dr. Thomson, in his History of Chemistry, justly says, that previous to Mr. Cavendish's investigations, "Dr. Macbride had already ascertained that vegetable and animal substances yield fixed air by putrefaction and fermentation."—Vol. i. p. 343.

But the extracts which we have made from Dr. Macbride's essays shew that he was entitled to more credit for his discoveries in pneumatic chemistry than has been hitherto awarded to him. The following statement of Dr. Thompson is not reconcileable with the fact of the publication of Macbride's essays in 1764:

"Pneumatic chemistry *had been begun* by Mr. Cavendish, in his valuable paper on carbonic acid and hydrogen gases, published in the Philosophical Transactions for 1766."—*Hist. of Chemistry*, vol. ii., p. 18.

About this time Dr. Macbride's practice rapidly increased, (being upwards of £500 a year); and, feeling assured that his abilities were appreciated, and that he was now in a position to insure success, he set up a carriage in November, 1767(*b*).

(*a*) Besides the ordinary mode of administering bark in effervescence with carbonate of ammonia, our distinguished contributor, Mr. Donovan, has lately succeeded in charging a solution of the syrup of bark with carbonic acid gas, which makes an agreeable and exceedingly efficacious draught.

(*b*) It may be interesting to state that in three years after (1770), Dr. Macbride's professional receipts amounted to £1069 18*s.* 5*d.* The fee at that period was usually a guinea (£1 2*s.* 9*d.*) On the fifth year following, his income from fees amounted to £1564 19*s.* 1½*d.* In 1777 he made nearly £1800. We have extracted those particulars from Dr. Macbride's fee-book, kindly placed at our disposal by Dr. Evory Kennedy.

In the December following he proposed a new process of tanning leather, which is noticed as follows in the Proceedings of the Dublin Society for March 31st, 1768:

"It appearing by the testimony of three eminent tanners of this city, viz., Mr. William Laban, Mr. Samuel Henderson, and Mr. Robert Hutton, that a calf's skin (the same being exhibited) which was tanned after a new method, lately discovered by Dr. David Macbride, was well and sufficiently tanned; and it further appearing by Mr. Laban's testimony, who tanned the said skin, that the same was completely done within the space of four weeks, whereas it would have taken from four to six months to tan the same skin as perfectly, after the method of tanning hitherto, and usually practised; Mr. Laban also testifying that the method of tanning lately discovered by Dr. Macbride is in every respect much easier and cheaper to the tanner than the common method of tanning, and that very great advantages must accrue therefrom to this manufacture:—Dr. David Macbride, in consideration of his important and ingenious discovery, was unanimously elected an Honorary Member of this Society."

It was also proposed, "That a silver medal be presented to Dr. Macbride, as a further mark of honour to him from this Society," which was agreed to at the meeting, on Thursday, 14th of April.

He subsequently received a gold medal from the Society of Arts and Commerce in London, as a mark of that body's appreciation of his useful discovery.

On the 14th of November, 1769, a petition from Dr. Macbride was presented to the Irish House of Commons, setting forth that he had "invented a method of tanning, founded on chemical principles, whereby leather is improved in its quality, tanned in one-third of the time required by the process hitherto known and practised, and with the saving of one-fourth in the expense of tanning materials, particularly of oak bark;" and, "That the petitioner is ready to disclose his secret, and instruct the tanners of Ireland in general, on such consideration as the House shall deem adequate to the importance of his discovery, and think a recompence sufficient, for giving up the profits which may be secured to him by the usual privilege of an exclusive patent."

A committee was appointed, which, on the 18th of November, brought up their report, concluding with the resolution, "That it is the opinion of the Committee, that the petitioner deserves the aid of Parliament." It does not appear that any further steps were taken by the House, or that the promised aid was ever conferred on the discoverer.

The improvement which was sanctioned by the Dublin Society, and for which compensation was sought for from the House of Commons, consisted in substituting lime-water for common water, in preparing "ooze," as it is termed by the tanners.

In September, 1772, Dr. Macbride communicated to Dr. William Hunter "An Account of two extraodinary Cases after delivery,"

which were published in 1776, in the fifth volume of the Medical Observations and Inquiries.

For some years after he obtained a medical degree, he employed part of his time in the duties of a medical teacher. In the winter of 1766 he delivered at his own house his first course of lectures, which in 1772 were published in London, in one volume quarto, under the title of "A methodical Introduction to the Theory and Practice of Physic." From an entry in his fee-book, we learn that he received from pupils, for his first course of lectures, twenty-four guineas, or £27 6*s.* Irish.

In 1774 these lectures were translated into Latin, and published at Utrecht, in two volumes octavo.

"The second edition, enlarged and corrected," was published in Dublin, in 1777, in two volumes octavo, under the title of "A methodical Introduction to the Theory and Practice of the Art of Medicine." The Publisher, at the same time, announced as "Preparing for the Press,—Medical Journals, kept by the Surgeons of His Majesty's Ships employed in exploring the Southern Hemisphere: being a necessary Appendix to Hawkesworth, Cook, and Foster. To which are added Letters, and Observations, shewing the most effectual ways of preventing and curing the Scurvy, and other Diseases commonly incident to Seamen in long voyages."

This work, which contains the substance of the course of lectures commenced in 1766, professes to give a "General View of the Theory and Practice of Physic," and is divided into two parts. The first consists of six books, and explains the principles on which the art of medicine is founded; the second or practical part was intended to consist of twelve books, of which nine only were published; and as to the three books in which the author proposed to treat of *local*, *sexual*, and *infantile* diseases, he never accomplished them.

The author modestly styles his work a compilation, chiefly designed for the use of students; it contains, however, many original observations, and gives a good summary of the rules of practice adopted by the most skilful physicians of the last century.

In the second edition he has published the first description of a disease which he named "morbus vesicularis," and which bears a close resemblance to the "chronic pemphigus," or "pompholyx diutinus," of Bateman.

Dr. Macbride's success in practice may be dated from the publication of the second edition of his essays, in 1767, in which year his receipts were nearly double the amount received in any of the preceding sixteen years. His great abilities being universally known, the public seemed now desirous to make amends for having overlooked him so long, the consequence of which was, that his numerous engagements, particularly as an accoucheur(*a*), having for a long time kept him in a state of agitation, both of body and mind, at last induced a total incapacity for sleep; still, however, he retained his

(*a*) From a memorandum in his fee book, we learn that he attended 1065 midwifery cases, from 1767 to 1777, both years included.

usual good spirits, and continued to practise up to the 16th of December, 1778, when an accidental cold brought on a fever, of which he died, in the fifty-third year of his age, at his house in Cavendish-row, on the 28th of December, 1778, and was buried in St. Audoen's Church(*a*).

During the twenty-five years of Dr. Macbride's professional career, he was the contemporary of some of the most distinguished physicians and surgeons of the last century; among whom we may enumerate, Rutty, O'Halloran, Mosse, Fielding Ould, Purcell, Wetherall, Clossy, Pringle, Hanly, Morris, and the elder Dease, whom he assisted in the experiments which he made on the various lithontroptics about the year 1775(*b*).

The portrait prefixed to this memoir has been reduced by Mr. Connolly from a large print, published in London in 1797, and engraved by J. T. Smith, after the original picture by Reynolds, of Dublin. The glass jar inverted in water, alludes to the Doctor's discoveries in pneumatic chemistry. We cannot say in whose possession the original picture is, but hope that this notice may lead to its discovery.

Dr. Macbride was married first to Miss Margaret Armstrong, on the 20th of November, 1753, at St. Audoen's Church, Dublin; and on the 5th of June, 1762, he was married in the same church to his second wife, Dorcas Evory(*c*), widow of George Cumming, Esq., of Bride-street, Dublin, merchant. He died without issue, and had

(*a*) Dr. Macbride was a subscriber, for four copies, to Pool and Cash's "Views of Dublin," published in 1760. In a note at page v. the account of his death is copied *verbatim* from Walker's Hibernian Magazine, with the addition that he "died in January, 1779." The following extract from Saunders' News-letter of the 29th December, 1778, is, however, conclusive: "Died yesterday, of a fever, at his house in Cavendish-row, in the fifty-second year of his age, David Macbride, M.D., universally and most deservedly lamented," &c.

(*b*) From Mr. Dease's graphic dedication of his work on the Hydrocele to Mr. Morris, then the most distinguished surgeon in this city, we learn that about this period, and even so late as 1782, the only public and authorized lectures given here were those in the University, on Anatomy, Chemistry, and Botany. Those on the other branches of medical science—on the foundation of Sir Patrick Dun, and directed, according to the wording of his will, to be delivered in Latin,—do not, at this time, appear to have been available to the students in Dublin, who then amounted to about 300; for Mr. Dease says: "Which circumstance" (their being delivered in Latin), "I have heard sometimes mentioned as an apology for not giving them at all." See A Comparison of the different Methods of cutting for the Stone, with some Remarks on the Medicines generally used as Solvents, &c., by W. Dease. Dublin: Williams, 1782—p. 144.

(*c*) Dr. Macbride, shortly after he settled in Dublin, paid his addresses to Miss Evory, and succeeded in engaging her affections; but the proposed alliance not meeting with the approbation of the young lady's father, she yielded to parental authority, and married Mr. Cumming. In the course of a few years Mr. Cumming died, and left his widow with an only son. The Doctor, not calculating on the death of his own wife, evinced his anxiety for the welfare of his "first love" by using all his influence to induce his friend, Dr. George Cleghorn, to take the widow. Of the lady's wishes on this occasion we are not informed; but we have it on good authority that Dr. Cleghorn's reply to his friend was, "Oh! no, Davy, that's not in my way!"

an only sister, Mary, and a brother, John, a captain in the Royal Navy.

In a curious and rare little book, "The Medical Review, a Poem, being a Panegyrick on the Faculty of Dublin, by John Gilborne, M. D., Dublin" [1775], the subject of this memoir is lauded in the following unpretending verses:

"A celebrated writer is Macbride,
Great is his merit, moderate his pride;
Cures all diseases that mankind befal,
Relieves the fair by rules obstetrical;
Prescriptions elegant his sense declare,
The sick retrieve by his auspicious care."

The following record of his death is taken from Walker's Hibernian Magazine for January, 1779: "Of a fever, at his house in Cavendish-row, in the fifty-second [fifty-third] year of his age, most sincerely and deservedly regretted by a numerous acquaintance, David Macbride, Esq., M. D. His amiable manners procured him the love and affection of all ranks of people, and his ingenious essays in physic and philosophy raised his reputation very high in the learned world. He was an honorary member of the Dublin Society, and one of the Governors of the Lying-in Hospital."

Dr. Houlton, of Dublin, in the same Magazine, paid his tribute to the memory of Dr. Macbride, in an elegy of fourteen stanzas, of four lines each.

Having pointed out the only sources from which we can now form an opinion of the subject of this memoir as a man of science, we shall conclude with the summary of his character in all the relations of life, so feelingly described in the following lines, reprinted from Walker's Hibernian Magazine:—

"*On the Death of David Macbride, Esq., M. D. By a Lady.*

"Accept these lines, tho' unadorn'd by art,
The genuine dictates of a sorrowing heart.
Mac Bride's no more—all earth and nature cries:
I have lost my friend—the hope of weeping eyes.
Farewell—he's gone, removed from anxious care,
From busy life, from arduous thoughts, afar;
From the relief of mortals here below,
To sooth their sorrow, mitigate their woe.
No selfish views e're lurk'd within his breast,
Nought there but noble thoughts could ever rest.
Why should I tell what virtues graced his mind,
An honour to his country and mankind.
With boundless knowledge and extensive skill,
A heart unbounded by a generous will;
His sympathetic soul felt others' woe;
Was virtue's friend—to vice a mortal foe.
"Thou cruel, envious, and rapacious grave,
You've got a victim which no art could save.
I know the stroke was from the hand divine,
To whom I may complain, but not repine.
Oh may thy greatness and immortal fame,
To distant ages signalize thy name!"

Jan. 6, 1779. J. R.

Dr. Breen, in an address delivered at a meeting of the Obstetrical Society, on the 27th of November, 1839, in which he has given an interesting account of the progress of midwifery in Dublin, justly speaks of Dr. Macbride as having "attained great eminence as a practitioner of midwifery in this city," and adds, "he had the high distinction of attending the Countess of Mornington, at the birth of the hero of Waterloo;" in support of which statement he concludes with the following narrative:

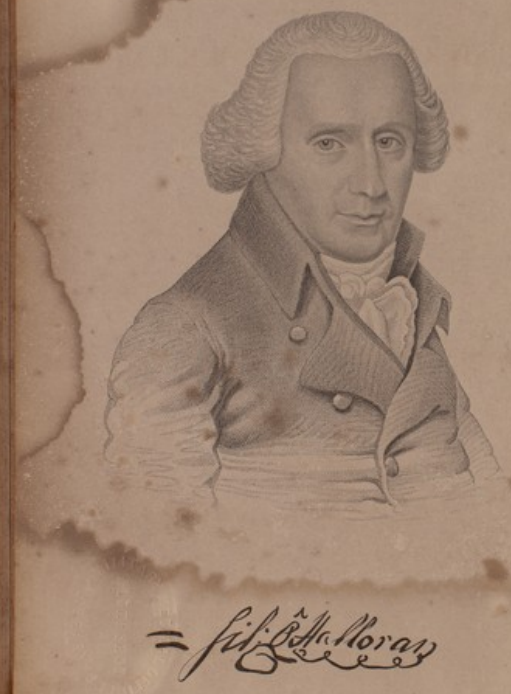
"At a contested election, when the then Arthur Wellesley was elected member for the borough of Trim, a petition was presented against the return, on the ground that the returned member was not one-and-twenty; some difficulty at the moment occurred in proving his age, and the late Dr. Evory, who possessed Dr. Macbride's fee-books, attended as a witness before a committee of the Irish House of Commons, with Dr. Macbride's entry of the birth of this distinguished individual, and, in addition to other evidence, the age was admitted legally proved by the Committee."—*Dub. Journ. of Med. Science*, vol. xvi., p. 528.

As every circumstance relative to the illustrious hero of Waterloo, will, in course of time, engage public attention, we felt anxious to confirm Dr. Breen's statement by reference to the fee-book of Dr. Macbride, now in the possession of Dr. Evory Kennedy, the inheritor of the late Dr. Evory's library.

Dr. Kennedy having kindly permitted us to examine the fee-book, which comprises an accurate account of Dr. Macbride's professional receipts, with the names of his patients, from the first of January, 1767, to the 16th of December, 1778, we were surprised and disappointed at not finding any corroboration of the statement made on the authority of Dr. Evory. The Countess of Mornington does not appear to have been at any time a patient of Dr. Macbride, while the names of many of the highest nobility frequently occur.

Colonel Gurwood, in his Despatches of the Duke of Wellington, gives the date of his birth as the 1st of May, 1769.

In 1790, The Hon. *Arthur Wesley* (as he is called in the Journals of the Irish House of Commons) was elected one of the representatives for the borough of Trim. The election commenced on Thursday, the 29th of April, and the poll continued four days, consequently the honourable member attained his majority while the election was pending. Dr. Breen's account is correct in every other particular.



Sil. O'Halloran

Dublin. Hodges & Smith. 1847.

BIOGRAPHICAL MEMOIR

OF

SILVESTER O'HALLORAN, M. R. I. A.,

SURGEON TO THE LIMERICK INFIRMARY; HONORARY MEMBER OF THE ROYAL COLLEGE OF SURGEONS IN IRELAND, ETC. ETC.

EXTRACTED FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR AUGUST, 1848.

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A MEMOIR,

&c. &c.(a)

In a recent volume entitled "Revelations of Ireland" the author asserts, that, "from a variety of causes, the bar in Ireland has enjoyed almost a monopoly of the talent of the country." True it is that the legal profession must, from the circumstances under which it is placed, ever enjoy a greater amount of public attention, for the time being, than any other. Political in its nature; and its members, unhappily but too frequently called upon to plead a country's in a client's cause; hourly brought before the public and their fellows in the court, the arena, or the senate; with the highest offices in the State open to them as the reward of talent, the price of fidelity, or the premium for political bias or partisanship,—we should naturally expect the advocate, the minister of justice, and the lawgiver, to rank highest among the professions, and the offices and rank to which the professions lead in this country. Without wishing in the slightest degree to detract from the transcendent talent for which the members of the Irish bar have been so long conspicuous, we must, however, claim for the medical profession at all times an equal share of ability with the members of the legal profession,—their brothers of the same race, kindred, and country;—and, for the last century and a half, a somewhat greater advance in general knowledge, a more extended professional and general literary reputation, and for the establishment of far more lasting monuments of charity, benevolence, and industry, as well as for equal progress in the advancement of truth, the revival of learning, and the propagation of nationality in this portion of the British

(a) We have been for some time past engaged in collecting materials for a biography of Silvester O'Halloran, but although several of his descendants had existed in Limerick up to a very recent date, we have not been able to gather much of his domestic history. Our esteemed friend, Dr. Charles Kidd, of Limerick, to whose talent and learning we beg to make this public acknowledgment, has, however, furnished us with a sketch of the life of his distinguished townsman, of which it will be seen we have largely availed ourselves in the following memoir. We also beg to express our acknowledgments to Captain Henry D. O'Halloran, of the 69th Regiment, the grandson of the subject of this memoir, who has likewise furnished us with such materials as were in his possession, and also placed at our disposal a miniature from which the accompanying engraving has been made. To the Rev. Mr. Murphy, P. P. Limerick, we are also under obligation. The miniature was copied by Mr. Connolly, and engraved here by Mr. M'Dowell.—Ed.

dominions. O'Connell, Plunket, Curran, and Bushe, as well as Grattan and Flood, the country claims as orators, statesmen, and patriots, not mere lawyers. Examine into our domestic history of the last century, when eloquence frequently took the place of law, and personal invective silenced argument; when judges, it is said, were often won by jokes, juries biassed by harangues, and witnesses generally browbeat by abuse;—and where do we find the history of the Irish bar and its members;—where are their writings, professional, general, or national;—where the monuments of their benevolence;—what institutions did they create;—what libraries establish;—what great benefits have they conferred upon the country at large? Not so the medical profession;—though not political as a body, its members upheld our nationality, investigated and preserved our history and antiquities, fostered and enriched our literature, blessed the country with noble and largely endowed hospitals, and benefited their own profession by the institutions which they created. Such men were Sterne, Molyneux, Mullen, Dun, Robinson, and Rogers, as well as Maurice O'Connell, O'Halloran, Charles Smith, Steevens, Mosse, Rutty, M'Bride, Brown, and many others whom we might enumerate, whose works have come down to us, and whose institutions still benefit our country and adorn our city.

We may with pride point to the labours of the medical profession for the last thirty years; for after the frightful collapse which ensued in this country, and particularly in the metropolis, during the first few years of the present century, the young school of medicine in Dublin first began to show signs of vitality, and sprung to its present gigantic growth in an almost incredible space of time; and the echo of its fame, the reputation and the writings of its authors and teachers, were soon carried abroad, and valued and honoured wherever medicine was acknowledged as a science.

Foremost amongst those members of the medical profession and men of science and letters who have upheld the character of the general and professional literature of this country during the middle and latter part of the last century, stands the individual with whose portrait and memoir we now present our readers. Descended through a long line of Irish ancestry, whose forefathers ruled for centuries in the land,—and counting among them the bard, the poet, the annalist, the priest, and the warrior, as well as the hereditary physician,—the name of O'Halloran has claims upon the respect and veneration of those amongst us who still love the soil, and are acquainted with the early history of their country. There are few Irish families of antiquity and note whose genealogy cannot be accurately traced for several centuries, and the history of that now under consideration can be followed up to a very early period indeed. In the "Alphabetical List of Ancient Irish Territories, and by what Families possessed, both before and after the English Invasion," left us in his History of Ireland by O'Halloran, we learn that the territory of the O'Hallorans of the Hy-Brune race was Clan-Feargal, which "comprehended twenty-four townlands situate in that portion of the

east part of Lough Corrib on which the town of Galway now stands. Aileran, surnamed An-Teagna or the Wise, regent of the university of Clonard, in the seventh century, and one of St. Patrick's biographers; and St. Finbara, first bishop and founder of the Cathedral of Cork, were of this sept; as also William Halloran, better known by the name of William Ocham or Ogham (on account of his profound knowledge in the ancient hieroglyphic character of the Irish). He was styled Prince of the Nominals; taught in the University of Oxford in the beginning of the fourteenth century, and was the great opponent of the celebrated Scotus in that University"(*a*). As may

(*a*) See O'Halloran's General History of Ireland, 4to. edition, vol. ii. pp. 388-9. From the house of Clan Feargal, of the tract Debrin Feardha, near Galway, the subject of this memoir was descended. The O'Connies were possessed of a portion of this tract till expelled by the O'Flahertys and O'Hallorans, descendants of Brien, eldest son of Eochaidh, monarch of Ireland. There was another family of the name of O'Halloran, whose territory, called Faith-in-Halluran, extended from Tulla to near Clare, in Thomond; but it would appear that Silvester O'Halloran sprung from the Galway family.

Sir James Ware says that Clan-Feargal, an ancient territory comprehending twenty-four townlands seated on the east side of Lough Corrib, on part of which the town of Galway now stands, was the ancient seat of the O'Hallorans.—Eccles. Hist. vol. ii. c. vii. p. 47. Mr. Hardiman, in his History of Galway, gives the following notice of some of the possessions of this family. Clanfergh, or Clan-Feargal, lay on the coast side of Lough Orbisen or Corrib. It consisted of twenty-four villages, in which Galway, Clare, and Roscam are now situate, and was the lordship or dominion of the O'Hallorans until after the arrival of Henry II.—p. 3, note [b]. "Four miles west of Galway, near Barna, are the remains of an old castle which formerly belonged to the O'Hallorans. The Lynch family acquired this ancient inheritance by marriage with an heiress of that old Irish sept."—p. 18, note [y]. The estate of Pulnoroomly, about a mile west of Galway, in possession of the Skerrett family, was acquired by purchase from one of the ancient Irish sept of the O'Hallorans, who were original proprietors of the entire district.

In Mr. Hardiman's notes and illustrations to Roderick O'Flaherty's Chorographical description of West or H-Iar Connaught, lately published by the Archæological Society, we find much valuable information respecting the O'Hallorans; see pp. 54, 59, 253 to 260, 393, &c.; all which prove that the Clan O'Halloran were originally located in the vicinity of Galway, and were intimately connected with the O'Flahertys. In a fragment of an Irish manuscript in the library of Trinity College, (H. 2, 17.), reference is made to the Clan Feargail. See also the Book of Ballymote, fol. 54. Mac Firbis, in his Irish Genealogy, gives the pedigree of the O'Halloran family for twenty-five generations,—from Eochy Moyvane, A. D. 358, to Dervock (David Oge). The ruins of the old castle of Barna in the vicinity of Galway, and the remains of a round tower at Roscam, still exist. "In the thirteenth century the O'Hallorans were dispossessed of their ancient inheritance of Clan Feargail, by the De Burgos, and were obliged to emigrate with the O'Flahertys to Iar-Connaught, where they built the castle of O'Hery, in Gnamore, and also, according to tradition, the castle of Rinvile, in Northern Connamara."—See the Archæological edition of H-Iar Connaught, p. 254; also the Ogygia, p. 376; *Cathreim Thoirdhealbhaigh*, or the Chronicles of the Wars of Thomond, A.D. 1309; O'Brien's Irish Dictionary, p. 514; and also the "Description of Connaught," preserved in the British Museum, p. 252. Mr. Hardiman possesses, and has published in the Archæological work already referred to, several interesting documents relating to the O'Hallorans: chiefly deeds

be seen by the accompanying notes, the family of O'Halloran had greatly degenerated, and lost all its ancient patrimony, about the beginning of the last century, when we find the last of the line located in Limerick, and intermarried into the Mac Donnell family; and from this union sprung two of the most accomplished gentlemen and best scholars which this country produced for many years before or after. Joseph Ignatius O'Halloran, D. D., born in 1720, and educated in the city of Limerick, entered the Jesuits' College at Bourdeaux, in 1736, and was intended for the study of physic. "His early genius," says Mr. Ferrar(*a*), "his diligence and his abilities, soon drew the attention of these fathers, and they judged him an acquisition of too much consequence to their body to omit any inducement to his embracing the monastic life. After sustaining his course of philosophy with singular reputation, with the consent of his parents, he entered his noviciate in the order. He passed through all the degrees with an eclat that did honour to the discernment of this society. When appointed professor of philosophy he was the first that had courage and abilities to open the eyes of the University of Bourdeaux with respect to the futility of the principles of Monsieur Des Cartes, and proved to demonstration the unerring principles of Sir Isaac Newton, adding all that could be collected from his own and from the experiments of the most attentive observers of nature in its support." "After teaching philosophy with distinction for several years, he was appointed to the chair of divinity, in which he made no inconsiderable figure, until, compelled by the revolutions of the society, he returned to his native country, where he has distinguished himself as well by his zeal in instructing the ignorant as by his talent in the pulpit." Of his works some sermons and religious tracts, as well as a few fugitive pieces, are said to have been published while he was professor of rhetoric at Bourdeaux.

Silvester the second son, the subject of this memoir, was born in the North Liberties of the city of Limerick upon the 31st of December, 1728. Of his boyhood and college career we possess but scanty information, except that at a very early age he studied physic, surgery, and midwifery, in the schools of London, Paris, and Leyden, at that period the great marts of medical knowledge. It must be remembered that at this time the College of Surgeons in Ireland had not been created, and that our School of Physic possessed but little reputation; indeed, up to the beginning of the present century, we know of no professional man of eminence in Dublin—Molyneux, Daunt, the elder Dease, Morris, Cleghorn, Purcell, and Harvey, for

bearing date from 1594 to 1718. "In 1585, The O'Halloran was one of the contracting parties in the Indenture of Composition for Iar-Connaught with Queen Elizabeth." See also the references to this family in Keating's History of Ireland. In the neighbourhood of Galway, and in the adjoining islands, the name is still preserved.

(*a*) The History of Limerick, Ecclesiastical, Civil, and Military, from the earliest Records to the Year 1787, &c. Limerick, A. Watson, and Co., 1787, p. 370. See also Fitzgerald's History of Limerick.

instance—who had not studied for a considerable time in the Continental schools.

The barber-surgeons were joined with the apothecaries as the Guild of St. Mary Magdalene, under the charter of James II., in 1687(*a*). At the same time it is quite apparent, from collateral evidence, that there was a separate grade of practitioners in Ireland who served apprenticeships to surgeons duly qualified and only practising as such, and who were, on the expiration of their apprenticeships, examined and licensed to practise surgery, and, perhaps, midwifery, by the Surgeon-General of Ireland for the time being(*b*). By the Infirmary Act, passed in 1765, a Court of Examiners, composed of "the Surgeon-General, the visiting surgeon, the two assistant surgeons, and the resident surgeon or doctor of Steevens's Hospital, and the five senior surgeons of Mercer's Hospital," met at the latter locality, and examined candidates who had "served a regular apprenticeship of five years to a regular surgeon"(*c*); so that we may fairly suppose, particularly from his having been surgeon to the Limerick Infirmary, that O'Halloran went through the usual course of study at the time.

But that we intend devoting a separate essay to the early history of medicine in Ireland at a future period, we would deem this a fitting place in which to make some observations upon that interesting subject; for, to no one could it with greater propriety be dedicated than the learned medical antiquary who forms the subject of this memoir, and who had himself commenced the investigation of the subject. We cannot, however, although not quite in the chronological order of a biography, refrain from alluding in this place to his "Proposals for the Advancement of Surgery in Ireland, with a retrospective View of the ancient State of Physic amongst

(*a*) See Dr. Moore's History of Pharmacy in Ireland, among the original communications of the present Number of this Journal, where the various charters are quoted, &c.

(*b*) For the particulars of this circumstance we refer our readers to the Memoir of Dr. Mosse, "surgeon and licentiate in midwifery," published in the fourth Number of this Journal, for November, 1846, vol. ii. p. 567. In Dr. Gray's Report on the Bill for regulating the Profession of Physic and Surgery, &c., Dublin, 1845, we read: "There are no records that I am aware of to show either at what time the surgeons of Dublin freed themselves from the corporate connexion, or whether there did not always exist an unrecognised body of surgeons who were never linked to the barbers, and who never claimed the honour. I am disposed to think there continued to be what we would now call illegitimate practitioners during the whole period included between the granting of the charter to the 'barber-surgeons,' in 1447, and the formation of the Royal College of Surgeons in Ireland, two years after the declaration of legislative independence."—p. 16. The charter here alluded to is the original one granted by Henry VI., and quoted and confirmed by the charters of Elizabeth and James.

(*c*) See 5 Geo. III. c. 20; see also the Memoir of the late Dr. Percival Banks, in the last Number of this journal, vol. v. p. 570. Occasional exceptions were made to "experienced surgeons" who had not exactly conformed to the letter of the Statute, as in the case of Thomas Wilkins of Galway, and John Murphy of Tralee; see 17 Geo. III. c. 8.

us"(*a*); at the conclusion of which we find the following propositions, portions of which evidently appear to have actuated the founders of our College of Surgeons nearly twenty years afterwards, and the spirit of which still actuates the boldest medical reformers of the present day. To O'Halloran, however, let the honour belong.

(*a*) This essay is contained in an appendix to O'Halloran's work on gangrene and amputation, published in October, 1765, and is dedicated to Lucius O'Brien, Esq., representative for the borough of Ennis.

From a quarto manuscript formerly belonging to the diocese of Down and Connor, entitled, "A Book of Presidents for the Ecclesiastical Court, Fran. Wotton, Registrarius," at present in the possession of J. T. Gilbert, Esq., of this city, who has kindly placed it at our disposal, it would appear that the bishops and ecclesiastical courts in Ireland were in the habit of granting licenses to physicians, surgeons, and midwives, as was done by similar authorities in England, as appears by the following interesting extracts:

The following is in the handwriting of the reign of James I.

"*Licentia pro Obstetrice.*

"To our well beloved in Christ A. B. of the parish of ——— Sendeth greeting in our Lord God everlasting. Whereas by due examination of divers honest & credible women wee have found you the said A. B. apt able & expert to exercise the office of a Midwife. Wee therfore doe admitt you & give you Authority to exercise the said office in any place within the Dioces of ——— aforesaid with the best diligence you may or can in this behalfe both to poore & rich, streightly willing & charging you to performe & accomplish all thinges about y^e^ same according to your oath thereupon made & given as followeth.

"1. That you be diligent faithfull and reddy to help evry woman labouring of child as well the poore as the rich, And that in tyme of necessitie you shall not forsake y^e^ poore woman to goe to y^e^ rich.

"2. Item—you shall neither cause or suffer any woman to name or put any other father to her child but only him which is the true father thereof indeed.

"3. Item—you shall not suffer any woman to pretend feigne or surmise her selfe to be deliv^red^ of a childe who is not indeed neither to clayme any other child for her owne.

"4. Item—you shall not suffer any child to be murdred,—maymed or otherwise hurt as much as you may & so often as you shall perceive any evill or jeoprdie likelie to be either in y^e^ woman or child in any such wise as you shall be in doubt what shall chance thereof, you shall then forthwith in due tyme send for other Midwives & expert women in yr behalfe & use their advice & counell therein.

"5. Item—you shall not in any wise use any manner of witchcraft, charmes, Sorceries, Invocations, or any other prayers then may stand with God's Lawes & y^e^ Kinges.

"6. Item—you shall not give any Councell or minister any herbes, medicines, potions or any other thinges to any woman being with chyld wherby shee should destroy, or caste out that she goeth withall before her tyme.

"7. Item—you shall not enforce any woman by paines or other ungodly means to give you more for your paines & labour for bringing her a-Bed than she would otherwise doe.

"8. Item—you shall never consent agree give or keep Councell that any woman be deliv^red^ secretly of that shee goeth with, but in the prsence of two or three honest women & there be two or three lights always reddy, with water also if the woman doe travell by night.

"I. That a decent and convenient edifice be erected in the capital, and three professorships founded: one for anatomy; a second for the disorders of surgery and midwifery; and the third for the operations of surgery; and that each do give a course of lectures in succession every winter free to all people.

"9. Item—you shall be secrett, and not open any matter apprteyning to yor office in the prsence of any man or other unless necessitie or other urgent causes constraine you so to doe, or any otherwise than shall be seemly.

"10. Item—If any child be dead borne you yorselfe shall see it Buried in such secret place as neither hogg, dogg or any other Beast can come to it & in such place & after such sorte done that it be not prceived or found as much as you may & that you shall not suffer any such child to be easte unto the Jakes or any other inconvenient or unseemly place.

"11. Item—If you know any Midwives useing or doeing any thinge contrary to the end of the prmises you shall forthwith detect, open & shew the same to y^e^ ordnary for y^e^ tyme being.

"12. Item—That you shall use yorselfe in honest behaviour towards other women being lawfully admitted to the Office of a Midwife in all thinges accordingly.

"13. That you shall truly present to the ordnary for y^e^ tyme being all such women as you shall knowe from tyme to exercise the office of a Midwife without Lawfull admission therunto.

"14. Item—You shall not assigne or make any Deputy or Deputies to exercise or occupy under you in your absence the Office and place of a midwife But such as you shall knowe to be right honest & discreet & also apt, able & having sufficient knowledge cunning & experience to prforme ye said place & office. Neither shall you consent that any childe borne by any woman who shall be deliverd by you shall be carried away wthout. being baptized in ye parish by ye ordnary Minister where the child is borne.

"15. Item—You shall not be privie or consenting that any priest or other prtie shall in yor prsence, company knowledge or sufferance baptize any child by any Mass, Latine service & prayers, the^e^ such as are appointed by y^e^ Lawes of y^e^ Church of England. But you shall forthwith upon understanding therof give notice therof to ye ordnary for ye Time being. In witness of the prmisses wee have caused our Seal wch wee use in that behalfe to be affixed to these prsents. Dated &c.———"

In the handwriting of the early part of the reign of James I. this precedent appears to have been copied from the Winchester Registry.

"*Licentia. ad exercendum Artem Medici.*

"To all Chrian. people to whom these presents shall come T. R. Doctor of Laws Chancler to the Rt. Reverend father in God ——— Ld. Bp. of ——————— sendeth greeting in our Lord God everlasting. Wheras wee have recd. sufficient testimony on the behalfe of ——— of ——— in the County of S——— as well of his honest life & good conversation as also of his knowledge cunning & experience in the Art of Physick & Surgery subscribed with the handes of those to whom he hath ministred physick & practized the Art of Surgery. And that upon due exion. wee have found him well seen & experienced in the Same science or faculty Knowe yee therfore that wee the said T. R. Doctor of Laws & Chancle aforesaid have Licenced, & by these prsnts. doe Licence & give Leave to the said —— to use the said exercise & to exercise the said Arts or Mysteries of physick & surgery in any place or upon any person within the Archdeconry of S. as by the Lawe & Statute of this realm wee may admitt him. He having first before us taken the oath of Supremacy of the King's most excellent Matie. in these cases provided. And we will that this our Licence or tolleration continue firm &

"II. That an exact list be taken through the kingdom of all reputable surgeons, with their names and places of abode: that no other presume to practise surgery, much less perform capital operations; and that all young surgeons, for the time to come, be interdicted practice till they shall procure a faculty of their abilities, signed by the above professors, or their successors.

"III. In order to procure this, the candidate or candidates must, by written notice, apply for a public examination, and this to be published before the exhibition, which should be from twelve to three o'clock. That this hold for three days: the first entirely for anatomy; the second for disorders of surgery, and if a candidate for midwifery, for this also; and the third to finish with performing all the operations of surgery on a body, with their apparatus and bandaging. When a proper faculty, signed by the professors, is given to the candidate, to which if some little honour were annexed, it might add greater stimulus to the young students.

"IV. That this course be attended with no kind of expense to the candidate; and that it be free to all Irishmen *only*, without distinction; genius being unconfined to principle or party, and such narrow considerations being worthier a little republic of Ragusa than the representatives of a powerful kingdom. And that the number be by no means limited, because the more surgeons of eminence, the better will the public be served.

good unto him untill it shall seem otherwise unto the said Reverend father in God or my selfe. In witness, &c. &c."

In the handwriting of Charles the Second's reign, circa, 1670.

"*Licentia Concessa A: B: ad practicand. Artem Chirurgicam.*

"To all xrian. people to whome these pnts. shall come: R. by y^e^ Grace of God: B. of L.: Sendeth Greeting in y^e^ Lord God Everlasting: Whereas for avoyding of any accident dayly happening to many of his Maties. loveing Subjects by the unskilfull practizers of Surgerie It was prvidently provided by speciall Acte of Parliament made for the reformation thereof In the third yeare of the Raigne of our Late Soveraign Lord of famous memory King Henry the Eight That it should not be Lawful for any persons within this Realme of England to use or exercise the Science or facultie of Surgerie, Except he were first Examined approved & admitted According to the Tenor of the said Statute. Know yee therefore that wee the said Reverend ffather having received sufficient testimonie from R: W: C: L: y^e^ Masters or govnors. of the misterie & comonality of Barbers & Surgeons within the City of London incorporated of y^e^ Due examinacion of A: B: of the parish of St. Sepulcher's wtout New gate London a free Brother of the said misterie heretofore approved and admitted to use & exercise y^e^ said Facultie And examined the said A: B: concerning his sufficiencie therein, Doe now by these presents approve the said A: B: to be an able & sufficient Surgeon & he being first solemnly sworne before Sr. E. S. Kt. Doctor of Lawes our Chancellor to y^e^ Supremacie of the Kings most excellent Matie. Wee doe by these presents admitt him the said A: B: to use and exercise the said Misterie of Surgerie Soe farr forth as by the Lawes & Statutes of this Realme of England, wee may lawfully admitt him thereto. In witness whereof we have caused the hand & seale of our office to be sett unto these presents dated y^e^ ——"

"V. That a printed list be published annually of the registered surgeons and men-midwives of the kingdom, with their places of abode, signed by the professors; by which means the public will, *as heretofore*, know where to apply for certain relief.

'Fungar vice cotis, acutum
Reddere quæ ferrum valet, exsors ipsa secandi.—*Hor.*'"

Upon the 7th of August, 1786, two years after the date of the Charter, Silvester O'Halloran was elected an Honorary Member of the Royal College of Surgeons in Ireland, having been proposed by Censor King, and seconded by Vice-President Bowes.

While on the Continent he paid particular attention to the study of the diseases of the eye, which at that time occupied the thoughts of many of the most learned professional men in Europe, and particularly those of Paris and Montpelier. This science was just then emerging from the mystery and obscurity with which the itinerant quacks and mountebanks of the end of the seventeenth century surrounded it; and the discoveries of Petit, Winslow, Morand, Cheselden, and Ranby, were gaining for this branch of knowledge the amount of interest which it deserved. While at Paris Mr. O'Halloran wrote a treatise upon the eye, for the purpose of clearing up some difficulties which then existed, particularly with regard to the seat of cataract. The manuscript of this treatise he laid before the distinguished Dr. Richard Meade, upon his return through London, who strongly advised its publication: and subsequently he placed it in the hands of Dr. Barry, President of the College of Physicians in Ireland(*a*), with the hope that it would also meet with the approbation of that body and their sanction; but it would appear that the college had "neither time nor curiosity" to examine into its merits. He completed the work, however, and sent it to the press in the early part of 1749, and it was published in Limerick the year following, under the title of "A new Treatise on the Glaucoma, or Cataract"(*b*). In this work, abounding in erudition and critical research, we perceive the dawning of that spirit of investigation and literary taste which subsequently distinguished this accomplished scholar and most acute surgeon; and when we remember that it was published before he was twenty-one years of age, and appears to have been written in his eighteenth and nineteenth years, it is, perhaps, one of the most extraordinary performances of the kind extant. As this work is but little known to the ophthalmic surgeon, and has not, we conceive, had that meed of credit awarded to it by subsequent writers, (with the exception of Haller), which it deserves, we here give a short account of its contents. It must be remembered that when it was written pathological ana-

(*a*) Dr. Edward Barry, son to Sir Nathaniel Barry, was President of the King and Queen's College of Physicians in 1749.

(*b*) For the full titles and imprints, &c., of all O'Halloran's publications see the list at the end of this memoir.

tomists and ophthalmic surgeons had not determined what glaucoma was; and although Brisseau, Maitre Jean, Ranby, and Heister, had established, by dissection, that cataract was an opacity of the crystalline lens, and not a filmy suffusion between that body and the iris, like—to use the language of the time—the vegetable production which floats upon the surface of water or other fluid in a bottle, as was generally believed before their day, their doctrines were neither generally received nor understood for many years after(*a*); and that the crystalline could not be the seat of the opacity, it was argued that it (the lens, the supposed seat of vision) was in the centre of the eye, whereas the cataract was so much anterior to it.

The subjects discussed in this treatise are;—the seat of cataract, to which he added several proofs that the "glaucoma was not a different disease, but a different name to express this disorder by," the difference really consisting in the complication of cataract with amaurosis and the curability of the former; next, the subject of the circulation of the humours in the eye, which, after the appearance of Hovius's tract, engaged much attention; and he also in it devotes some space to what he terms anatomical discoveries, in which he endeavoured to show that the iris was composed of radial fibres only, and that the vitreous humour was not surrounded by any proper membrane: he showed, however, that the crystalline lens had no adherence to the ciliary ligament, and described pretty accurately the position and relations of these parts; and asserted that the ciliary ligament and iris receded from the cornea opposite the external and internal angles of the eye. Both in this work and in his succeeding essays on the same subject, he denied the existence of a posterior chamber, and broadly asserted that the iris was not plane, but that

(*a*) Antoine Maitre Jean, *Traite des Maladies de l'Oeil*, Troyes, 1707; Brisseau, *Traite de la Cataracte et du Glaucome*, Paris, 1709; Heister, *Tractatio de Cataractâ et Glaucomate*, Altorfii, 1717. It is generally believed that Brisseau's first observation was made upon the eyes of Bourdelote, Physician to Louis XIV.; but O'Halloran has shown that his original observation was made in 1705, on a soldier who died of diarrhœa, and that the account of the dissection and the examination of the eyes was read before the Royal Academy at Paris, on the 18th of November of that year. "But the academicians seemed to make slight of this discovery, nor did they think proper to give it a place in their works. However, this cool reception did not deter Brisseau from maintaining his new opinion: viz. that it was the crystalline lens which was constantly obscured in the cataract. However," continues O'Halloran, p. 10, "it is to be noticed that though Brisseau and Maitre Jean were the first who evidently demonstrated the cataract to be an opacity of the crystalline lens, yet they were not the first who made that observation, for M. Lasnier, an eminent surgeon of Paris, who died in 1690, made the same remarks forty years before. And though he was countenanced in this opinion by Rohault (*In Tractatu suo Physico*, pars i. cap. 35), and Gassendus (*Opera*, tom. i. p. 371); and that in a little analysis of Mariotte's, *Nouvelles Couvertes touchant la Vue*, it was publicly asserted 'that oculists had found that there was no other way of curing that disorder of the eye called a cataract but by depressing the crystalline,' *Journal des Sçavans*, 1668; yet it was not sufficient to gain it any esteem in the world."

it bulged into the anterior chamber. Now, although the contrary is the normal position of this membrane, there are a great many cases of cataract in which it presents a convex surface towards the cornea, and even in the natural healthy eye we have very frequently remarked the same peculiarity. The removal, however, of the cornea, and consequent escape of the aqueous humour, on dissecting the eye, must always exaggerate this appearance. Among the anatomical discoveries claimed by O'Halloran, in his treatise on the Cataract, is that of a *cartilaginous substance* found by him in the semilunar fold of conjunctiva in front of the caruncle, and which is analogous to the nictitating membrane of some of the lower animals. He appears to have studied the anatomy of the eye very carefully, and made several experiments and dissections in order to arrive at the truth. Among these latter was that of suspending a young dog for some time by the hind legs, then tying both jugulars after the eyes had become suffused; and, having thus produced a natural injection of the internal parts, killing the animal and displaying the vascular arrangement. By this means he showed and figured in the plates appended to his book a very beautiful and minute injection of the vessels on the posterior capsule of the lens. There are two other subjects connected with the anatomical department of this work worthy of notice, viz., the theory now revived by a German oculist, that the aqueous humour is secreted from the back of the iris, and that the hyaloid membrane may be rendered opaque by immersion in various chemical solutions. It is true that there are many errors in the anatomical and physiological portions of O'Halloran's treatise, but they are the errors of the age, and our object here should be to set forth the opinions, not so much to canvass the doctrines of those whose memoirs we indite.

A work of this character, the first of the kind that issued from the Irish press, naturally produced a favourable impression for its author, and ophthalmic practice appears to have followed. A century ago this country was occasionally visited by itinerant oculists, of whom the most remarkable was the celebrated Chevalier Taylor, concerning whose feats the learned world are already acquainted(*a*). As might be expected from the publication of O'Halloran's essay, numbers flocked to receive their sight at the hands of the Limerick oculist, who soon bid fair to eclipse Taylor(*b*).

(*a*) See an Introductory Address delivered at the Park-street School of Medicine, Dublin, 1845, by W. R. Wilde, M. R. I. A., &c., and published in the Lancet for April, 1845.

(*b*) In the Number of Faulkner's Journal for November 26th to 30th, 1745, we find an advertisement from Taylor, who then resided in William-street, to the following effect: "The first Wednesday in January next will begin a short course of lectures on the means of preserving sight, calculated for the studious, to which the gentlemen of the faculty, the College, the clergy, and others of literature, are hereby invited by Dr. J. Taylor, oculist to His Majesty, &c." He also lectured in Stafford-street, and in the theatre in Aungier-street. In the 384th Number of the Philosophical Transactions, vol. xxiii. for 1724–25, we have an account of the operation for depression having

M. Daviel's splendid operation of extracting the cataract through an incision of the cornea, then occupied considerable public attention; and although by no means what the operation is at present, and at the time of its promulgation scarcely understood, still it bid fair to eclipse all former means proposed for the removal or displacement of an opaque lens. Although it is now well known that the French military surgeon commenced his operation by incising the cornea with a lancet, and afterwards enlarging the cut with a scissors, or, according to some accounts, passing a cataract needle through both sides of the cornea, and dividing all that portion of the membrane which lay beneath it with a scissors; yet as the precise mode of performing the operation was not made known by its author, and the first account of it sent to England was only from a spectator, considerable doubt and obscurity existed with regard to his precise method of operating. As the original account was communicated to the Royal Society, O'Halloran addressed a paper on the subject to that body in 1752, and this communication he afterwards amplified into a tract entitled, "A Critical Analysis of a new Operation for Cataract." It was published in this city in 1752(*a*). In this treatise he discusses with considerable ability and research the causes of cataract, the means proposed for its removal(*b*), and details a series of experiments which he performed in order to elucidate the subject. He then gives an account of the operation for

been performed by a Mr. Caywood, "Oculista Dubliniensis," given by Mr. Samuel Molyneux to the secretary of the Royal Society. In this case the eyes of the patient, a pensioner in the Royal Hospital, were, upon his death, some years after the operation, examined by Sir Thomas Molyneux, and the lenses were found to have been absorbed. The case is alluded to by O'Halloran. Besides those special oculists, ophthalmic operations appear to have been performed here by the general surgeons in the middle of the last century. Thus O'Halloran, in his "Critical Analysis," speaking of the success of Daviel's operation for extraction, writes: "In Dublin it bids fair for coming into repute, for my ingenious correspondent and learned friend, Dr. Rutty, informs me that it has been practised with success by Messrs. Dillon and Rooney, surgeons of repute and experience;" and one of these gentlemen invented a scissors with sharp backs, which cut by opening, in order to avoid the contusion and laceration of the cornea.

(*a*) This is, perhaps, one of the scarcest of O'Halloran's works, and for a long time we despaired of its recovery. Our readers will find it, however, bound up with Aitkin's Principles of Midwifery, and other "Medical Tracts," No. 41, in the library of the Royal College of Surgeons. It consists of thirty-nine pages, and is dedicated to "Edward Barry, Esq., of the College of Physicians, Dublin, Fellow of the Royal Society, and Physician-General to the army;" which dedication shows that the slight passed on O'Halloran's former work by the College of Physicians was not then remembered.

(*b*) To Petit, the surgeon, is generally attributed the merit of having first extracted an opaque crystalline, in 1708, in a case in which it became accidentally dislocated into the anterior chamber during the operation of depression; but O'Halloran shows that the Arabian Physician, Jesus Hali, as well as Arculanus, the Italian commentator, Mayerne, and Freytage, had long previously described the operation, performed in one instance, he says, by a "female oculist, on my Lord Rich, son to the Earl of Warwick, with success." See Critical Analysis, pp. 19 and 20.

extraction, on which, did our space permit, we would willingly enlarge, inasmuch as it was one of the best and most original descriptions of that operation given at the time(*a*). The contusion and subsequent opacity of the cornea, caused by the scissors, militated to a certain degree against the splendid success which must otherwise have attended Daviel's operation, and to avoid which the Limerick oculist proposed to incise "the sclerotica, near or at the border of the cornea transparens," a mode of operating which he subsequently reduced to practice.

In order to follow out this subject we must now pass over thirty-four years of our author's eventful life, when, with matured experience, he presented his last essay upon the eye to the Royal Irish Academy, of which learned body he was elected a member upon its establishment a short time previously. This paper, which was communicated by the President, the Earl of Charlemont, on the 22nd of November, 1788, and was published in the second volume of the Transactions, is entitled, "A Critical and anatomical Examination of the Parts immediately interested in the Operation for a Cataract, with an attempt to render the Operation itself, whether by Depression or Extraction, more certain and successful," is divided into sections, containing, a general review of the subject,—anatomical observations on the structure of the iris, and situation of the crystalline, &c.,—the question of adhering cataracts,—the difficulties attending the operation of depression demonstrated,—and the method of extraction explained; to which are added, engravings of the anatomy of the parts. In it we learn that since the period of his former communication, in 1752, he had reduced to practice the mode of operating which he recommended in the "Critical Analysis." Instead of the scissors employed by Daviel and his followers, the disadvantage of which we have already explained, O'Halloran invented a *knife*, double-edged, and also slightly concave on the flat of the blade. His incision is thus described: "With the concave part next me I pierce the sclerotica very near the edge of the cornea,—suppose the third of a line,—at either the external or internal canthus, according to the eye to be operated upon."—p. 140.

Now, from this extract it might appear that O'Halloran was in the habit of performing extraction through the opaque sclerotica behind the iris, as subsequently practised by Sir James Earle, and revived in modern times by Quadri and Sichel; and we confess that a superficial perusal of the dissertation in the Transactions of the Royal Irish Academy (which is undoubtedly inferior in clearness and perspicuity to any of the author's other writings), might, at first, lead to that opinion. The contrary, however, is the fact. By

(*a*) In the manuscript memoirs of the Medico-Philosophical Society of Dublin, of which we gave an account in the preface to the first Number of the present series of this Journal, we find that at a meeting of that body, held upon the 5th May, 1757, Dr. Nathaniel Barry read part of a letter from Mr. Silvester O'Halloran, a surgeon of Limerick, giving an account of his couching a cataract by the new method of Daviel, with success, &c.

the sclerotica O'Halloran meant that undefined line at the junction of cornea and sclerotica which exists between the perfectly transparent edge of the former and the ciliary ligament and attachment of the iris, which he believed, as already stated, receded considerably upon each side, in the transverse axis of the eye. His incision was a perfectly lateral one, made by two cuts, commenced at the point of the transverse axis, where from the receding of the iris, he believed there was more space, and extended into the transparent cornea. To use his own words, "advancing the incision to the edge of the cornea transparens, as the distance between the iris and sclerotica approaches closer to the cornea the farther you go from the sides of the eye;" and that this must have been a corneal incision is evident from the passage of the instrument being "proved by part of the aqueous humour escaping, and by your seeing its point within the cornea between it and the iris." "Thus," he continues, "nearly one side of the sclerotica (cornea) from top to bottom, at its junction with the cornea, becomes divided; with the point of this very instrument you prick the crystalline capsule, and the smallest inclination of it inside the pupilla will do this; and then gently press on the globe of the eye, the cataract will slip out."—p. 140. La Faye, Warner, and Sharp, had, it is true, previously performed the extraction with a knife, but at a considerable distance within the external border of the cornea, so that extensive opacities were frequently the result.

We have dwelt thus at length upon O'Halloran's operation, because it has been generally overlooked, and because, from the term "sclerotica" having been employed by him, it required some explanation.

Besides his various published works, O'Halloran wrote "A new Philosophical and Medical Treatise on the Air, in two Parts, wherein its real properties are investigated against Toricelli, &c., and Physicks attempted to be settled on more solid and rational Foundation." This is a manuscript quarto of 172 pages, in the library of the Royal Irish Academy. It is divided into chapters and sections, and is written out with considerable care in the handwriting of the author; it does not, however, bear any date upon the title-page, but from the state of the writing in the text, and various additions and marginal notes made to it in the same hand at a later period of life, it would appear to have been written and revised at different times. At the commencement and the conclusion of the volume we find a preface, the former dated in September, 1755, the latter in May, 1756, from which somewhat of its history may be gleaned. He states that when he first commenced the study of physics he "carefully considered every particular part of that unbounded science, and remarked such doubts as appeared. Amongst other parts, the system of the air's gravity, and the supposed weight of air; bodies supported without becoming sensible of it, seemed to me very odd. And when in other places the amazing elasticity which most bodies, and particularly air, were supposed to have, seemed entirely to destroy its gravity, I did not scruple to take down notes of these things, and

now and then make experiments to clear up fresh doubts, till such time as in the year 1749, that I published my new treatise on the cataract; then I found myself quite at liberty to pursue my *first* inquiry. In 1751 I intended publishing it, and actually made some steps towards that; but as I proposed going abroad again for some further improvements in my profession, and particularly in the obstetric art, I thought it more prudent to defer my design for some time longer, and to try at my leisure what further improvements I could make." It then appears to have been prepared for the press with considerable care, and this preface thus concludes: "I flatter myself, however, if I have not completed, I have at least struck out a road for future philosophers, as, if well pursued, will make us truly worthy that name. And if in any place, through inadvertency of design, any expressions may be found which might seem censorious, I hope they will be imputed more to a laudable design for the improvement of real knowledge than to an intent of reflecting on any particular science or persons. And let us often think on that praiseworthy saying of the sage Seneca, 'Puto multos ad sapientiam potuisse pervenire nisi putassent se pervenisse.'—O'H. Limerick, September 20, 1755(*a*).

He wrote another preface on the 2nd of March, 1756, and a third on the 20th May following, in which he says:

"In the ensuing treatise, though we have attempted to introduce a new system of philosophy, one nearer nature, as being more correspondent with her works than the established one, yet our induction has been only from effects, not by laying down of imaginary principles. The small success that has attended the greatest men in attempts of this nature, and the very little advantages that mankind have gained by such methods of inquiry, should convince us how fruitless it must ever prove. But to explain the method we have pursued: for instance, we have proved that there is through nature a *vis inertia* or sluggishness of matter, so that there must be a force exerted to put matter in motion, and this force must be continued to preserve this motion; that solid bodies must be supported by solider or firmer; and that nature must have certain limits. From this we inferred that the massy body of our globe could not be supported in its motion round the sun by the ether, and that it was really a body fixed and permanent, and that our world was limitted by the celum empyreum, or firmament; that as air is a medium absolutely necessary for the distinction of luminous bodies, and that the distance of enlightened bodies considerably augments their diameter, we naturally concluded that the space from the

(*a*) Upon this front leaf of the volume we find the O'Halloran arms, with an heraldic description of them, thus:
Crest.—A lizard proper.
Arms.—Gules, a horse argent, caparisoned, trotting on a chief argent. Three mullet stars azure, pierced.
Motto.—Locum ꝛ mabam. (I wound and kill.)
Name.—Ohallupam. (O'Halloran.)

earth's surface to the celum empyreum was replete with air; that this space could not be very high, and that the stars could not be these monstrous massy orbs, and at so illimitable a distance. In the further pursuits of this system, where we had not nature to conduct us, we have communicated what seems to us most natural, but still as conjecture, but we have not attempted to inquire into first causes. This system has been the consequence of our inquiries into the properties and effects of air, and these inquiries began almost as early as our knowledge of philosophy, for the very experiments shown me to prove the air's gravity incline me to think that they had some other cause. This made me dedicate some time to this inquiry, and become better acquainted with the different writers on this head. The experiments and reasonings on this head which lay scattered, I had collected, and put into some form for publication, in 1751, as presuming they might furnish some useful hints to the curious. But as I intended spending some further time abroad, I considered that I had better opportunities of making new experiments, as well as of perusing many books on this head which are not to be met with but in large libraries. On these accounts I was determined to let it lie some considerable time longer in obscurity, and I found no cause to repent of this delay."

The following are the contents of this work:

"Part I.

"Chapter I.—Of the air, its height and gravity, according to the modern acceptation.

"Chapter II.—That air (much less heavier bodies) is not porous; that is to say, that one body cannot insinuate itself into the interstices of another without also proportionately increasing the surface of the body pervaded.

"Chapter III.—That the levity and subtilty of certain bodies (the air for instance), so far from being the cause of their pervading heavier bodies, will be their greatest obstacle; in which the phenomena of the diving-bell and the detonation of gunpowder will be occasionally considered.

"Chapter IV.—Showing the true cause of the suspension of liquors in cylindrical tubes, with remarks on thermometers.

"Chapter V.—That air is a body perfectly homogeneous, neither generated nor corruptible, but to have existed from the beginning; with remarks on other bodies.

"Chapter VI.—Proposes from the foregoing a new cosmogony.

"Chapter VII.—The system of Copernicus and Galileo examined, and the advantages of the preceding one further illustrated.

"Part II.

"Chapter I.—A description of the air, its real height, gravity, and colour.

"Chapter II.—Of the contractile and dilatative force of air, with remarks on elasticity, heat, and cold, &c.

"Chapter III.—Of respiration.

"Chapter IV.—Of epidemic disorders, and how far the air really contributes towards them.

"Chapter V.—Of winds.

"Chapter VI.—Of the seeds of insects supposed to be lodged in the air.

"Chapter VII.—Shows the cause of the blood's fluidity, and explains other phenomena which depend on it.

"Chapter VIII.—Treats of salutary and unwholesome air."

This work exhibits a vast amount of learning and great depth of research. The four last chapters of the second part are well worthy the attention of those engaged in the investigation of the subjects on which they treat(a).

In the "Repository" of the Medico-Philosophical Society, preserved in the Royal Irish Academy, we find a letter of O'Halloran's, dated June, 1762, directed to Mr. Cleghorn, giving an account of a monstrous fœtus, in which the abdominal viscera were contained in a large cyst attached to the abdominal parietes at the seat of the umbilicus.

To our friend, Dr. Thomas Wright, we are indebted for the use of a collection of manuscripts in the handwriting of O'Halloran. These consist of a memoir upon "hydrocephalus from an external injury, with remarks on hydrocephali in general," written in 1781; also a "selection of a few anomalous cases of midwifery," to which there is no date, but from the notes of the cases it is evident that it was written subsequent to 1773; and three letters addressed to the distinguished William Dease, in 1786, from which it would appear that the essays enumerated above were sent, through Mr. Dease, for publication, to the Royal College of Surgeons. In that dated 22nd April he says: "My absence in the county of Tipperary for some days will, I hope, plead my excuse for not acknowledging your esteemed favour of the 8th inst. sooner. I am much pleased that the cases I sent

(a) In the fourth chapter of this part O'Halloran states that "the winter of 1674 was remarkably warm and mild, with scarce any rain in Ireland, which made people fear that the following season would be a very fatal one; but the succeeding harvest was remarkably good, and universal good health reigned all over the kingdom, and the notion of plagues being produced by an infected air is deemed by that learned gentleman Dr. Molyneux of Dublin, for a very vulgar error."—See also Molyneux's Paper in the Phil. Trans. p. 1694; and biographical memoir of him in Dublin University Magazine for 1841.

O'Halloran rather inclined to the opinion that the "efferent cause of epidemic disease was not in the air; but unwholesome diet, a scarcity of it, or an immediate alteration of our accustomed manner of living, certainly produce diseases; for it appears by what has been said in the last section, that let the alteration of the seasons be ever so unnatural, provided that provisions of all kinds are plenty, we need apprehend no bad consequences from the change of weather. We shall still make this assertion clearer by examining the great mortality that happened all over Ireland in the year 1740. In the beginning of November, 1739, we had a very sharp, cold, northern wind, and which continued for almost three weeks; this was succeeded by the severest frost known here in the memory of man, *which wholely destroyed the potatoes*, the chief support of the poor, and provisions of all sorts became excessive dear, and they would have perished for want but for the generous and bountiful contributions of the public. About the beginning of March, when the frost began to abate and business became brisk, they fell into a better and wholesomer diet, but the juices made from their former hard fare ill agreeing with a wholesome and more nutritious chyle, produced many gripes and dysenteries, which swept off numbers of people. But as the summer following, which was remarkably warm, advanced, the remains of this leaven turned out into violent fevers equally fatal."

met with your approbation, and that the College approved of my endeavours to second their views, so honourable, I hope, to our country, and so useful to mankind. I should be glad to know if they were handed over to Mr. Henthorn for publication. If so, accept of the following as a codicil to them." At a future period we hope to insert these various communications at length in our Medical Miscellany, but here they would occupy more space than we could devote to the subject. The insertion of the following extract from the letter of the 2nd June, will, we feel, be acceptable: "You apologize for not writing earlier as wishing to lay my papers before the College before that period. I am highly sensible, my dear Mr. Dease, of your friendship and predilection for me, and this even before I had the pleasure of a personal acquaintance with you. I have been well informed that, through your solicitation, I was admitted an Honorary Member of the Chirurgical Society, with my esteemed friend Mr. Adair.(*a*) I have a letter of the secretary's, informing me that they waited for a Royal Charter before they would make any publications; and I as naturally concluded, when this event took place, that I was as much a member of the new society as of the old. There is an old adage, *qui cito dat, bis dat*. As the smallest demur has taken place, it becomes no longer an object worth consideration by me. Being a member of all the literary societies in Europe will not add a single iota to a man's real merits; but such societies reflect honour to themselves, when they embellish their catalogue with meritorious and illustrious names. This little stricture is, my dear Sir, reserved for your own perusal. I have not seen John Hunter's work, but know that it has been advertised in the English papers above a month. I know him personally, and have seen him operate at St. George's, where my friend Bromfield attends. As I lodged in Parliament-street, when last in London about my History, I had frequent cards from some hospitals, particularly St. George's, whenever operations took place. Hunter's character is respectable, and his collections much esteemed; but, considering his confined and narrow education, I should expect nothing very remarkable from

(*a*) This allusion to a Chirurgical Society again brings us back to the state of the surgical profession in Ireland at the period specified. So early as the beginning of the year 1780, the principal surgeons in Dublin, feeling the disadvantages of their legal and corporate connexions with the barbers, formed themselves into a society called "The Dublin Society of Surgeons," which met once a month at a tavern, for the purpose of transacting business. The minute book, containing the rules and regulations of this body, is still in existence in the College of Surgeons. It was the intention of this body to publish transactions, and the MSS. of O'Halloran, alluded to in the text, appear to have been forwarded to Mr. Dease for that purpose. Both Silvester O'Halloran, and Robert Adair, of London were elected Honorary Members of this body. It was the "Dublin Society of Surgeons" which procured the charter of George the Third, and achieved the incorporation of the Royal College of Surgeons in Ireland four years subsequently. Henry Morris was President of the Society, and the names of its members are all enumerated in the first section of the early charter of the College.

him: *however, I should suspend my judgment.* You conclude your letter with an offer of your services; I accept of this offer with the same candour I would give it. I told you that I had left in town a treatise on injuries on the head, which was to have been published in eleven weeks. I had entered into a written agreement with a Mr. Whitestone,—who, I believe, is nobody; at least, I am sure with respect to me he is devoid of truth. He had long amused me, but upon inquiry I found he never committed the work to press. Whether he made any indirect use of my manuscript, or had a copy made out for his own purpose remains to be explored; but the manuscripts I have got out of his hands. Well acquainted with booksellers, and in general with their not being 'righteous overmuch,' I wish to make it the interest of one of them to engage in the present, as I did Ewing some years since, but Whitestone is not the man."

From the memoir supplied us by Dr. Kidd we quote the following account of his other professional work:

"Among O'Halloran's succeeding literary performances we find a Complete Treatise on Gangrene and Sphacelus, with a new Mode of Amputation, published in 1765, which is, perhaps, one of the scarcest of his works at present.

"He attributes gangrene to a 'vitiation of the humours,' and a 'want of the balsamic and nutritive properties of the blood;' recommends surgeons not to be too hasty in amputating, but to wait till the case is at its last, instead of the indiscriminate practice of amputating the moment gangrene is suspected; advances many forcible arguments to support his position, and several good recoveries in his own and others' practice; advises a discontinuance of the practice of making incisions in mortified parts, and recommends bark and wine. He also enters at very considerable length into all the varieties of the disease, and divides mortification into three classes: *gangrene, sphacelus,* and *esthiomene,* or the highest degree, from which recovery is impossible.

"The second part of the work, on Amputation, is, perhaps, not as orthodox as that on Mortification; it is referred to, however, in Thompson's very valuable lectures on the subject, and again by the Coopers. The history of amputation, however, previous to the time that O'Halloran wrote, throws considerable light on the subject; for when one considers the number of different, and not unfrequently opposite opinions, that distinguished the earlier advances of surgery, it is not, perhaps, to be wondered at that O'Halloran, as he does here, should propose such a thing as to defer laying down the flaps of the wound till the end of the first ten days! Ambrose Parè, and after him Dionis, had ventured, it is true, on the 'fearful' innovation of tying the arteries in place of the actual cautery; many surgeons, among others Baronius, in the seventeenth century, still preferring to err with Galen than go right with the illustrious Frenchman. Wiseman, a century after, insisted on the ligature, and the necessity of drawing the flaps over the stump, and either

fastening them with stitches or a light bandage; the wound at this time being invariably a large, suppurating one, healing very slowly, the ends of the bones, of course, projecting and perishing: indeed, at this time it was thought impossible to heal a stump before the bone had exfoliated. Yonge was perhaps the first, in an obscure production, termed *Currus Triumphalis e Terebintho* (of all places in the world to look for such a thing!), that offered a hint of curing the wound '*per symphisin* in three weeks,' without fouling or scaling the bone. Even Larrey himself, with all the best surgeons of his time, were in the habit of introducing *charpie* under the flap to prevent union by the first intention.

"At this time appeared O'Halloran's book, which seemed something like the advice given to Phaeton reduced to surgery, *in medio tutissimus ibis*. A very general dogma prevailed,—quite a maxim, in fact,—that when the fresh-cut flap was laid over the end of the bone, inflammation and abscess were inevitable. O'Halloran recommended to defer laying down the flap till the danger of inflammation was over; in the mean time to dress the flap and stump as *distinct* surfaces, to preserve their power of uniting *per symphisin*. He performed the operation several times! and even states that after ten or twelve days the edges of the wound have united together very quickly.

"'To most men,' in the fine figure of Coleridge, 'experience seems like the stern-lights of a ship, which illumine but the track it has passed.' This cannot be said of the subject of our memoir; he evidently thought for himself, but, in the subject under our present consideration, with less happy effect than in those previously alluded to. Here, indeed, ancient dogmas and prejudices were against him, and his reasoning led him but half-way out of the ancients' track into still greater darkness and obscurity.

"His next professional work, entitled, 'An Attempt to determine with Precision such Injuries of the Head as necessarily require the Operation of the Trephine,' was printed in the Transactions of the Royal Irish Academy, in 1791. As he subsequently published 'A new Treatise on the different Disorders arising from external Injuries of the Head,' which embodied these observations, we shall consider them both together. They were written at a time when Mr. Pott (the only respectable authority on the subject at the period) complained of the darkness and obscurity of this part of surgery. Enabled, however, by close and diligent observation, and extensive practice for thirty years, during which, on an average, we have been told, he used to boast of three fractures every week, the result of party-fights in several of the southern districts, he set about to determine the question proposed in his paper published by the Academy, perhaps the nicest and most involved in surgery: at a time, too, when the French Academy directed the *trepan*, or *trephine*, in all cases of fractured skull indiscriminately, on the more than questionable principle, 'Veniente occurite morbo,'—and when Pott, from whose opinion there seemed to be no appeal, countenanced the same ruinous

mode of proceeding. Our own Dease, however, had commenced the good work of reformation in 1778.

"Abernethy, I need scarcely say, exposed the error of Pott's practice in a very masterly manner; but it is only a matter of justice to O'Halloran to state that he was one of the first who broke through the dogmatism of Pott and his friends of the Academy: 'Non fingendum, aut excogitandum, sed inveniendum, quid natura faciat ante ferat,' are the memorable words of Bacon, which he himself uses. 'To point out with perspicuity and precision the cases in which it (the trephine) can be useful to the patient, is the object of this Paper,' says O'Halloran; 'long experience having convinced me that many fractures require no operation.' Abernethy, exactly twenty years after (1811), for which he gets a world of credit, acquainting us of the French practice being so very faulty, and that of Mr. Pott, 'who advised the operation *invariably*, to prevent the inflammation and suppuration he so much apprehended,'—'many cases having occurred of late,' says Abernethy, 'where, even in fractures with depression, the patients have done well without an operation;' but no allusion whatever is made to the subject of our memoir, who had told the world the great fact long before.

"When we recollect, indeed, that after O'Halloran came Desault, and Schmucker, and Abernethy, and Larrey, and the great Sir Astley, it is but fair to assign O'Halloran that distinguished place among these men to which his labours so eminently entitle him. Indeed, reading this Essay, one is at a loss which to admire most, the masterly style in which it is written, or the crowd of facts he adduces to support his views. After a few preliminary observations relevant to the subject, he begins by citing a number of cases in which the fracture, contrary to the ordinary practice of the time, did not require the trephine; these are followed by some excellent practical remarks, and a second series of cases, many of them apparently less grave than the previous ones, yet where the proper use of the instrument saved the life of the patient. We find him urging at the same time, with no little force and reason, that the *symptoms* were to be the guide, not any axiomatic rule or law of any sort; in point of fact, the advice of the best surgeons at the present hour.

"He also takes up the consideration of the subject, whether the trephine should not be used in all cases of manifest *depression*. Some cases are given, not unlike many of those in the work of Klein (*Chirurgische Bemerkungen*), his opinion being that, under such circumstances, 'no consideration should make the surgeon decline or procrastinate' the operation.

"The concluding part of the Essay being taken up with the subject of 'Concussion of the Brain,' generally supposed to require the trephine, which, however, he opposes, notwithstanding the advocacy of Mr. Pott and Dionis, a writer of the previous century,—O'Halloran, laying down the then new but very sound rule, that concussion of the brain, characterized by *immediate* stupor and insensibility, does

not require the trephine unless accompanied with evident depression of the skull, or extravasation, neither of which produces bad symptoms for *some time after* the accident which has given rise to them.

"Among his other remarkable achievements, O'Halloran, we may say, was the founder of the County Limerick Infirmary. An old lady, yet alive, recollects distinctly his renting three or four houses, which he threw into one, for the reception of the sick and maimed, all his ingenuity and address being scarcely equal to the task of keeping it open. He was associated, it seems, with a gentleman named Vandeleur, who was also a surgeon. As subscriptions increased the beds were multiplied, and the benefit to the public was soon found to be so great, that further means were taken to extend the usefulness of the charity, a new building having been erected. This happening to be in the county, and an Act of Parliament having been just passed while it was in progress, for the support of such institutions, it was called the 'County Infirmary,' to enable it to come within the requirements of the Act. We have been curious enough to look into some of the earliest books connected with this institution, preserved with wonderful care and accuracy, and find the name, as given under the accompanying engraving, signed to almost every meeting of the Committee; O'Halloran himself being generally in the chair, or taking a very active part in the business of the meeting, as betrayed in several instances by his handwriting. About this time, the local history tells us, that Whiteboys first made their appearance in the south, and with them party-fights of every shade and character, so that the Infirmary soon became a sort of *sine qua non*, quite as necessary as the gaol, of which at present it seems but the outer porch. I may, however, add, that the building formed into an hospital by O'Halloran is not that now in use for this purpose.

"A strange mixture of industry and carelessness, O'Halloran is yet remembered by all the old people in Limerick, as a man of wonderful ability, with, at this period of his career, but little practice outside the walls of the Infirmary; his entire time nearly given up to literature and the discovery of antiquities. His house is yet in existence, in the old, but by far the most interesting part of the city, the resort of all the foreigners and *literateurs* that happened to visit this part of the country at the time. The tall, thin doctor, in his quaint French dress, with his gold-headed cane, beautiful Parisian wig, and cocked hat, turning out every day very responsibly to visit his patients,—visits, as he described them himself, that partook too much, according to his taste, 'of the nature of those of angels.' Among his other recommendations, an old friend of his has told me, that he valued that one lauded in the Gospel, 'being given to hospitality.' This gentleman having often dined with him, particularly the day he was elected an honorary member of the College of Surgeons, when, at a late hour of the evening, the 'Health' of the College was drunk by the Doctor, with a capital speech and a crowd of fine compliments.

"At some meeting of this sort, a story is told of his falling out with some one,—a gentleman ever boasting of his bravery, but withal a most arrant coward, something like a person he speaks of in his history(*a*). The Doctor challenged him, but next day the gentleman felt considerably like Bob Acres, and sent the most abject apology, accompanied even with a stipulation that, if O'Halloran pleased, he would allow him to horsewhip him in the public room,—anything rather than fight. O'Halloran consulted his friends, who seemed unanimous that he should give this person a threshing. 'Look'ee, Sir Lucius, there's no occasion at all for me to fight,' says Bob Acres: 'when it comes to the point, if it is the same to you, I'd as lieve let it alone.' So thought this foolish braggart. O'Halloran, however, was in the hands of his friends, and he was obliged to conform to their directions. The morning arrived; the room was crowded with people, anxious to see the gentleman paid off. O'Halloran, with his cocked hat and ruffles, arrived, and, to the great satisfaction of every one present, was quite as good as his word, as he laid on in the most unmerciful manner. This at once brought him into notice,—indeed, did more for him than if he had just discovered the circulation of the blood. Such the caprice of the time, and such the qualification for a Munster surgeon in 1770."

Having thus enumerated his several medical and scientific productions, it now but remains briefly to notice his various literary and antiquarian labours; we say briefly, because, however inviting the subject, it is less suited to the pages of a purely professional periodical than those labours to which we have devoted the previous portion of this essay. Whatever opinion may now exist with regard to O'Halloran's historical researches, it should always be borne in mind, that he was one of the few modern historians in this country who possessed the power of reading our Irish manuscripts. His first essay in this department of literature was the "Insula Sacra," a small work, apparently printed for the purpose of preserving our ancient Annals(*b*); and a more worthy theme could not possibly have engaged an Irish antiquary's attention towards the close of the last century.

Two years afterwards appeared his Introduction to the Study of Irish Antiquities, a work of great erudition and research, and rather in advance of than behind the knowledge of its time, but imbued in many parts with the fanciful theories which are set forth at length

(*a*) "This story is too good to be lost. We recommend it to the readers of Michelet, always talking of the characters of the *Bourgeoisie*. The prince of Saxe Hilburghausen, a desperate braggart, one day descanting on the high antiquity of his house,—that his ancestors were dukes and so-forth in the reign of Charlemagne,—General O'Donnell, an Irishman, descended from the people, coolly answered: 'Mon Prince vous etez bien heureux d'avonce etir né en Allemagne. Si vous etiez chez moi a peine duriez vous *le droit de bourgeois!*'"

(*b*) This little work, which was printed in Limerick in 1770, is the only one of his writings not now before us. It is enumerated by Ferrar.

by Dr. Ledwich(a). To this work, some animadversions upon Mac Pherson's History of Great Britain and Ireland, and remarks upon Sir John Dalrymple's Memoirs on the same subject, were appended. This is the work to which the author refers in his letter to Mr. Dease, given at page 19, when speaking of Ewing, the bookseller, by whom it was published. The work appears to have been completed in October, 1771.

In 1774 O'Halloran published his "Ierene Defended," which was written to refute certain passages in Dr. Leland's and Mr. Whittaker's works, which seemed to affect the validity and authenticity of ancient Irish history. This is a quarto tract of thirty-six pages, addressed in the form of a letter to Sir Lucius O'Brien, Bart., the President of the Antiquarian Society, which then existed in the city, and some of the records of which are still preserved in the Royal Irish Academy(b).

"To follow this able writer in chronological order," continues Dr. Kidd, in his memoir, from which we have already quoted, "we should be led into the attractive but somewhat discursive field of Irish literature, in which were spent the latter part of his intellectual labours. Distinguished by no ordinary talent, and an erudition that investigated every variety of Irish subject, O'Halloran's name was well known all over the Continent; indeed, as he often expressed it to some of his still surviving friends, he was 'never more at home than when abroad.'

"In Limerick, a literary society, composed almost exclusively of medical men, if not founded, was chiefly supported by his labours. At his death, however, it was dissolved, and I have not been able to discover its records, or any traces of its former existence. Two other old practitioners, now no more, Dr. Hardinge and Dr. Grogan, and an intellectual old gentleman named Hogan, were no insignificant pillars of this establishment(c). His General History of Ireland, however, during the latter period of his life, engrossed his chief attention. This appeared originally in two quarto volumes in London,

(a) At page 204 of this work we find a most interesting and learned dissertation upon the mineral riches of Ireland, which he appears to have written as a censure upon Dr. Gerard Boate's assertion, in his Natural History, that all the mines known in Ireland were "discovered by the New English, that is, such of them as came here in and since the days of Queen Elizabeth." Our space will not permit us entering at length upon this subject, nor is it one that requires to be discussed at the present day; but we would recommend the perusal of this chapter to those engaged in describing the resources of Ireland.

(b) The Antiquarian was a section of the Royal Dublin Society. O'Halloran was one of the committee.

(c) See the Editor's preface to the first Number of the present series of this periodical, p. 31; see also the Anthologia Hibernica, vol. iii. p. 251, for April, 1794, in which we find an article by Silvester O'Halloran, M. R. I. A., Honorary Member of the "Physico-Surgical Society," being "an attempt to ascertain with some degree of precision the question relative to vacuum and plenum, read at the Limerick Literary Society, June 2nd, 1792."

in 1778. His Introduction to the Antiquities had spread over the Continent in every direction; and he informs us, that it was everywhere received with approbation,—compliments of a very flattering nature having been received by him from some of the most distinguished characters in France and Italy; and in 1778, he says, "so great had the demand for it become, that three hundred copies were obliged to be shipped for Madrid, besides an immense quantity for India, Italy, and France."

"In what light this work might be considered in his own country, he seemed at a loss to conceive, but comforts himself with the assurance, which we cannot but admire for its candour: 'I am sensible,' says he, 'that men reluctantly part with their prejudices and their opinions; and the latter periods of our history have been so shamefully misrepresented, that it will require some time to establish antecedent facts. But let it be considered in what light it may, my intentions fortify me against the event.' When preparing his History for the press, we know that he enjoyed almost the entire surgical practice of this city, and his time was entirely occupied between it and the reading and deciphering old Irish manuscripts, of which he possessed a large collection. 'Though few people possess a greater affection and veneration for their native country, I little thought,' he says, in the Introduction to his General History, 'that this would, one day or another, engage me to draw my pen in its defence. It appeared to me, that if some generous attempt at a general history was not speedily undertaken, the Annals of our country, so important to letters, would be for ever lost. Could I have foreseen the tenth part of the labours and difficulties I had to encounter, in all probability it would never have appeared.' To us, writing at this distance of time, it seems almost incredible how O'Halloran could have written his history in a place like Limerick, where, even at the present moment, there is not one literary or philosophical society of any account. He had, however, himself transcribed some valuable Gaelic manuscripts in the Irish College at Paris, and he obtained several others by advertising in the Dublin newspapers of the time(a).

(a) O'Halloran's General History is now but little referred to, as the most valuable and accurate portions of it are to be found in Colgan and O'Flaherty. It is distinguished throughout by great national enthusiasm and considerable erudition, but its topographical descriptions, though on the whole tolerably correct, have been in many instances revised and altered by modern investigators. With the accurate dissertations of Dr. Petrie, Mr. O'Donovan, Mr. Hardiman, and Mr. Curry, with the Transactions of our Academy, the Annals of the Four Masters, and the Tracts of the Archæological and Celtic Societies, it will, no doubt, lose by the comparison;—still it was an astonishing performance at the date of its publication; for by it, to quote the concluding paragraph of his second volume, "the Irish of modern days have an opportunity of renewing their acquaintance with their great, their long-neglected ancestors, and I am persuaded that neither they nor their country will be worse for this information." O'Halloran's Irish History is still well known on the Continent, and it is, we believe, the only one which has been translated into German.

"Silvester O'Halloran was married at rather an early period of life, and had three sons and one daughter, all now dead: one of his sons died in mere boyhood. One son, General Sir Joseph O'Halloran, K. C. B., served in the East India Company's service for upwards of fifty years with distinguished merit(*a*). Another son died while occupying some high military appointment in the West Indies. The Doctor seemed to have early imbibed a favourable impression towards a military life, and one of his oldest living acquaintances lately informed me, that, while residing in London, in 1745, he entertained serious notions of joining Charles Edward, then in the zenith of his progress through Scotland. He died at a very advanced age, in the early part of the present century, and was buried in the little churchyard of Killeely, near this city, beneath a tombstone on which he had himself caused to be engraved a Latin inscription recording the virtues of his wife and daughter; but no friendly hand has added a line to record the labours and genius of this most distinguished Irishman."

In Miss Brooke's preface to the "Relics of ancient Irish Poetry," published in 1788, she says that she is greatly indebted to the learning of Silvester O'Halloran for much of the information contained in that work. It was not unusual, even at the time that O'Halloran wrote, for poems to be addressed by bards and poetasters to distinguished medical practitioners(*b*); and an Irish poem of this nature was addressed to the subject of this memoir by Thomas Meehan, a Clare poet of some note, and one of the last of the rhymers, towards the close of the last century. It is preserved in the Royal Irish Academy, and we are indebted to our learned friend, Mr. Curry, for a translation of it.

The following is a list of works published by O'Halloran, as well as the Papers communicated by him to the Transactions of learned societies:

"A new Treatise on the Glaucoma, or Cataract. By Sylvester O'Halloran, of Limerick, Surgeon. Dublin: printed by S. Powell, Crane-lane. 1750." Plates. 8vo. pp. 115. This work was concluded upon the 12th April, 1749. It is dedicated to the celebrated Dr. Meade.

"A Critical Analysis of the new Operation for a Cataract." Dublin: Powell. 1755. 8vo. pp. 39.

"A complete Treatise on Gangrene and Sphacelus, with a new Method of Amputation. By Mr. O'Halloran, Surgeon. Limerick: printed by A. Welsh, for the Author." 1765. 8vo. pp. 289. This book was originally published by subscription, and dedicated to the Earl of Hertford, then Lord Lieutenant of Ireland. It was reprinted in London by Vaillant the same year.

"Insula Sacra, or the general Utilities arising from some permanent Foundation for the Preservation of our ancient Annals demonstrated, and the Means pointed out." Limerick. 1770.

"An Introduction to the Study of the Antiquities of Ireland, in which the Assertions of Mr. Hume and other Writers are occasionally considered. Illustrated with Copper-plates. Also, two Appendices containing: 1. Animadversions on an Introduction to the History of Great Britain and Ireland, by J. Mac Pherson, Esq. 2. Observations on the Memoirs of Great Britain and Ireland, by Sir John Dalrymple.—By Silvester O'Halloran." Dublin: printed by Thomas Ewing, in Capel-street. 1772. 4to. pp. 384.

"Ierne Defended, or a candid Refutation of such Passages, in the Rev. Dr. Leland's and the Rev. Dr. Whittaker's Works, as seem to affect the Authenticity and Validity of ancient Irish History. In a Letter to the Antiquarian Society." Dublin: Ewing. 4to. pp. 36. 1774.

"A General History of Ireland, from the earliest Accounts to the Close of the Twelfth Century, collected from the most authentic Records, in which new and interesting Lights are thrown on the remote Histories of other Nations, as well as of both Britains. By Mr. O'Halloran. London, 1774: printed for the Author by A. Hamilton; and sold by G. Robinson, J. Murray, and J. Robson, and in Dublin, by Messrs. Faulkener, Hoey, and Wilson." 2 vols. 4to. —Vol. i. pp. 307; vol. ii. pp. 416. This work is dedicated to Murrough O'Brien, Earl of Inchiquin, and was published by subscription. The subscription list exhibits the names of a great number of Irish gentlemen, then resident abroad, and chiefly in foreign service. O'Halloran's Introduction and History were republished in 3 vols. 8vo. by Fitzpatrick, Dublin, 1803. This is the edition quoted by Michelet, in his *Histoire de France*, liv. i. chap. 4.

Another edition, in 3 vols. 8vo., was also published in Dublin, 1819, by Christie. A fourth edition was published in Cork.

"A Dissertation on the ancient Arms of Ireland." Originally sent to the Irish Antiquarian Society, and published in the 1st Volume of the *Anthologia Hibernica* for 1793.

"Sylvester O'Halloran, M. R. I. A., Surgeon to the County of Limerick Hospital, his Critical and Anatomical Examination of the Parts immediately interested in the Operation for Cataract; with an Attempt to render the Operation itself, whether by Depression or Extraction, more certain and successful. With a Plate." This paper was read before the Royal Irish Academy on the 2nd November, 1788, and is printed in the 2nd Volume of the Transactions of that body, pp. 121 to 141. Index, p. 63.

"Sylvester O'Halloran, &c., his Communication of the original Martial Ode which was sung at the Battle of Cruha (in 155), by

(*a*) Our friend Charles P. M'Donnell, Esq., has just placed in our hands the following extract of a letter received last year: "The late Lieutenant General Sir Joseph O'Halloran was married to an aunt of the present Marquis of Anglesey; he served fifty years in India, and was a most distinguished officer; he was a tall, thin, soldier-like looking man, and very amiable. He died in London about five years ago, aged eighty years, but in mind and appearance he seemed thirty years younger."

(*b*) A most curious collection of these poems will be found in Peter Lowe's "Discourse of the whole Art of Chyrurgerie," printed in 1612.

Fergus, Son of Finn, and addressed to Goll, the Son of Morna; with a literal Translation and Notes." Published in the Transactions of the Royal Irish Academy. Antiquities, pp. 7 to 17. Index, p. 63.

"Sylvester O'Halloran(*a*), &c., his Attempt to determine, with Precision, such Injuries of the Head as necessarily require the Operation of the Trephine." Transactions of the Royal Irish Academy, vol. iv. Science, pp. 151 to 169. Index, p. 64.

"A new Treatise on the different Disorders arising from External injuries of the Head; illustrated by eighty-five (selected from above 1500) practical Cases. By Mr. O'Halloran, M. R. I. A., Honorary Member of the Royal College of Surgeons in Ireland, and of the Physico-Chirurgical Society, and Surgeon to the County Limerick Hospital. Dublin, 1793: printed by Zachariah Jackson, for W. Gilbert, Great George's-street." 8vo. pp. 335.

"A Philosophical and Medical Treatise on the Air, in two Parts, wherein its real Properties are investigated, against Toricelli, &c.; and Physicks attempted to be settled on more solid and rational Foundation. By Mr. O'Halloran, of Limerick, Author of a New Treatise on the Cataract." This is a thick quarto manuscript, of 172 pages, closely and legibly written, in the Library of the Royal Irish Academy, to which institution it appears it was presented by the Author.

Mr. Ferrar informs us in his History of Limerick, that O'Halloran was also the author of "A Comedy and a Farce, not published, with several essays, medical, historical, and political, in the magazines, &c.; in all of which he not only appears skilful in his profession, but learned in the Irish language and ancient laws, and a warm advocate for the honour and interests of his native country."

(*a*) In most of his printed works the Christian name is spelled with a *y*: but in writing he always spelled it with an *i*.

BIOGRAPHICAL MEMOIR

OF

JOHN RUTTY, M.D.,

SECRETARY TO THE DUBLIN MEDICO-PHILOSOPHICAL SOCIETY;
AUTHOR OF
"A SPIRITUAL DIARY," "THE NATURAL HISTORY OF THE COUNTY DUBLIN,"
"AN ESSAY UPON THE MINERAL WATERS OF IRELAND,"
"A MATERIA MEDICA," Etc. Etc.

ROYAL COLLEGE OF PHYSICIANS IN IRELAND LIBRARY

FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR MAY, 1847.

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DUBLIN:
PRINTED AT THE UNIVERSITY PRESS,
BY M. H. GILL.

MEMOIR,

&c. &c.

It has been often remarked, how unjustly fortune acts in the disposition of her favours amongst the members of the medical profession, and how frequently prosperity is withheld from sterling merit, while it appears, in some instances, to be capriciously and profusely granted to the undeserving(*a*). The same remark may be applied with perhaps still greater justice to the reputation awarded by posterity to the cultivators of medical science. In how many instances have the real labourers in science been not only unrequited during life, but forgotten after death? That this should very generally happen to those engaged in the service of that untutored and ungrateful master, the Public, is no more than what is to be expected by all who consider the materials of which that Public is composed. But it is surely matter of reproach, when the members of our enlightened profession, suffer the unrighteous verdict of the world, in a matter which concerns them, to be recorded without appealing against it; and this they do when they permit the memory of the true cultivators of medical science to pass away into oblivion, without, at least, testifying their sense of the debt due to them as benefactors and instructors of mankind. The plan which has been carried into effect in this Journal, of publishing memoirs of the physicians belonging to this country, is, indeed, no more than an act of justice too long deferred; and this is more peculiarly the case in those instances where to the merits of the physician are to be added the virtues of the man. In the character of Dr. John Rutty, whose memoir we are now about to trace, we shall find an unceasing ardour in the advancement of science, combined with an endeavour to attain to the highest order of moral excellence. Such a character is not alone our property; it belongs to mankind: and in endeavouring to disinter the particulars of his life and labours from the obscurity and oblivion in which they are now nearly lost, we feel that we discharge no less a duty to the present race of his professional brethren, than to that country for the illustration and improvement of which he so long and so faithfully laboured.

Dr. John Rutty was born on the 25th of December, 1697. The place of his birth we have not been able with certainty to ascertain; but it appears to have been in some part of Wiltshire, where his family was settled; neither are we informed as to the occupation of his father. He appears to have been born and educated among the Quakers; and relates in his Diary, that, after being from his

(*a*) We are indebted to our learned friend and contributor, Dr. Jonathan Osborne, Professor of Materia Medica to the School of Physic, for the materials of this interesting memoir of Dr. Rutty.

thirteenth to his eighteenth year at various mixed schools, "among aliens, living as without God in the world, intent all the while on his learning," he was about his twentieth year transplanted to "a family of Friends." There some inclination to marriage was "overruled by a secret hand," and he continued a bachelor to his death. About his twenty-second year he removed to London, and, most probably attracted by the celebrity of Boerhaave, went to Leyden, where he graduated. His Diary states his object at this time "was all nature and physic, also serious thoughts of proper qualifications for a livelihood, as he had scarce any patrimony."

In 1720 he wrote a paper in the Philosophical Transactions upon Spina Bifida.

In 1724 he came to Dublin, and in 1729 was enrolled as a licentiate of the King and Queen's College of Physicians. For above twenty years after his arrival we are uninformed as to his practice in the profession; but from the commencement he kept a regular diary of the weather, and, at the same time, "opened a scheme for the improvement of the Materia Medica," to which branch of medical science he was peculiarly devoted throughout the entire of his long career.

His first publication was a new edition of Wight's History of the Quakers in Ireland, with a continuation of it from the year 1700 to 1751; and to this he subjoined a treatise on the discipline exercised in that Society, which appeared in quarto in 1751.

In 1753 he began to keep a Spiritual Diary, which was published after his death, and has afforded us an insight into his character, not usually accorded to the writers of biography. It is remarkable for its quaintness of expression; and passages frequently occur, well calculated to provoke a smile; but its rare and distinguishing excellence is its honesty. He spares not himself, nor does he, as is the case in so many modern productions of this class, reap a rich harvest of pride out of assumed humility, or affect to labour under peculiar weaknesses, which all turn out to be so many cardinal virtues, or Christian graces, in disguise; on the contrary, we find him minutely dwelling upon his faults, with a view to their rectification, and to his greater advancement towards that religious perfection which was the object he constantly held in view. In his will he directed this work to be published; and in a short preface, after alluding to the restraint imposed on St. Teresa, when, in publishing a similar work, she was prevented by her spiritual directors from describing many of her faults, except in a general way in her preface, he says, that his "plan has been to enter minutely into the corruptions of the human heart," and he wishes his reader, in "observing the power and prevalence of sin, as maintaining its strong hold for a series of years, to be assured, that sanctification is not the work of a day, nor a week, nor a year; and that the Christian warfare ceaseth not but with our lives."

In 1757 he published, by subscription, his work on the Mineral Waters of Ireland, which comprised a series of inquiries and experiments carried on for many preceding years. His analysis was the

best that the chemistry of the time afforded; and, in a great number of cases, he evaporated the water in order to ascertain the quantity of saline contents. His tests for chalybeates were solutions of galls, logwood, or sumach; and he perceived the important distinction between those which only answered to the tests when freshly taken from the source, but ceased to do so afterwards, and those which continued to retain the iron in solution. In ascertaining the other ingredients of this class, he also used soap, sulphuric and muriatic acids, syrup of violets, and nitrate of silver. For the vitriolic waters, in addition to the above, he immersed plates of silver or iron, and thus was able to ascertain the presence of copper in those of Nobber, Kilbrew, Ballycastle, Ballymurtagh, and Cronebawn. For the alkaline waters he also used vinegar to produce effervescence, and likewise muriate of ammonia, and in some cases resorted to the odour produced by bringing them in contact with red-hot iron. The sulphureous waters were principally tested by the acetate of lead. The following list of the waters described in the work cannot be uninteresting, and may be useful in exciting attention and inquiry towards them on the part of those medical gentlemen who may be resident in their neighbourhood.

COUNTY.	LOCALITY.	DESCRIPTION OF WATERS.
Antrim	Ballycastle	Vitriolic.
,,	Knocklade	Chalybeate.
,,	Carrickfergus	Nitrous.
,,	Kilroot	Saline.
,,	Ballycastle	Chalybeate.
Cavan	Carrickmore	Alkaline.
,,	Mountpallas	Chalybeate.
,,	Swadlingbar	Sulphureous.
,,	Derrindaff	,,
,,	Coolurgin, near Bailliborough	Chalybeate.
,,	Belturbet	,,
,,	Bailliborough	,,
Cork	Castle Townsend & Skibbereen	Sulphuro-chalybeate.
,,	Kanturk	Chalybeate.
,,	Near Five Mile Bridge	,,
,,	Macroom	,,
,,	St. Bartholomew's Well	Alkaline.
,,	Cape Clear	,,
,,	Mallow	Tepid.
Clare	Lisdonevarna	Chalybeate.
Donegal	Gorcumeaul	,,
Down	Granshaw	,,
,,	Killaghee	,,
,,	Ardmillan	,,
,,	Cardonnel	,,
,,	Dromore	,,
,,	Tierkelly	,,
,,	Ballynahinch	Sulphureo-chalybeate.
,,	Mourne Mountains	Chalybeate.

COUNTY.	LOCALITY.	DESCRIPTION OF WATERS.
DUBLIN	The Burn's Arms, The Pump, The Plough, Vernon's Head, Wheat Sheaf, Francis-st.	Saline.
"	Next door to the Churn, Thomas-court	"
"	Engine-alley	"
"	Coombe	"
"	Ballydowd, or Hermitage, near Lucan	Petrifying.
"	Howth	"
"	Banks of the Dodder, near Rathfarnham	"
"	Chinkwell, near Portrane	"
"	Loggshinny, near Rush	"
"	Smith's Quarry	"
"	Diswellstown	"
"	Templeoge	Chalybeate.
"	Lucan	"
"	Tobberbony	Alkaline.
"	St. Margeret's	Tepid.
"	Ballydowd	"
"	Kilmashoge	Chalybeate.
"	Garryduff	"
"	Curtlagh	"
"	Garristown	"
"	Glanmile	"
FERMANAGH	Drumgoon	Alkaline.
"	M'Guire's Bridge	"
"	Largy	Chalybeate.
"	Drumeroe	"
"	Derrylester	Sulphureous.
"	Lisbleak	"
"	Killasher	"
"	Mechan	"
"	Ashwood	"
"	Derryhence	"
"	Owenbreun	"
"	Pettigo	"
"	Killinshanvally, nr. M'Guire's Bridge	Chalybeate.
"	Trillyveal, near Claby	"
"	Lisnaskea	"
"	Aghalun, near Brooksborough	"
KILKENNY	Ballyspellan	"
"	Johnstown	"
KERRY	Maherebeg	Saline.
"	Tralee	Chalybeate.
"	Fellswell	"
"	Castlemaign	Sulphureo-chalybeate.
"	Dingle	Chalybeate.
KING'S COUNTY.	Frankford	"
KILDARE	Dumard	"
LIMERICK	Castle Connel	"

COUNTY.	LOCALITY.	DESCRIPTION OF WATERS.
LOUTH	Ballymascanlan	Chalybeate.
LEITRIM	Drumsna	Sulphureous.
"	Anaduff	"
MEATH	Summer Hill	Chalybeate.
"	Nobber	Vitriolic.
"	Kilbrew	"
MONAGHAN	Tullaghan	Petrifying.
QUEEN'S COUNTY	Mountmellick	Chalybeate.
"	Cappard	"
ROSCOMMON	Athlone	"
"	Kilroran	"
TYRONE	Dunbonrover	"
"	Strabane	"
"	Newtown-Stuart and Omagh	"
"	Dunaghy	"
"	Aghaloo	Sulphureous.
TIPPERARY	Ballyporeen	Chalybeate.
"	Toomevara	"
"	Grove	"
WESTMEATH	Grange More	"
WICKLOW	Bally Nastoe	"
"	Bally Murtagh	Vitriolic.
"	Cronebawn	"
"	Drumkit	Chalybeate.
"	Glancullen	"
"	Shankhill	"
"	Ballynastoe	"
WATERFORD	Crosstown	Vitriolic.
"	Coshmore	"
"	Bandon	Chalybeate.
"	Kilmeaden	"
WEXFORD	Enniscorthy	"
"	Wexford	"
"	Cloger	"

Mineral waters were in high favour with the public at the time when this work appeared(*a*). The saline waters of Francis-street, in Dublin, were used at the close of the seventeenth century, but had become neglected, till revived in consequence of the researches of the Physico-Historical Society. From his experiments they appear to have contained an alkaline carbonate, common salt, and nitre; and, to produce any sensible effect, it was requisite to drink no less than four or five pints. It is probable that most, if not all, their saline contents were derived from decomposition of animal matters, conveyed to them through sewers or land-drains; but spas of any kind were at this time considered as of such value, that nothing short of full experience to the contrary could disturb

(*a*) It is to be regretted that Dr. Knox, in his work on Irish Watering-Places, did not avail himself more extensively of the abundant material contained in Rutty's various works on this subject.

their hold on the public mind. The chalybeate water of Templeogue was daily brought into town, and vended in St. Stephen's-green. We find the unhappy Stella residing at one time at Templeogue, and afterwards at Wexford, to obtain the benefit of chalybeates, when she was labouring under the "hope long deferred." The spring of Ballyspellan was in such high repute when Dr. Taafe published his Treatise on it in 1724, that it was emphatically called "The Irish Spa." Dr. Sheridan's poem is in the recollection of all readers of Swift. It begins with:

"All ye that would refine your blood
As pure as famed Lewellyn,
By waters clear, come every year
To drink at Ballyspellin."

Continuing the same rhymes, he ends his fifteenth verse thus:

"My rhymes are gone, I think I've none,
Unless I should bring hell in;
But since I'm here to heav'n so near,
I can't at Ballyspellin."

This produced a rejoinder from Swift, beginning with:

"Dare you dispute, you saucy brute,
And think there's no repelling
Your scurvy lays, and senseless praise,
You give to Ballyspellin?"

It continues the same rhymes through fifteen verses, each ending with Ballyspellin, most of them unfit to be quoted, and was believed to have occasioned the breach between them, that was never made up.

Even Rutty departs from his usual sobriety, and, in his observations on the chalybeate water near Gorey, quotes the following verse of a song on it:

"Consumptive lad,
With asthma bad,
Grew rampant and picqueering;
And widow pale,
From head to tail,
Was cured at Tobbernecring."

A general neglect of the mineral waters of Ireland has taken place from the close of the last century up to the present time, and unmeritedly so with regard to several of the sulphureous and chalybeate springs, which, in many instances, are sufficiently impregnated for all practical purposes. Many of them are, moreover, situated in healthful and beautiful localities. The general deficiency, however, of accommodation suited for invalids, and the want of any notable thermal or saline aperient waters, have caused them to be overlooked altogether by the *squadrone volante* of fashionable valetudinarians, a circumstance much to be deplored in a national point of view.

This work on the mineral waters was not received by the public as the author had a right to expect. The following reflection occurs

in his Diary, 10th 12th mo., 1757: "On the printing and sale of my book, O how was I deceived as to its reception! Few but subscribers came, and had it not been for those, I had suffered greatly in the expense: learn then the worth of the world."

It was immediately attacked by the celebrated Dr. Lucas, who, before acquiring notoriety as a patriot, had published in London, in 1756, an Essay on the properties of mineral waters in general. This work, entitled, an "Analysis of Dr. Rutty's Medical Synopsis of Mineral Waters," produced a reply from Rutty, and a controversy ensued, which lasted during three years. Several able pamphlets were written on this occasion, but, generally speaking, Lucas had the best of it; still we find Rutty maintaining his temper:—thus in his Diary, 9th 8th mo., 1757, we read: "Was this day presented with Lucas's sarcastical remarks on my book. This is a wholesome discipline, though severe: a controversy ensued. God mingles trouble with pleasure. There are some imperfections and errors in my work, I thank God he had found no more." And when he had occasion to mention Dr. Lucas subsequently, in his work on the County of Dublin, he calls him the "ingenious Dr. Lucas;" and in other places speaks of him with consideration and respect.

As we intend presenting our readers with a biography of Charles Lucas shortly, we will not now enter into the subject of this controversy, but reserve it for another occasion. Among the tracts connected with this controversy we have met the following: "The Argument of Sulphur or no Sulphur in Waters discussed;"(*a*) in which "the phlogiston, sulphur, and oily matter, according to Dr. Lucas, as defended in his essay," were impugned. In this work Rutty was assisted in his chemical experiments by Dr. F. Hutcheson, the Professor of Chemistry, and by Mr. Patrick Bride. This was answered by Lucas in a few months by a very caustic pamphlet, styled "A cursory Examination of the Methodical Synopsis, &c., and of the Argument of Sulphur or no Sulphur, &c., in a letter to the celebrated John Rutty, M. D., seriously recommended to the Perusal of the reading Subscribers to the Doctor's Work."(*b*) This again was answered by two friends of Rutty; by the first in a small tract of fifteen pages, entitled, "Cursory Remarks on a 'Cursory Examination,' &c. By Theophrastus Antiphlogisticus;"(*c*) and the second by "A Letter to a Friend in Dublin, containing some Remarks on the 'Cursory Examination,' &c. By an Apothecary."(*d*) About the same time "The Author of the Manufacture of Drugs" mingled in the fray, in a tract which he published on "An artificial sulphureous Water resembling the Natural, a Thing hitherto supposed

(*a*) Dublin, M'Culloh. 1762. pp. 109.
(*b*) Dublin, Ewing. 1763. pp. 87. Finding that many of the writings of the Dublin physicians, particularly about the middle of the last century, are not only unknown but exceedingly scarce, we purpose affixing to each of these memoirs of medical men a list of their various writings, &c.
(*c*) Dublin, Saunders. 1763.
(*d*) Dublin, printed in the year 1763. pp. 21. There is no printer or publisher's name to this, but it is dated Belfast, 10th April, 1763.

impracticable in Chemistry."(*a*) Within three weeks from the issue of this pamphlet Lucas published a powerful reply, both to it and the two preceding tracts, in a "Second Letter to the learned and ingenious Dr. Rutty."(*b*)

Along with the "Sulphur or no Sulphur" work, with which they were printed, appeared, "The Analysis of Milk, and the several Species thereof, by John Rutty, M. D.;" and also "A practical Dissertation on the Uses of Goat's Whey," a tract furnished to Rutty by Dr. James Kennedy of Downpatrick. Did our space permit, we would wish to present our readers with some notice of those very rare works. We shall not, however, lose sight of the subject.

The observations which he had made on the weather and prevailing diseases of Dublin, and the results of which he communicated on several occasions to the Physico-Historical Society, and elsewhere, formed the chief materials of his "Chronological History of the Weather and Seasons, and the prevailing Diseases in Ireland," published in London in 1770. His Diary of the Weather was commenced in 1725, and was continued without interruption till 1765, except during the summer of 1737, when, during his absence in England, it was kept by Dr. Richard Weld.

In this work, besides the fevers that are briefly described under each year, the following epidemics are more peculiarly remarkable, viz.: in November, 1729, an epidemic catarrh, fatal to most old persons; November, 1739, a similar disease, passing from Germany through Great Britain, and peculiarly fatal to children. After the hard frost which commenced in December, 1739, and lasted to the middle of February, 1740, the summer was attended by small-pox and dysentery. The winter of 1740 remarkable for a famine, owing to a failure in the potatoe crop, followed by typhus during the dry and hot summer that succeeded. This is described by O'Connell, who computed that, during 1740 and 1741, the number of those who died of famine, fever, and dysentery, amounted to 80,000. 1743 an epidemic croup, sweeping off the children of whole villages in the southern and midland counties, and apparently the same disease as that described by Dr. Fothergill in London at the same time, as the putrid sore throat(*c*). Summer of 1735, and spring of 1754, agues. 1751 and 1760, distemper among horses. 1762, influenza, traced as having passed through Great Britain from Copenhagen. By the numbers of burials recorded, there is the most striking evidence of the fatality of influenza, and also of the truth of his general observation, that the greatest mortality in Dublin occurred in those years in which there was the least moisture.

The Physico-Historical Society, of which we have already given an account, having committed to him the investigation of the natural history of the county Dublin, he appears to have made it

(*a*) Dublin, Williamson. March, 1763. pp. 23.
(*b*) Dublin, G. and A. Ewing. pp. 59. March 30th, 1763.
(*c*) See Medical Memoir to Irish Census for 1841, pp. viii.–xxiv. for a general account of all these epidemics.

the occupation of his walks and hours of recreation for many years; but it was not till the year 1772 that he published it. It is in two volumes, and dedicated to the Dublin Society. He obtained thirty pounds from the College of Physicians to help to defray the expenses, and there appears a list of 350 subscribers. At the commencement he takes a view of the situation of the city of Dublin, and the following description of the scenes which afforded recreation and enjoyment to our predecessors so many years ago, can hardly be read without interest now:

"This city enjoys a situation for pleasantness hardly to be equalled, whether one would entertain himself with a survey of the artificial beauties on the western side in the many public buildings which adorn it, among which I shall only mention two which were the foundations of private persons, because they do honour to human nature, particularly the hospital founded by Dr. Steevens, and that for lunatics and idiots by Dr. Jonathan Swift; or if on the same western side he would choose to survey the natural beauties, he may take a ride to the deer-park contiguous to the city, and direct his course along the banks of the Liffey, extending several miles up the country, frequently adorned with hills and gentle declivities, partly wild and partly interspersed with woods, and sometimes with corn-fields and pensile gardens, exposed to the south, which supply the city with pease a week or fortnight earlier than colder situations.(*a*) Or if he would divert himself with a walk, he hath his choice of three very agreeable ones, viz.: one to the south-east, to that called Stephen's-green, said to be one of the largest squares in Europe; a second to the east and north-east, being that part of the Strand which is lately reclaimed from the ocean by a vast bank, called the North-wall; the third, to the west, on the bank of the Bason, or great reservoir of water for the city; which said several walks may be said to vie with each other in delightfulness. Again, on the north side of the city are numerous gardens, supplying the inhabitants with their produce; and if we travel further northward, and nearer the coast, we have the sea frequently and beautifully intersected with islands; or if, in another position, we take a view from the south-west to the south-east, our sight is agreably bounded with a range of mountains, making up almost a semicircle, some of which seem to pierce the skies(*b*) with their awful and magnificent summits: so that, upon the whole, which way soever one turns his eyes, a situation more delightful, or a greater variety of pleasing objects can hardly be conceived."

(*a*) The present Strawberry Banks.
(*b*) This may refer to Sugarloaf, which, in the View of Dublin, appended to the rare map published in 1728, is represented with a slender conical summit, terminating almost in a point. This mountain is altogether composed of quartz rock, and a remarkable process of disintegration has gone on at its summit, producing a vast mass of *debris*, principally on the western face of the cone. How far the actual form of the mountain may have been thus altered within a short period of time would be an interesting inquiry to the geologist.

The descriptions of the uses and applications of vegetables, indigenous or cultivated in the district, are excellent, and derived both from reading and his own observation. It strongly suggests the value of a work on the same subject, suited to the wants and habits of the present time, but is also an evidence of the difficulty of effecting improvement among the great masses of our people. As an instance, he describes the uses to which the ashes of the full-grown thistle are applicable as an alkali; and yet, although it has been proved that those ashes contain above thirty-five per cent. of potash, yet we never see them collected or lixiviated; and they are very generally not even pulled up, or placed to rot on a dunghill, till after they have shed their seeds and secured a succession of noxious weeds over the surrounding country. In this part of the work are many melancholy instances of the vain efforts made by the Dublin Society, and other patriotic bodies, to stimulate indolence into activity by premium and bonus, proving that the true industrial resources of a country consist, not in its soil, or its water power, or its minerals, but in the truth and integrity, the energy and perseverance of its inhabitants.

The description of the economic uses of so many productions of nature going to waste around us, is, however, well suited to illustrate how much it is in the power of the physician to be of use to his fellow-creatures, not only by the exercise of his benevolent vocation of healing the sick, but by the application of his knowledge of the material world to their general advantage and enjoyment.

In the zoological department there are plates of the bull's-eye, the cherrychirper, the ska, the cock widgeon, the easterling, and the popjack diver. The account of fish is the most defective. Under the head of minerals he has bestowed the greatest pains in his observations and experiments on clays and marls, and, next to them, on those kinds of stone which furnish materials for the builder. He in this work also resumed the subject of mineral waters, and has given a series of experiments on the water of St. Patrick's Well at Finglas, contrasted with Malvern Waters; also a series of experiments made annually on the springs of Francis-street, during the twelve years that had elapsed since the publication of his work on Mineral Waters. These shew the saline contents to vary so much as to leave but little doubt that their impregnation was from extrinsic and accidental sources.

The chalybeate spa of Lucan mentioned in the "Mineral Waters" was that which exists at present, at a short distance to the left from the high road entering the village from Dublin; but in the year 1758, that is a year subsequently to the publication of that work, the present sulphureous spa, near the river, in Mr. Vesey's demesne, was discovered, and soon came into high repute. The water was conveyed to Steevens' Hospital for the service of the patients, and he has arranged the cures performed by it under the heads of cutaneous diseases, ulcers, scrofulous cases, and diseases of the first passages; and he has not omitted a decidedly unfavourable case, in which, he says, the remedy was used "because it began to be modish, rather than

from proper advice;" adding, "that a few such cases must have blasted the reputation of this inestimable spring for ever, had they not been confronted by such a multitude of indisputable instances of its good and powerful effects."

In the zoological department of this work there is not much originality. The author has, however, successfully followed up, for the county of Dublin, what had been previously effected by Harris for Down, and Smith for Cork and Waterford. And the letters S. and H., prefixed to so many of his descriptions, shew how largely he availed himself of the knowledge of his predecessors. Notwithstanding, many of his own remarks possess much interest to the naturalist. The differences between the English and Irish hare has attracted the attention of naturalists within the last few years; and has also been remarked by sportsmen. Rutty, however, alluded to the fact of the well-known inferiority of the fur of the Irish hare in the manufacture of hats in his day. Mr. Thompson, who, some time since, made a communication to the Royal Irish Academy on the subject, has, however, just informed us, that "characters on which to found satisfactorily specific differences between the Irish and Alpine hare do not exist, either zoologically or anatomically, although the habits, or rather haunts, of the animals are so markedly different."

The work concludes with the details of his history of the weather. His hygrometer was a sponge dipped in brine, which, he adds, is an excellent magnet in respect to the moisture of the air, varying in weight nearly 200 grains. From 1717 to 1726 he used the diaries furnished by Isaac Butler, "astronomer," who was subsequently employed in the Physico-Historical Society to collect specimens of natural *history*, and was also engaged as "*satellite*."(*a*) The diary of the weather terminates in 1765, thus presenting a series of observations extending over forty-eight years, that being, as far as we are informed, the longest registration of the weather of Dublin now in existence.

In his Spiritual Diary he says of his preparations for this work: "From 1740 to 1745 I was engaged in the natural history of the county Dublin, and was led a long dance on birds, fishes, and fossils, and in *compotations* for information, and was greatly hurt in my spirituals by these means." It is certain that the turn of his mind disposed him strongly towards natural history. Botany in particular appeared to him so important, that he wished to diffuse a taste for it among his medical brethren, but with what success may be seen from the following entries in his diary. "20th, 8th mo., 1760. A botanick walk, wherein in a manner *solus*, this noble and useful science being in utter contempt." "1st, 6th mo., 1767. A botanick walk on principle, but miserably attended; our medical, as well as ecclesiastical state is sick." "23rd, 3rd mo., 1769. Invited eight apothecaries to our botanick excursions on principle." "29th, 5th mo.,

(*a*) See Preface to vol. i. of our present Series, page xxvi.

1769. The botanick walk; O the perverseness, the indolence, the ignorance, and the sin of the apothecaries!" "29th, 5th mo., 1770. Yesterday's botanick walk gave peace and delight upon reflection, even as a testimony against the idle sons of Æsculapius in this city, immersed in sloth and sensuality."

During his long professional life the Materia Medica was his favourite study, and all his other pursuits appeared to be followed only in subservience to this. He was ambitious to impart to it an exactitude and certainty which have been the great objects with all endowed with any adequate notion of its importance and its imperfections. Thus in his Diary, 6th month, 1756: "O! what infants we are in natural knowledge, and particularly in the Materia Medica after centuries of years, as appears in Le Clerc's History, whilst mere copyists are innumerable." Also, "3rd mo., 1760. God hath brought thee through a very thorny path of thy life. Now impends the great work of thy life, the Materia Medica. Lord preserve."

It was not completed till June, 1773: "Now finished the fair transcript of my Materia Medica, the principal work of my life; a work of no present advantage to me, but I hope will prove so to others. Exercised a little Sabbath on this occasion." It was written in Latin, and sent over for publication to Holland. In the instructions concerning his will, written in February, 1774, he says, that last summer he had sent the Latin MS. of his Materia Medica to Holland, and that if the printing of it be delayed till after his decease, he gives the said MS. to Thomas Fowler, of Micklesham, Wilts, that he, with advice of Drs. Fothergill and Lettsom of London, may dispose of same; the profit to go to Thomas Fowler. It did not appear till some time in 1775, the year of his death, and we have no means of ascertaining whether this labour of forty years was ever seen in print by the author(*a*). It was dedicated to him in an elegant Latin preface by Van Royen of Leyden, dated 25th September, 1773, in which he styles it *desideratum novumque immensi laboris opus*; yet declines to assent to some of his identifications of ancient medicines, and particularly of hellebore and squill, regretting that the observations of the ancients should have become so generally useless, in consequence of their want of systematic arrangement of the subjects of natural history. The great rarity of the work renders it necessary that we should give the following brief epitome of its contents. The prologomena consists of

1. An alphabetical list of diseases, with the medicines suited for them, according to the Greek, Latin, and Arabian authors.
2. A classification of medicines according to their sensible qualities.
3. Do., according to their sensible operations.
4. A catalogue of simples having the same name as used by the ancients.

(*a*) The title of it is as follows:—"*Materia Medica, antiqua et nova, repurgata et illustrata sive de Medicaminum simplicium officinalium Facultatibus.* Tractatus Authore Johanne Rutty, M. D. Opus XL. Annorum. Londini: E. & C. Dilly. Rotterodami: Holsteyn & Beman. 1775."

5. Substances really different, though called by the same names by the ancients and moderns.
6. Substances called differently by us from the ancients.
7. Medicines of modern discovery, unknown to the ancients.
8. Remarkable medicines mentioned by the ancients, but not described by them so as to be certainly recognised.
9. Medicines derived from the Arabians or modern Greeks.
10. Medicines derived from America.

The body of the work is in alphabetical order, and under the head of each simple substance he gives its sensible qualities, its chemical properties according to the tests used at that time for determining acidity, alkalinity, astringency, &c.; and lastly, an account of its physiological and medical properties. This latter class of facts is derived from the older authors, with some of his own observations subjoined. It is in the paucity of those that the work is most defective. He seems to have had an unjustifiable want of confidence in his own experience, which must have been both extensive and accurately recorded, and to have preferred to rely on the authority of the ancients, which, in this department, is peculiarly unworthy of confidence, not only by reason of the uncertainty of identification, but by the differences of race, of climate, of diet, and of habits in their patients, from our's. The work never reached a second edition, and it appears that it must have had a very limited sale, which is to be ascribed not only to the expensive quarto form in which it appeared, or to the Latin language in which it was written, and which at that time was rapidly falling into disuse; but principally to the circumstance that Dr. Cullen's excellent and practical work on the same subject appeared almost immediately afterwards, and soon secured to itself the suffrages of the British medical public, which it continued to retain for several succeeding years.

Thus the "Opus Quadraginta Annorum," which was intended by the author to place the Materia Medica on the basis of positive facts, and so to effect its total reformation, was neglected even from its first appearance, and passed rapidly into oblivion. It is now so scarce that not one of the public libraries of this city contains a copy.

From the time of his election into the Physico-Historical Society in 1744 he took a prominent and active share in their proceedings, and their thanks were repeatedly voted to him for his exertions. This Society met in the committee-room of the House of Lords, and numbered among its members several peers and other persons of distinction, who appear to have enlivened their philosophical pursuits by social entertainments conducted in a manner so little to the mind of Rutty, that they became the subjects of constant self-admonition and lamentation in his Diary. Thus: "21st, 5th mo., 1756. Impends a drinking day at a Parliament meeting. Lord preserve from captivity and from the damnable sin. Accordingly marched off refreshed." "8th, 1st mo., 1756. Feasted with the new philosophers."

"5th, 8th mo. A feast wherein a little swinish." "11th, 11th mo. Feasted; idle, punning wit there not enough discouraged." "20th, 4th mo., 1757. Piggish at a feast." "22nd, 11th mo., 1758. Impends a feast. Take care." "23rd, 5th mo., 1759. A compotation disagreeable and beyond the holy bounds on a philosophical expedition."

The Medico-Philosophical Society was founded from the following circumstance: "22nd, 11th mo., 1756. A happy thought of presenting C. S. [Charles Smith, M. D., author of Natural History of Cork, &c.] with an old MS., partly laid a foundation for a most useful and virtuous society in this land of indolence. Blessed be the Lord! for I never dreamt of the good consequences I humbly hope entailed on this seeming accident." Rutty's numerous communications to this Society are still extant in the "Repository," the Minute-Book, and unpublished Memoirs and Proceedings of that body, now preserved in the libraries of the Royal Irish Academy, and the Association of the College of Physicians. Of the entire number of papers in the Repository, amounting to 230, he contributed ninety-nine, principally on subjects relating to the materia medica, mineral waters, or natural history. In this Society, as elsewhere, he had to complain of the prevailing apathy with regard to science, and of the disposition to convert meetings ostensibly held for its promotion into scenes of conviviality. Thus: "16th, 4th mo., 1759. O how little public spirit even in our temporals; I am forced to tug the oar almost alone in the service of a medical Society." "19th, 6th mo., 1766. At the Medical Society almost alone: a sad world in nature and in grace. O where is public spirit!" "3rd, 10th mo., 1770. At our medical convention some real profit, but with a mixture of ungodly jokes. I fear I countenanced them too much. Must we go out of the world to fly from its contagion?" After Rutty's death the Society became more and more negligent of the object of their institution, till at last they ceased to keep any records. They insensibly degenerated into a social club, dining at each other's houses on the most expensive scale; and thus for many years before its final extinction, about twenty-five years ago, they gave occasion to a well-known punster to say that from a Philosophical they had become a Fill-œsophageal Society(*a*).

It must, however, in justice be confessed, that Rutty's notions on the subject of abstinence were not such as could be expected to meet with general acceptance either in this or any other country. He was, in fact, an ascetic; and probably so, both from holding that abstinence was meritorious in a religious point of view, as well as from having often experienced in his own person that depression and hebetude which the slighest infraction of its rules produces in some individuals. Thus: "12th, 4th mo., 1754. Feasting rather beyond the holy bounds. O how difficult to keep innocent in company! Solitude is surely more eligible, yet society useful, but the sanctified use of it very laborious." "16th, 7th mo., 1775. Dogged; ate too much." "18th, 9th mo. Dined on bread and three glasses of wine and a repast of a domestic tea. 19th. A luxurious dinner on potatoes, onions, and cauliflowers, and three glasses of wine. 20th. Dined on broth this third day of my exercise of temperance, and was lightsome on it." "21st, 10th mo. Dined on saffron cake and tea." "7th, 11th mo. Dined on bread and water to cure crapula." "12th, 7th mo., 1756. Dinner chocolate, and ate to live." "3rd, 3rd mo., 1758. Dinner on nettles." "19th, 5th mo. Dogged on fasting." "13th, 9th mo., 1764. Ate bread and drank water for dinner." "17th, 11th mo., 1765. Dined on bread and water on principle." Though he smoked, yet it was not without compunctious visitings that "the pipe enslaved."

(*a*) For an account of this society see Preface to vol. i. of our present Series, p. xxviii.—February, 1846.

As a physician his practice was evidently not lucrative. His obscure style of living appears to have excluded him from coming into competition with the fashionable practitioners of the time, and his character for benevolence must also have caused him to be imposed upon by many. His complaints on the unrighteous detention of his fees are numerous, and will, no doubt, powerfully awake the sympathies of many of our readers. His indignation on this point was often roused to a degree which he found difficult to repress. "13th, 10th mo., 1755. Eleven patients, and not one fee, and my patience abused considerably. I muttered a little, I hope not unrighteously." "29th, 11th mo., 1755. The medical profession exhibits strongly the vanity and wickedness of the world, where the more work the less pay." "18th, 9th mo., 1756. A pretty handsome supply of paupers, but few of the rich." "26th, 1st mo., 1760. Much medical work and little wages. Lord give patience!" "17th, 5th mo., 1760. Eight patients and not a penny." In common with many who have allowed their services to be taken for nothing, he received his full share of ingratitude and of disregard of the value of his prescriptions: "1st, 7th mo., 1755. Contempt from a patient, and pretty calm under it." "16th, 8th mo. A rencounter with a clamorous woman on a patient dying, and in dread of the mob, but was delivered, blessed be the Lord!" "26th. Great impertinence from a patient; borne tolerably, blessed be God!" "12th mo., 1757. Insulted and vexed by unrighteous contempt from even a poor patient, whom I was obliged to desert."

We have not been able to procure any account of the peculiar style of Rutty's practice as a physician. The merits of the medical practitioner, often unknown to, and even unappreciated by those whose lives have been saved by them, are forgotten along with the occasions which have called them into action, and the memory of them usually perishes with the existing generation. He does not appear to have held any hospital appointment, but availed himself of the opportunities of witnessing the practice of Steevens' Hospital, as he alludes to it in his Materia Medica. Only one professional letter has come into our hands, which we insert as a specimen of his style and character in this point of view. It was addressed to

the grandfather of the gentleman who obligingly lent it to us, and was intended for him and his wife, which accounts for the use of the plural pronoun.

To Joshua Strangman, Mountmellick:

Dublin, 4th ^{mo}, 1749.

"Loveing Friend,—In answer to thy let^{r}. I received yesterday I should be glad it were in my power to send you any directions, that might be to the purpose, and of real service, at this distance.

"To be enabled to judge whether either of y^{e} waters you mention, or any other medicine, may be proper, all y^{e} lights that can be given in so difficult and long depending a case are little enough, and therefore I can give no judgment of this or that method on y^{e} present representations of y^{e} cases until I have a more minute account from your physician, and particularly of her present degree of strength, and the variation of it, and of y^{e} pulse from their former state, and what medicines have been already ordered, besides several other particulars that must occur: without this precaution patients run giddily into a right or wrong course, and had better have been quiet and done nothing.

"I am willing to serve you to y^{e} utmost of my power, and have told you y^{e} road in which alone I can do so, who am,

"Thy sincere ffriend,

"Jno. Rutty."

We are indebted to Dr. Roget for the following letter of Rutty's to his cousin, Dr. W. Rutty, who was second Secretary to the Royal Society, from 1727 to 1730. It is one of many from the same hand, still preserved in the archives of that body:

"*Dublin, March* 21, 17$\frac{2}{3}$.

"Dear Cousin,—I am favoured wth thine of Feb 6 by wc^{h} I find thou hast done me much more honour y^{e} ever I expected, indeed I wish my papers had b^{n} better prepared for so publick an examination. However I am greatly obliged to thee for those judicious remarks upon it, and will endeavour to convert y^{m} to y^{r} advantage of my subject as much as I can. Thou very justly observest y^{t} w^{t} is likely to take up a good p^{t} of one's time ought to answer in its usefulness and I am so far from being offended at thy freedom in communicating thy sentim^{ts} y^{t} I should deem no friendship valuable where y^{t} liberty were not allowed. However I cannot but observe one or two things upon yo^{r} remarks. First as to y^{e} determination of how far y^{e} modern medicines were known to y^{e} ancients, I cannot help thinking this to be a considerable article, althô at last there shou'd be left but a very small number of those y^{t} are comon to us and them, since this is absolutely necessary in order to a rejection of uncertainties out of o^{r} accounts of y^{r} powers of simple medicines, w^{ch} w^{ch} uncertainties y^{t} y^{e} present acco^{ts} are pretty much perplex^{d} whilst y^{e} very words of Dioscorides are transcribed and apply'd to different medicines is allow'd. But when once y^{e} medicines concerned shall be reduced to comon, doubtful & new, as there is a necessity in an affair of this nature to make use of authorities for facts, we shall know w^{t} authors to have recourse to under each head, w^{ch} otherwise cou'd not be done. So y^{t} I cannot but look upon thy article to be like removing the rubbish in order to build securely.

"The difficulty attending an acco^{t} of tast & smell from not only o^{r} inability to express by words many ideas we receive y^{t} way but also from y^{e} diversity of both in different persons must be allowed in a great measure, but still I cannot think y^{t} this article can be totally rejected without great injury.

"The difficulties mentioned are allow'd to obtain in many medicines & accordingly wherever y^{e} tast and smell is uncapable of description it shall be acknowledged nor shall it be presumed to class such medicines from thence: We must not expect but to find anomalies here as well as do y^{e} botanists in y^{r} distributions: But from y^{r} now several years experim^{ts} made this way by me & my boys I do affirm y^{t} in a very great number of medicines, there is not only such an uniformity in o^{r} accounts but there is in y^{e} medicines such a natural, evident, unstrain'd affinity between y^{m} in that respect w^{ch} also for y^{e} most part holds in correspondent virtues that to suppress this were to suppress perhaps y^{e} best list of succedanea y^{t} can be given.

"It is always to be supposed y^{t} useless subtilty in y^{e} subdivisions of tasts & smells is avoided & y^{t} y^{e} predominant evident tasts only are noticed & such in w^{ch} y^{e} generality of mankind will pronounce the same thing upon trial.

"But not to carry this article to fondness & althô this be free from an objection attending y^{e} chymical analysis y^{t} it alters y^{e} natural state of bodies, yet tast & smell are allow'd to be very defective witho^{t} other helps & so accordingly as you very well observe y^{t} chym^{l} analysis & exp^{ts} y^{e} mechanick properties, y^{e} obvious texture, y^{e} menstruums in w^{ch} they dissolve as far as water & spirit of wine are also designed to be adopted. I wou'd fain call in all pertinent assistances & give to each its due weight.

"I cannot but be apprized of y^{e} objection y^{t} he y^{t} grasps at all loses all, one man's life not being long enough & can only answer y^{t} I have a prospect of a considerable share of leisure, y^{t} I have made a little further progress in y^{t} affair already y^{e} appear'd in my specimen & y^{t} I am determined to take care ab^{t} securing it to posterity if I leave it unfinish'd.

"For an acco^{t} of y^{e} laurel water I refer to D^{r}. Sotherland in Cheapside to whom y^{e} acco^{t} was transmitted by D^{r}. Weld of this city. D^{r} Madden indeed is now upon some further exp^{ts} ab^{t} it & hopes w^{t} he has finish'd 'em to transmit 'em by me to thee.

"In y^{e} mean time I am very much

"thy affectionate cousin

"Jno. Rutty.

"Please to direct for me at Theophilus Harrison's, Apothecary in Fishamble street."

This letter refers to his paper on Laurel Water, which was published by the Royal Society the same year; and particularly to his work upon the Materia Medica, which occupied so much of his time and thoughts.

Although not strictly within the subjects belonging to this Journal, yet the character of Rutty would be inadequately understood did we omit to state his sentiments on the subject of religion. All his labours and his whole course of life were influenced by an ardent and constant desire to regulate his conduct according to the precepts of the Gospel. His tenderness of conscience was such, that he even accused himself of undue attention to temporal things when occupied in the studies of natural history and the Materia Medica. Reflections of self-reproach on this head are scattered throughout the Diary. Those infirmities of temper which are usually disregarded, provided they are concealed or polished down so as not to offend society, were to him subjects of constant animadversion and correction. This appears from such entries as the following: "Snappish—scolded too vehemently—mechanically and sinfully dogged—brittle upon a slight occasion—snappish on a cross call—vociferation too loud to my servant—a little crabbed with two incurables," &c.

A warmly-attached member of the Society of Friends, and an elder of that body, he constantly mourned over the instances of declension in zeal and discipline which came under his view. He seems to have occupied that peculiar position among them which can never attract popularity. He who wishes to maintain long-established institutions in all their integrity, and yet to oppose existing abuses, which have grown up along with them, will be acceptable to neither Whigs nor Tories. He has nothing wherewith to gratify the lovers of change and innovation, and is regarded with apprehension by those to whom abuses have become sources of comfort or profit. No party gathers round him; he is considered a troublesome man, and soon finds how difficult it is to stem the corrupting influences which sooner or later deteriorate all human institutions. Rutty had his full share of such disappointments, yet to the last he indulged in no bitterness, but contented himself with self-examination and the diligent performance of his own duties.

His Christianity was adorned by a truly Catholic spirit. Severe to himself alone, he looked with complacency on all who professed to derive their religion from the sources of revelation. At the beginning of every month he held a conference with a member of another religious body, whom he calls "my brother," in order to promote their spiritual improvement. He highly esteemed the writings of Bishop Ken and other divines of the Church of England. When Wesley was in Dublin two interviews are mentioned in their respective diaries, equally gratifying to each. Of Dr. Doddrige, the famous Independent, he writes: "1764. Read Dodderige, a laconic, pathetic, energetic, and heart-searching minister. O what a pigmy I am before him!" Of Roman Catholic authors he says: "1765. Thomas a Kempis is one of my companions in solitude, and, blessed be the Lord! I relish him better than ever;" and again: "1771. A sweet occurrence in a mass-book entitled The Path to Paradise, where there is a collection, in one view, of twenty-seven petitions, truly apposite and pertinent to the state of almost every Christian. Truly I was surprised to find so much gold in a mass-book."

In 1771 he had an attack of paralysis, which is thus noticed: "17th, 8 mo. A memorable call; a slight hemiplegia in tottering limbs, and a faultering tongue." "21st. The paralytic disease increases." During the following month he recovered, after a confinement of three weeks, and was able to resume most of his ordinary occupations till December, 1774, when he writes: "The marasmus senilis is come; a deep hollow in my thigh." His last entry is on the 8th of that month: "The voice of God now sounds louder in my great infirmity of being scarcely able to bear the cold."(*a*)

The apothecaries' account of medicines furnished to him in his last illness (now before us) contains frequent repetitions of large quantities of sulphur, with occasionally spirits of hartshorn and guaiacum, till the 22nd of April, when he commenced the use of an "astringent cordial," which was continued to the 25th. He died on the next day, the 26th of April, 1775, being in the seventy-fourth year of his age.(*b*)

He was interred in the Friends' burying-ground in York-street (the site of the present College of Surgeons) on the 27th, and the entire expenses of his funeral (from the executors' account) did not amount to three guineas. He had provided for this by the following clause in his will, viz.: "And in testimony against the vain pomps of the world, I desire that my corpse may be conveyed to the place of interment in no other covering than a plain deal coffin."

His property, which principally consisted of copyhold lands in Wiltshire, he bequeathed equally amongst a number of children of his brothers and sisters, and a cousin. He also left several legacies to objects of charity.

In 1755 his residence was in Pill-lane; he resided for many years in the house in which he died, at the eastern corner of Boot-lane and Mary's-lane, which still remains, though much out of repair. He held the drawing-room floor of this house at a rent of £10 per annum.

His Spiritual Diary passed through two editions, and was edited by some person of a different religious denomination, who added a commendatory preface. He has also subjoined a testimony concerning Rutty, drawn up the year after his death, and signed by a

(*a*) *Wesley's Journal, 6th April*, 1775. "I visited that venerable man, Dr. Rutty, just tottering over the grave, but still clear in his understanding, full of faith and love, and patiently wating till his change shall come."

(*b*) Our readers, are, we presume, aware, that, up to the year 1805, the site on which the present College of Surgeons stands was occupied as a Quaker's burial ground. Prior to the erection of that building, any remains that could be collected were removed to the present cemetery in Cork-street.

number of leading members of the truly benevolent and aimable society to which he belonged, from which we cannot omit the following extracts:

"He was esteemed a skilful and successful physician, and was well beloved in this city, being an exemplary and useful member both of civil and religious society. His temper appeared pleasing and well guarded; mild in reasoning with persons from whom he differed in judgment, even on important and interesting subjects. He was accounted temperate in eating and drinking. He generally used to rise early in the morning to his studies.

"He was plain in dress and address; he declined ostentation, and adopted a lowly way of living; he was charitable to the poor, many of whom almost daily resorted to him for his advice and help; others, prevented by their distempers, he visited at their dwellings, and exercised a tender care toward them.

"The remembrance of his useful services has endeared his memory to us and to many more. In a good old age he departed this life with thanksgiving to God, and, we believe, in the fruition of the renewed foretaste of those good things which God has in store for those that love him."

We cannot terminate this memoir without expressing our acknowledgments to Messrs. Jonathan Hill, Samuel Bewley, and Forbes. Unless we had obtained their assistance many facts had remained unknown, for they furnished us with the means of learning much which otherwise had been lost for ever. The first-mentioned gentleman received the account of many particulars from his venerable father, who was intimately acquainted with Rutty.

LIST OF DR. JOHN RUTTY'S PUBLICATIONS.

1730.—A Dissertation on Laurel Water. In *Philosophical Transactions.*

1732.—"Extract of a Letter from John Rutty, M. D. to Dr. Mortimer, Sec. R. S., concerning the Poison of Laurel Water."—*Phil. Trans.*

1751.—"A History of the Rise and Progress of the People called Quakers in Ireland, from 1653 to 1700, &c., &c. First compiled at the Request of their national Meeting, by Thomas Wight of Cork. Now revised and enlarged, to which is added, A Continuation of the same History to the Year of our Lord 1751; with an Introduction describing summarily the Apostacy of the Professors of Christiany from primitive Simplicity and Purity through its several Stages, and the gradual Reformation from thence; and a Treatise of the Christian Discipline exercised among the said People. By John Rutty. Dublin: printed by J. Jackson, in Meath-street, Bookseller. 1751." 4to. pp. 484. The introduction amounts to seventy-eight pages.

1752.—"A Treatise on Christian Discipline." This work we have not seen; it is thus defined in the *Anthologia Hibernica*, vol. ii., p. 259; but it is probably the work described above.

1756.—"Account of the Copper Springs lately discovered in Pennsylvania. By John Rutty, M. D., of Dublin. Communicated by Mr. Peter Collinson, F. R. S."—*Phil. Trans.*

1757.—"An Essay towards a natural, experimental, and medicinal History of the Mineral Waters of Ireland; wherein, the several impregnating Minerals being investigated by a Series of Experiments, each Water is reduced to its proper Class. The Virtues of such as have been used are given from practical Observations. Divers new Waters, especially of the sulphureous and vitriolic Kind, are enumerated, and more accurately described than hitherto. The whole illustrated with Tables, exhibiting a clear View of the Experiments in concert, and a Comparison of the Irish to the English and other foreign Waters." By John Rutty, M. D. Dublin 8vo. 1757. pp. 478.

An edition in quarto was published in the same year.

1759.—"Thoughts on the different Impregnations of Mineral Waters, more particularly concerning the Existence of Sulphur in some of them. By John Rutty, M. D."—*Phil. Trans.*

This paper was in answer to Lucas's work, already referred to.

1760.—"Of the Vitriolic Waters of Amlwch, in the Isle of Anglesey; with occasional Remarks on the Hartfell Spaw, described in the first Volume of the Edinburgh Essays and Observations, Physical and Literary, and in the forty-ninth Volume of the Philosophical Transactions; and their Comparison with other Waters of the same Class. By John Rutty, M. D."—*Phil. Trans.*

1762.—"The Analysis of Milk and the different Species thereof." Dublin. 8vo. pp. 19. 1762 (written in 1758).

1762.—"The Argument of Sulphur or no Sulphur in Waters discussed; with a Comparison of the Waters of Aix-la-Chapelle, Bath, and Bristol. Wherein the Sulphur is restored to the two first, and the Contents of the last are ascertained with a somewhat greater Degree of Precision than in the Essay of the late Adept, and the injured Credit of divers other salutiferous Springs is vindicated, from the Evidence of that Author's own Experiments, corroborated by many others; being the Subjects of a Correspondence between the Author of the Methodical Synopsis of Mineral Waters and W. R., Esq., and some others. And to this is subjoined a more explicit Account of the Nitre of the Ancients."—8vo. pp. 109. Dated Dublin, 7th, 7 mo., 1762. Printed by Alex. M'Culloh (see p. 561).

1770.—"A chronological History of the Weather and Seasons, and of the prevailing Diseases in Dublin, with their various Periods, Successions, and Revolutions, during the Space of forty Years; with a comparative View of the Difference of the Irish Climate and Diseases, and those of England and other Countries. By John Rutty, M. D."—London: Robinson and Roberts. 8vo. 1770. pp. 340.

1772.—"An Essay towards a Natural History of the County of Dublin, accommodated to the noble Designs of the Dublin Society; affording a summary View, first, of its Vegetables, with their mechanical and economical Uses, and as Food for Men and Cattle; a Ca-

talogue of our vegetable Poisons; and a Botanical Calendar, exhibiting the respective Months in which most of the Simples in Use are found in Flower. Second, of its Animals. Third, of its Soil, and the State of its Agriculture; its Fossils, Mines, Minerals, and some lately discovered Mineral Waters, particularly the Sulphureous Water at Lucan, and its Medicinal Virtues, from practical Observations. Fourth, of the Nature of the Climate, from the Diaries of the Weather kept in Dublin for fifty Years past: interspersed with Meteorogical and Œconomical Observations. By John Rutty, M. D."—2 vols. 8vo. Dublin: printed for the Author, by Sleater, in Castle-street, and Jackson, in Meath-street. 1772. Vol. i. pp. 329; vol. ii. pp. 488.

1775.—"Materia Medica, antiqua et nova, repurgata et illustrata, sive De Medicaminvum simplicium officinalium Facultatibus. Tractatus Authore Johanne Rutty, M. D. Exhibens, I. Simplicia nobis veteribusque communia de quibus fere quicquid veri aut verosimile apud Græcos veteres et Recentiores Latinos et Arabes reperitur, Religitur, cnnaratur, et Notis illustratur. II. Simplicia Dubia et noviter detecta quorum Vires indagantur, et Observationibus atque Experimentis Recentiorum illustratur. Adjectis Classibus simplicium secundum Qualitates et Eperationes sensibiles."—Opus xl. Annorum. Londini: E. & C. Dilly. 1775. 4to. pp. 560. Rotterodami: Holsteyn & Breman.

This publication was the *last* during Dr. Rutty's life-time.

POSTHUMOUS PUBLICATIONS.

1775.—"Observations on the London and Edinburgh Dispensatories," published the year after his death.—See *Anthologia Hibernica*, vol. ii. p. 259. This work likewise contains a brief and very incorrect notice of Dr. Rutty.

1777.—A Spiritual Diary. First Edition.

1796.—"A Spiritual Diary and Soliloquies. By John Rutty, M. D., late of Dublin." Second Edition. London: Phillips. 8vo. 1796. pp. 421. Diary commences 13th September, 1753; terminates December, 1774.

We had hoped to have been able to present our readers with a summary, or at least catalogue, of Rutty's papers preserved in the Manuscripts of the Medico-Philosophical Society, but our space does not at present admit of it. We intend to redeem our promise very shortly, and print several of the communications contained in these valuable records

Dr. Rutty having been a member of the Society of Friends accounts for our not being able to present our readers with a Portrait this time.



John Oliver Curran.

MEMOIR

OF

JOHN OLIVER CURRAN, M.B.,

PROFESSOR OF THE PRACTICE OF PHYSIC TO THE APOTHECARIES' HALL, &c. &c.

EXTRACTED FROM
THE GALLERY OF ILLUSTRIOUS PHYSICIANS AND SURGEONS IN IRELAND IN THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR NOVEMBER, 1847.

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BY M. H. GILL.

MEMOIR,

&c. &c.

THE present year is now drawing to a close; and all who have witnessed its singular and melancholy scenes must look back upon it with wonder and with dread. Its history will be a darkened page in the annals of our country, recording events whose nature may warrant the incredulity of after times. It will be difficult to believe at a future, and, we hope, a happier day, that, within a short distance of the capital of England, the seat of British intelligence, British power, wealth, and plenty, nearly a million of her subjects died of hunger or its consequences; of want, not resulting from their own improvidence, but from the long-threatened, yet not till then complete failure of a crop which was their only support. The record of this great and dreadful fact is engraved in characters so deep and strong that ages will not efface them. We have witnessed a nation's crisis, not of life but of death. The transition from misrule to neglect, from neglect to misery, from misery to famine, and from famine to pestilence, is easily understood; and now, in social disorder and paralyzing consternation, we see the cup of our country's sorrows continuing to overflow.

This is not the place to examine the various sources of the physical and moral calamities of Ireland, but we notice her last crushing sorrow, because that many others have followed in its train; for, while the poor were swept away in myriads, numbers of the better classes of society, including the best and bravest of our countrymen and brothers, who especially devoted themselves to save their fellow-men or mitigate their misery, were dragged down and perished with them. The young and high-born daughters of our land, the matrons of many a virtuous and happy home, the active and charitable proprietors, the devoted clergy, and, above all, the members of the medical profession, have fallen victims in numbers that are and ever will be unknown save to Him, who has declared that a cup of cold water given in His name shall in nowise lose its reward.

Among these martyrs stands pre-eminently the subject of this memoir. But a few days have elapsed since this good and faithful servant was laid in the grave, and hence his history, hastily drawn up, must be considered as imperfect and unworthy of him. Yet this is not the first time that a rude and simple monument has covered the noblest clay.

The sources of posthumous fame are many, but the glory of most men who have earned it seems ultimately to hang on some single attribute. The warrior, could he revisit the world, would point to

his conquests; the ruler to his laws; the philosopher to his discoveries; the divine to his teaching; the physician to his cures. In all, though their objects and labours may have been numerous and varied, there is more or less of dependence or connexion among them, and it is rare to see the memory of a great man consecrated for efforts and acts which seem opposed or uncongenial. But the brief career of John Oliver Curran will be remembered for what to most men seem opposing qualities;—for he was the impersonation of charity; all gentleness on the one hand, and the stern assertor of the right and contemner of power on the other. The Hampden of Irish medicine, he withstood the tyrant, but laid down his life in the cause of his country's safety, his profession's honour, and his friend's defence.

John Oliver Curran was born at Trooperfield, near Lisburn, in the county of Down, upon the 30th of April, 1819. His father is a member of the medical profession, but for many years he has ceased to practise it. In 1824 the elder Curran removed with his family to Douglas, in the Isle of Man, where he remained until his son completed his thirteenth year. During his residence in this locality Oliver Curran received the first rudiments of his education, originally at a mercantile school, and afterwards at a classical seminary. When a mere school-boy he was remarkable for a modest and obliging disposition, great clearness of intellect, and intelligence beyond his years; so much so, that while the majority of his companions were labouring to comprehend the ordinary course of instruction usually imparted in preparatory schools, his apt mind seized with avidity, and at once understood, the point at issue, and thus frequently anticipated the information of his preceptors. Being naturally of a contemplative mind, and grasping after such information as the books within his reach afforded, he seldom indulged in the common plays and amusement of boys of his age, but spent the greater portion of his play hours in reading and study.

In 1833 he entered the University of Glasgow, and applied himself with great assiduity to the study of mathematics, logics, and classics. Upon entering this university he successfully competed for the prizes in the Greek and Latin classics, and at a subsequent period for those of logics and moral philosophy. Of the matured state of his understanding at this early age, it may be mentioned, that at the time of Sir R. Peel's election for the Lord Rectorship of the University of Glasgow, young Curran was appointed one of the Committee for Lord Campbell. Even while engaged in the preliminary course of education, such was his ardour in the pursuit of knowledge, and such was his desire to outstrip his competitors in this noble race, that he at one time seriously impaired his health by over-application. During the last two sessions at the Glasgow University he devoted himself to the study of medicine, and attended the lectures on many of the elementary branches of that science.

In 1838 he entered the University of Dublin, as a student of both arts and medicine, but, having once determined upon his future profession, all his studies, physical, mathematical, and classical, were

made subservient to that one end. In addition to the ordinary curricula prescribed both by the universities and the schools of physic, he applied himself with great assiduity to the study of modern languages, French in particular, a subject to which we would earnestly direct the attention of young medical men, and from which Oliver Curran, both in his studies upon the Continent, in his extensive reading, and in his intercourse with foreigners, derived no inconsiderable advantages. In his whole college career, and even in his very boyhood, he exhibited an uncommon aptitude for mathematical and philosophical pursuits; for astronomy in particular he had marked predilections, and when quite a boy constructed several ingenious instruments for making observations in that science.

To acquire a knowledge of the practical part of his profession, he became a student at the Meath Hospital, and attended with unwearying assiduity the medical wards of that institution, and the clinical instruction of Drs. Graves and Stokes. There are rewards and prizes during the undergraduate course of a young medical man, which, if gained, point with a tolerable degree of certainty to the success of his future career, and these, one and all, were sought and obtained by the subject of this memoir. In 1842 he obtained the stethoscopic and clinical prizes in the Meath Hospital, and Dr. Stokes's first prize for the practice of physic in the Park-street School of Medicine. In 1843 he obtained, by public examination, the situation of intern pupil in Jervis-street Hospital,—a post which he aspired to in order to become practically acquainted with the manipulations and mechanical part of surgery. This mode of election by general *concours*, to public medical and scientific situations, had long occupied the attention of our deceased friend; and although we are not prepared to go the length of saying that it is by any means the best, yet its introduction into this city would be a manifest improvement on the present system. He was afterwards Dr. O'Ferrall's clinical clerk in St. Vincent's Hospital.

In the summer of 1843 he took his degree of Bachelor of Medicine, and immediately afterwards proceeded to Paris, where he remained a year, assiduously devoting his entire time to dissection, observation of the practice pursued in the Parisian hospitals, and the cultivation of the acquaintance of the most eminent physicians and surgeons in that city of science,—an acquaintance which soon ripened into friendship, the result of mutual admiration and esteem. The estimation of Dr. Curran's ability and practical knowledge of his profession may be learned from the fact, that, during his stay in Paris, the French Government offered him an appointment as physician to the English and Irish labourers employed upon their railways. During his residence in France he addressed some very amusing and instructive letters to his relatives in the Isle of Man, upon the state of society, manners, &c., in Paris. These, though not intended by their author for publication, were printed in a local newspaper, and afterwards collected by his friends. He returned to Ireland the following year; and in 1846 he became a Licentiate of the King and Queen's College of Physicians, and in the same year was

elected Professor of the Practice of Medicine to the school of Apothecaries' Hall, one of the physicians to the Dublin General Dispensary, and also Secretary to the Council of the Pathological Society. Shortly after the Dublin Medical Journal passed into the hands of its present Editor, and at the time when it assumed its present form, Dr. Curran became one of its chief contributors,—a post which he filled up to the date of his last illness. He also communicated, during the last two years, some literary articles to the pages of our able contemporary, the Dublin University Magazine. In the summer of 1846 he returned to the Continent, chiefly for the purpose of visiting and remarking upon the lunatic asylums there; and the result of his observations appeared in the philosophical review of the Parliamentary Reports on Lunacy, which appeared in the third Number of our present series. During this sojourn on the Continent, he passed from France into Holland and Belgium, visiting the various hospitals, scientific institutions, and men of learning, in these countries. Subsequently to this visit several of the medical societies abroad conferred upon him their honorary or corresponding diplomas. Dr. Curran was a graduate of Trinity College, a member of the Royal Irish Academy, and had long been a most useful working member of the Royal Dublin Society, in which body he was one of the Council, and also a member of the Committee of Chemistry. In a word, there was no medical, and few literary or scientific societies in Dublin, of which he was not a member, and in most of them he took an active part.

We have thus briefly enumerated some of the epochs in the life, and noted down a few of the labours, of this excellent man; and before we enter more minutely into these labours, or offer our opinion upon his character and conduct, we think it right to notice a remarkable personal peculiarity which Dr. Curran rigidly adhered to up to the date of his last illness. He had never tasted animal food for upwards of three-and-twenty years; he had never drank wine or malt liquor except once, when he had typhus fever, in 1840, and his food consisted exclusively of milk, fruits, and farinacea.

It will be in the recollection of the readers of this periodical that a very learned review of Mr. Smith's book on "Fruits and Farinacea the proper Food for Man" appeared in our Number for September, 1845. This was Dr. Curran's first essay at reviewing; and for its critical analysis, its depth of learning, its philosophical inquiry, and literary composition, we believe few first efforts of the kind will bear comparison with it. As, however, there were some novel doctrines on the subject of dietetics, both in the work itself and in the critique, Dr. Curran, at our request, added a short history of his own experience in the matter, from which we extract the following passage:

"When about four years of age, having been much bantered by some friends on petting lambs and rabbits, and afterwards eating the flesh of such animals, in a fit of childish indignation he declared he would never again eat flesh. This resolution was adhered to, and his parents (who were not very much impressed with the necessity of animal food, and who believed that the whim would soon wear off) not interfering, abstinence from animal food soon acquired the force of a habit, which has grown with his growth and strengthened with his strength, having now been persevered in for more than twenty-one years. Since the period mentioned he has entirely abstained from eating anything that ever had life, as well as from eggs and cheese; whilst he never partook of even one glass of wine, spirits, or any intoxicating liquor, nor does he make use of tea or coffee. His health has been invariably good, and at school and college he was possessed of more activity and strength than any of his associates of the same age, whilst he exceeded all in endurance. Though sedentary habits must have prevented the full development of his muscular powers, he has on more than one occasion walked sixty English miles in one day, without any other inconvenience than blistered feet. His weight is at this day within a pound of what it was at the same season seven years ago, but increases half a stone every summer, losing as much during the winter."

It was not, as some persons have supposed, any religious feeling which induced our friend to adopt and steadily adhere to this mode of life. In society and at the social board he partook of his frugal fare with apparently as much zest as those around him did of the costliest viands and the choicest wine, and he hob-nobbed in milk or ice-water with as much gaiety as others did in champagne. How far his mode of life might have influenced his last fatal illness it is difficult to say: but during the latter part of his disease wine was administered in considerable quantity.

As a lecturer he was remarkably plain, forcible, and explicit; in argument or debate, logical, forbearing, and persuasive;—learned without pedantry, he appeared rather to receive than impart instruction. His well-stored mind, the result of varied and extensive reading, travel, and observation, together with a modest demeanour, and towards his friends a most winning manner, rendered him in conversation most charming and instructive, while his high religious feeling never permitted a word or expression to escape his lips which might not be written on his monument. To those who had not the pleasure of his acquaintance, or mixed much in his society, this may seem excessive praise, but those who knew him best and longest will bear witness to its truth. The number of warmly attached friends which he possessed tell how susceptible his own heart was of the purest affection. Towards those he loved this affection became devotion,—a feeling so strong and generous that he sacrificed his life at its shrine. It was not alone, however, his learning and his knowledge which gained him admirers, nor his warm heart which surrounded him with friends; there was that within him evidenced in his life, and graven on the history of his actions, which commanded the respect of all,—unpurchasable HONESTY, and unbounded philanthropy.

To the student of medicine, the character, pursuits, and rapid elevation of this young man should form a model worthy of the closest imitation. Talents of a high order he undoubtedly possessed: but it was to his untiring energy, and unceasing study of his art,

that his elevation was due. Disdaining the grinder's crux or the school's dogma, he was the very antithesis to those who have been, with but little preliminary education, and perhaps less practical knowledge, pushed rapidly through the curriculum of a corporation or University at some of the doctor manufactories of the present day.

> Well may the dull their foolish fathers blame,
> Who jilted trade of many a useful name;
> To woo a mistress that will smiles dispense
> Alone to learning, talent, toil, and sense.

It was knowledge, not diplomas, which formed the object of his ambition, by which he hoped to win, and did win, the good opinion of the profession and the public. As a practical physician, imbued with the most philosophical views, as a teacher, as a writer, and, above all, as a man who stood forth nobly, at a considerable sacrifice, for the honour and the dignity of the medical profession, the school of Dublin has sustained in him a heavy loss.

As a writer, Dr. Curran was not much known to the medical world, his chief original article being that on scurvy, which appeared in our last Number. This is before our readers, and they can judge of its importance, its research, and the promise which it gave of future success. It was chiefly as a reviewer that Dr. Curran had as yet excelled. It is unnecessary for us in this Memoir to lay open the secrets of editorship, still we cannot in inditing this notice of one of our most valuable contributors, refrain from pointing to a few specimens out of many of his able productions, in addition to those already alluded to. The review of "Homœopathy and Homœopathic Writings," which appeared in February, 1846, shewed how well fitted he was to enter the list with the votaries of Hahnemann. There was this remarkable peculiarity in the construction of Curran's mind,—pure and void of all guile himself, he did not always read human nature, as presented to him in the living subject, aright; he could not bring himself in a moment to believe that hypocrisy and deceit influenced the actions or polluted the lips of those with whom he conversed; yet no man sooner recognised a quack from his writings, and to this quick perception may be traced some of those necessary castigations which the honour of science, and the vindication of truth, has caused us to insert in our Periodical during the last two years. Severe, however, as were his strictures, they were never personal, nor "whetted on ill-natured stone;" it was books, principles, practice, and literature, not men, he analysed. The Pathological Reports were entirely published under his superintendence, and the Medical Periscope which appeared in August, 1846, shewed how conversant he was with foreign medical literature.

His writings are eminently remarkable for their unbounded research, their power of argument and perspicuity of style; no man understood better the force and value of the English language.

Although Dr. Curran took no active part in politics, and was not associated with any of the political confederations of the day, he felt warmly, and took a lively interest in the national cause. To

elevate us in the scale of nations he not only toiled, but by his conduct and deportment in his life and actions (the true tests of patriotism), mainly contributed.

We now approach a period in our friend's short but bright career, in which he played a part in the history of this unhappy land, which future annalists will, no doubt, hand down to distant posterity, as an instance of philanthropy, devotion, and patriotism, worthy a primitive and more refined age.

Plague, pestilence, and famine, spread over the face of the land, and threatened the annihilation of our population. To meet their ravages, some temporary machinery was constructed by the Government, a Board of Health among the rest. We have no desire in this Memoir to enter upon the subject of the applicability of the measures prescribed by the State to meet the exigencies of the times, nor at all allude to matters of a political nature. During the last winter and spring the fever was chiefly confined to the country parts, and the ordinary appliances in the city were deemed sufficient for the number of our poor affected by the epidemic. As, however, summer approached, Dublin was attacked by the pestilence, and extraordinary measures had to be taken to afford shelter and relief to the multitudes who daily sickened in the lanes and alleys, the garrets and cellars, of the ruined and dilapidated districts of our capital. Temporary fever hospitals had to be erected, and an additional staff of medical officers appointed. One of the first persons appointed by the Board of Health was Dr. Curran. The official document intimating the circumstance to him stated that he was to receive a "*remuneration of five shillings per day.*" Astonished and indignant at such a scale of wages being offered to a member of the medical profession, he immediately consulted some of his friends, stating his unwillingness to accept the post on such terms, and his desire to resign immediately. Those he consulted considered that it would be more advisable to take the opinion of other members of the profession on the subject, particularly as it was a matter which concerned not only the respectability and welfare of the body at large, but the interests of all those who might hereafter be appointed. Accordingly, some twenty members of the profession were immediately summoned, and met together the following day, to consider the propriety of Dr. Curran's resigning, and the advisability of holding a public meeting to remonstrate against medical grievances in general, and the act of the Board of Health in particular. At this meeting Dr. Curran stated his intention of resigning, but agreed to wait for some days and abide by the decision of the public meeting.

A requisition calling a public meeting of the profession at the Royal Dublin Society House was immediately signed by those who were present, advertised in the newspapers, and within the two next days it bore the signatures of upwards of seventy physicians and surgeons resident in Dublin, including every man of eminence unconnected with the Board of Health. The meeting was fixed for Tuesday, the 1st of June last; a committee was appointed to conduct the proceedings; resolutions were drawn up, and placed in the

hands of the respective persons who were to move them. That meeting was never held. One of the chief causes of this arose from the circumstance of the chairman having upon the day previous refused to act, and others having objected to move resolutions, under the impression that a memorial was more advisable than a public meeting(*a*). These are the naked facts. We have no desire to enter upon the question at issue at present between the profession and the Board of Health, it has been already ably discussed elsewhere, but the following statement is here necessary. As soon as it was determined not to hold the meeting, Dr. Curran immediately resigned, informing the Board of Health that, consistent with the dignity and honour of the profession to which he belonged, he could not accept the remuneration offered in their appointment. Some time previously to this appointment Dr. Curran had been elected one of the physicians to the Dublin General Dispensary,—an office of immense labour, and entirely without emolument. Those only who have toiled amongst the poor of a large city can form any idea of the extent of this labour. In the wretched abodes of misery, in the crowded, ill-ventilated rooms, each often inhabited by several families of the very poorest classes, and located in the most miserable and filthy situations, where infection ever remains endemic, and where want adds fuel to the pestilence,—there lay the public practice of Dr. Curran,—there was his charity expended,—there his skill exhibited,—late and early, there he toiled.

The calamities which had invaded Ireland having threatened the Continent, the French Government sent M. Rodier and M. Henri Gueneau De Mussy as medical commissioners to inquire into the management of fever, and to study the character of the epidemic in Dublin. Now, one of the most amiable traits in Dr. Curran's character was his unceasing attention to foreigners; few medical men of other countries visited our metropolis during the last few years who did not experience his devotion to their service, in introducing them to the profession, conducting them round the various institutions, and escorting them to the most interesting localities in and about our city. M. De Mussy had long been the personal friend of Curran; and during the course of his inquiries into the character of our epidemic he was much assisted by his friend, who accompanied him to the various fever localities and hospitals. In one of these visits they witnessed that heart-rending scene which elicited the ever-memorable letter of John Oliver Curran, detailing the frightful neglect of the fever-stricken population of our metropolis, which appeared in Saunders's News-Letter and the Freeman's Journal of the 24th of last August. We will not quote one sentence of this spirited and benevolent appeal to the sympathies of Europe; the scenes which it so graphically and feelingly described are engraven upon the hearts of the humane of every country in which they were published; they have been fully acknowledged by all competent authorities; their truth has been sealed with blood: the echoes of this appeal are still

(*a*) The resolutions and memorial intended to be adopted at this meeting were embodied in the representation to the Lord Lieutenant.

murmuring through every land that possesses a literature. This letter has become a part of our history. Let it then never be forgotten by the Irish people that to this courageous, honest, and indignant appeal, made in their behalf to the sympathies and benevolence of Europe, were the gates of fever sheds, the barred portals of hospitals, and the stern hearts of rulers, opened, to afford them shelter and a cup of water, when they blackened, exposed to the sun and sky, in the lanes and ditches around our metropolis.

Gueneau De Mussy, in his active and untiring inquiries late and early at the fever sheds, contracted typhus of the very worst description; from the moment he took ill Curran became his nurse, seldom leaving him day or night, neglecting all his other duties, and devoting himself with the noblest heroism to his friend, till at length the fatal typhus claimed him also for its victim. The disease very soon exhibited a most malignant type, presenting all the characters which it assumes in those who have much exercised their intellectual faculties. To violent delirium succeeded prostration and collapse; and, notwithstanding all that the skill and brotherly aid of some of the ablest men of the profession could effect, he sunk rapidly upon the ninth day of the fever, and expired at 9 o'clock on Sunday morning, the 26th of September, 1847, in the twenty-eighth year of his age(*a*). The gloom which spread through all classes as soon as his death became known need not be described,—it has scarcely yet passed away.

The entire British press, with one exception(*b*), have paid just tributes of respect to his memory.

(*a*) In recording the death of Dr. Curran, and alluding to the illness of our friend De Mussy, we feel a mournful pride, while we offer our thanks to the several young medical men and students, who, with dauntless courage and untiring zeal, watched for days by the sick bed of these gentlemen.

(*b*) The journal to which we allude is the Dublin Evening Post, the official organ of the Irish Government and the Board of Health.

The brutal ferocity of an article published in that journal on the 12th of October last, attempting to asperse the memory of this good and pure-minded young man, is only equalled by its utter want of truth. It is,—can we believe such heartlessness?—an *answer!* to the tribute paid to his worth by a contemporary journal, the Lancet. It is *not true*, as the writer well knew, that Dr. Curran contracted the fever of which he died, "in the cellars and garrets of the poor," and it is as ungenerous as it is false to assert it. It is *not true*, as the writer in the Post must be very well aware, that Dr. Curran visited these miserable dwellings of the poor "in pursuit of that information which, but for evil councils, he could have obtained with comparatively little risk of infection in well ventilated hospitals;" and to put forward such a statement is to rob his character of that benevolence and charity which the writer, not knowing or feeling himself, can neither understand nor appreciate in others.

It is *not true* (we have the authority of his nearest relatives for saying so), that Dr. Curran ever regretted his dignified refusal of the wages of the Board of Health, or that his own unbiassed judgment would have led him to accept it. It is equally *untrue*, and that the writer knows also, that he was driven to "sinks of contagion" by the advice of his friends; his gratuitous attendance upon the poor of Dublin having commenced long prior to his five-shilling appointment.

It is a fact of which the (medical) Editor of the Post must be fully con-

"The kind and generous disposition," says the Freeman's Journal, "which characterized Dr. Curran in the private relations of life, won for him the esteem and affection of all who had the privilege of his acquaintance. Among his professional brethren his opinion, notwithstanding his youth, ranked with that of the seniors of the profession, and he was as justly as he was generally recognised as one who, had he been spared, must ere long have taken a first place. To his mourning friends,—and the circle embraces all who knew him,—there is some consolation in the reflection that it was Dr. Curran who gave shelter to the fever-stricken, and relieved our city from the odium of cruelty and neglect."

The Medical Gazette, alluding to his treatment of the poor, justly observes:

"That any man should be found who could thus give up his time, and exercise gratuitously his professional skill in the treatment of cases in which his life was constantly exposed to the greatest danger, is a fact which must surely satisfy the Government that they have taken a false step in this matter. It is not often that so great a sacrifice is made, or that the honour of the medical profession is so sternly considered as it has been in this instance."

The Lancet, the stern and uncompromising advocate of Irish medical independence, contains the following remarks, as just as they are true:

"His public life had extended over but a few months; but in that short time he had endeared himself to friends and opponents; and all sects and parties among his fellow-citizens have been loud in his praises. His was indeed true glory, and deserves of his country a better monument than the soldier or the politician.

"His spirited remonstrance to the Board of Health roused the profession in Ireland; the chords were struck by the right hand, and his single signature was, as our readers know, promptly backed by more than eleven hundred names, from the Presidents of the Colleges of Physicians and Surgeons, down to the youngest practitioners. More recently, his vivid and benevolent descriptions of the heaps of fever-stricken dead and dying waiting for admission to the fever-sheds, at Kilmainham and other places, produced an extraordinary excitement in Dublin, and led to a better and more humane state of action than had previously prevailed among the Board of Health, the Relief Commissioners, and the Irish Executive. And now he has sadly, but perhaps appropriately, closed his brief but glorious career, by setting the seal of his life to his professional and philanthropic devotion. Benevolence has marked him for her own. He has added another name to 'the noble army of martyrs' which our profession must furnish to science and to civilization. Not even Sidney Bernard(*a*), the volunteer martyr of the 'Eclair,' deserves to be more dearly remembered than Oliver Curran,—the one an assistant-surgeon, the other a young dispensary physician. Our young men may be proud when they furnish such examples to the profession and to mankind. Galen fled from Rome on the approach of pestilence, and Sydenham retired from London before the great plague; but here are novitiates of modern times nobly eclipsing in fame the ancient sages and veterans of medicine."

Saunders's News-Letter also paid its tribute of respect; and Lemoinne, the able conductor of the *Journal des Debats*, has penned an eloquent eulogium upon our friend, who was, he truly observes,

"One of the hopes of his country. His death is a loss to Ireland, to whom he had consecrated his life,—to his friends, who had for him such respect and affection.

"Poor Curran! Such a pure, simple, disinterested, and patriotic soul! Never have I heard a word uttered by him which was not upon Ireland and for Ireland. His unhappy country, which he saw writhing and dying in misery, hunger, and fever, was his sole thought—his greatest unhappiness.

"As we well know, the best and most worthy homage we can pay to his memory is, to appeal on behalf of Ireland, for recompense for the loss she has sustained, that the life of sacrifice and devotion which he led upon this earth may be counted in favour of his unhappy country."

Among the many wants in Irish character,—of industry, love of truth, respect for the laws, hatred of murder, and others equally dark and lamentable, which we must own to, and should strive to correct,—there is none that has exercised a more pernicious influence than want of independence. By what means this has been produced, whether it is inherent in the race or is the acquired result of circumstances, we cannot here discuss; but we allude to this peculiar national trait, because the subject of this memoir was an instance of the contrary: no man ever possessed a more independent spirit than John Oliver Curran. This independence of character not only influenced his actions, but at times rendered him positive in opinion.

It has been truly observed, in some of these quotations, that Dr. Curran was one of the most promising young physicians in Dublin; he had already made rapid strides in his noble career, and gave bright promise of the future.

Let it ever be remembered by the Irish medical profession that

scious, that the Government were warned of the danger and imprudence of shutting up Cork-street hospital; and also of its having been re-opened a few mornings after Curran's letter appeared.

The reason of Dr. Curran resigning his appointment,—to an office, it must be remembered, not then in operation,—has been explained in the text of this biography, and the many gentlemen who attended the preliminary meeting alluded to can vouch for its accuracy.

The numerous friends of Dr. Curran know that the accusation of the Post, that in his conduct so often referred to he was but a "dupe" and a "victim," is a groundless calumny.

To the Editor of the Dublin Evening Post these remarks are not applied; but to the medical writer in that periodical. We must, however, remind our friend, that although his paper is the organ of the Government, there is an editorial censorship to be observed, and a respect for truth and honour, for which he should be answerable.

(*a*) Sidney Bernard, the Eclair martyr, was also an Irishman, and had been an apprentice of the late Dr. Colles.

he was the man who first raised his voice against the insult and indignity offered to that body, by refusing to accept the miserable stipend proposed as remuneration for risking their lives in defending the Irish peasant and artisan from the ravages of the pestilence which now stalks amongst us. And yet, while he thus spurned the degrading offer, for the benefit of his brethren, he daily toiled without fee or reward, in the haunts of misery and distress, to relieve suffering, and to succour the fever-stricken poor: and in his generous endeavour to rescue others, in his love for his friend and his duty towards the stranger, he himself fell a sacrifice to the Moloch of pestilence. His death is a national calamity.

Disregardless of danger, he grappled with the plague; patriotic and generous, he devoted his time, his genius, and his knowledge, to his country, to science, and his friends. In John Oliver Curran his family have lost the most feeling and affectionate of relatives; an aged father his only son; his friends a soul of sterling and enduring worth, unalloyed by selfishness, unpurchasable from its allegiance; the Irish School of Medicine, the University, and the Royal Academy, one of their most promising sons. Science may mourn the most devoted of her votaries; Ireland a man whom she could never spare, now least of all; and humanity a friend. For our rising literature his able pen was wielded; for our dawning nationality his manly voice was raised. Gentle and unobtrusive in his manner, a tone of serious thought and an extraordinary fund of information, with a remarkable facility and clearness of expression, graced his conversation, and rendered him one of the most delightful and instructive of companions. If being utterly devoid of envy towards others, and a holy, never-failing desire to do good, could insure a man the world's friendship, then had Dr. Curran no enemies(*a*).

(*a*) The portrait which accompanies this Memoir will be recognised as an admirable likeness of our deceased friend. It has been lithographed by Lynch, from a drawing made after death by Mr. Ford, whose courage as well as artistic skill, in sitting for several hours in such close proximity to infection, we feel bound to mention. We had also the assistance of a daguerreotype and a cast, the former, however, of little value.

MEMOIR

OF

THE LATE THOMAS LITTLE, M. D.,

LL. D., T. C. D., F. R. C. S.,

SURGEON TO THE SLIGO COUNTY INFIRMARY.

FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR NOVEMBER, 1849.

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MEMOIR,

&c. &c.

This eminent surgeon and physician was the eldest son of William Little, Esq., formerly Deputy Examiner in the Irish Court of Chancery, which office he held under his brother-in-law, Lyndon Evelyn, M.P. for St. Ives. Upon the abolition of this office, Mr. Little was appointed to the secretaryship of the Paving Board, a Government situation under the old Corporation of this city, which post he held for a great number of years, until superannuated in 1828, at the age of 77. The subject of this memoir was born in Jervis-street, Dublin, on the 11th November, in the year 1782, and, consequently, at the period of his death by cholera on the 14th of August, 1849, was in his sixty-seventh year.

In 1799 he matriculated in Trinity College, Dublin, and in the following year was bound apprentice to Mr. Mac Evoy, the celebrated surgeon. This able and eccentric man, the Irish Abernethy of his day, notwithstanding the wide gulf which, in those times, separated the master and the pupil, the professor and the student, and in his case the more particularly, owing to a natural harshness and even coarseness of manner, and quickness of temper, which seldom observed the refinements of life in his hospital and lecture-room intercourse with his pupils, early elicited in his young disciple the warmest admiration and most profound reverence for his genius and abilities; and to the last, Mac Evoy's maxims, whether delivered in lecture, or dropped in casual conversations, were treasured up with astonishing fidelity, in a memory that seldom allowed a professional fact or a scientific hint to escape; and, on the other hand, it is well known with what eccentric affection, and by what awkward demonstrations of good-will, old Mac Evoy honoured his young friend.

In the year 1803, Mr. Little, then in his twenty-first year, became a prominent and popular member of the College corps, in which he was soon raised from a private to be corporal, a sergeant, and finally to that important post of *fugleman*, and afterwards contested the lieutenancy, but whether successfully or not the writer's recollections do not enable him to record. At this period he was remarkable for feats of activity, and his performance of the very difficult functions of fugleman at reviews in the Park frequently elicited the admira-

tion of the veterans of that day, in whose eyes this now obsolete and absurd department of military tactics possessed a peculiar and most vivid charm. It was about this period, when performing one of his favourite feats of vaulting over an open room door, as it swung under his hands, that he received a frightful compound fracture of the right tibia and fibula, a few inches below the knee, which at one time promised so badly that Mr. Mac Evoy had brought his instruments and assistants into the sufferer's bed-room, to perform amputation; but, having fortunately discerned some contra-indication to this *dernier resort*, its consideration was deferred, and the result was a perfect cure.

It was at this period also that Dr. Little formed many valuable acquaintances with men who have since distinguished themselves in law, literature, science, the Church and the State; and much of the zest of his well-known and incomparable conversational powers was derived from anecdotes of the morning drill and midnight watch of these troublous times, in company with the Cramptons, Blackburnes, and Norths, of past and present days, on which occasion a well-furnished canteen of shrub punch formed quite as necessary an item of the academico-military equipment as the firelock or cartouch-box, and under the influence of which upon young, ardent, and excitable minds, it is not difficult to imagine that many and many a manœuvre was accomplished, and many a *chef d'œuvre* of strategy effected, more suited to enliven a page of Lever or Maxwell than to establish the military reputation of the academic corps in the stern eye of a Wellington or a Napier.

In the year 1804, by the interest of Mr. Obrey, then Surgeon-General, and an old friend of his father's, Thomas Little having expressed a decided predilection for a military life, an inclination probably fostered by the recent memory of the glories of his fugleman-days in the College corps, was appointed on the medical staff at Cork, where he renewed his acquaintance and friendship with his old school-fellow, the lamented Richard Carmichael. Through the subsequent rather long lives of both this friendship was matured by frequent meetings and constant correspondence, and by a mutual appreciation of each other's characters and talents; within a few months both were removed, the one by a fearful accident, the shock of which was felt from one end of the country to the other, and the survivor almost as suddenly by an attack of cholera in its most acute and deadly form of invasion.

While stationed on the Staff in Cork, an attachment, which subsequently resulted in his marriage, and which would go far to establish the popular fancy of the destiny which attaches to this condition, was formed between Dr. Little and Miss Swayne, daughter of Benjamin Swayne, Esq., a gentleman of independent fortune in the neighbourhood of that city. The youth of the parties, and other considerations, rendering the match not a desirable one to the old people, all interest was made to remove the gentleman, who was at that time considered one of the handsomest and most agreeable men

in Cork, the result of which was his immediate appointment to the assistant-surgeoncy of the 23rd Dragoons, then named for the Peninsula. He joined this corps at Chatham, but, by some change of design at the War Office, in a few weeks they were ordered to Fermoy, within eighteen miles of Cork, where the intercourse was immediately renewed, as a matter of course; all parties yielding with a good grace to what now might be considered a special manifestation of *destiny* in its favour.

When the 23rd were in reality ordered, in about eighteen months afterwards to the Peninsula (where, by the way, our readers will recollect they were shortly afterwards nearly annihilated at the battle of Talavera), Dr. Little (now a married man) effected an exchange into the North Mayo Militia, as surgeon, which commission he purchased, and subsequently sold for £500, as was the fashion of the times. This step it was which laid the foundation of his long and successful connexion with the province of Connaught, and of his undisputed reputation as the most distinguished practitioner and operator who had ever pitched his tent west of the Shannon.

During the eight years that Dr. Little was surgeon of the North Mayo Militia he had rapidly acquired a character as an operator of extraordinary merit, and a physician of great success and skill, so much so that the poor of the various localities where the regiment was quartered, in the provinces of Leinster, Munster, and Connaught, attracted by the reputation which preceded and accompanied him, were accustomed to flock in hundreds to his military hospital, where that unbounded zeal in his profession, that untiring activity of mind and body, and that universal philanthropy, which he retained to his last day of life, and to which, in fact, that valuable life was ultimately sacrificed, led him to toil unceasingly in unpaid, but not unrequited services; for the tenants of the neighbouring gentry, carried back to their landlords and friends the warmest, and sometimes exaggerated eulogiums on his skill and attention, so that he invariably and at once occupied the leading practice of the entire neighbourhood. When the Dispensary Act appeared (in 1807) he immediately endeavoured to impress upon the gentry of the localities where the regiment then happened to be quartered, the immense value of its provisions for the sick poor, and succeeded in establishing, *en route*, three dispensaries, one in Rathkeale, county Limerick, one in Arklow, county of Wicklow, and a third in Tuam, county of Galway.

In the year 1814 the North Mayo Militia, then lying at Tuam, were disbanded, and Dr. Little, having resolved on adventuring metropolitan practice, took a house on Ormond-quay; but during his sojourn in Tuam, then a flourishing town (very different indeed from the indigent and deserted aspect it now presents), and the centre of a thickly populated and even wealthy country, practice flowed so thick and fast upon him, and the solicitations of his brother officers, almost all men of wealth and influence in the adjoining county of Mayo, were so urgent that he should remain

where he was, that, after some reflection, though with much regret, he disposed of his house in Dublin, and soon afterwards, at the early age of 34, found himself in the receipt of nearly £1500 a-year, the proceeds of his professional labours, perhaps double the annual sum ever derived from medical practice in the province of Connaught before.

Under the patronage of Lord Decies, then Archbishop of Tuam, a prelate of unbounded benevolence and princely hospitality, the first dispensary ever established in the county of Galway was opened in the year 1814, by the suggestion and under the management of Dr. Little, with a small hospital adjoining, of eight beds, for operative surgical cases; and such were the circumstances of the country, or the estimation in which its services were held, that for many years its average income was about £400 a-year. To this miniature hospital, some twenty-five years since, crowds of the halt, and maimed, and blind, from every county in Connaught, and from many of Munster, Leinster, and the North, were constantly flocking; and in a small cabin of an insignificant country town in the far west, the curious in surgery would be surprised to find a rapid succession and unceasing variety of the most formidable cases, either awaiting or in the different stages of convalescence after operation. To the present day there are hundreds of the aged poor about the counties of Limerick, Clare, Mayo, Galway, Sligo, and Roscommon, who will tell, with the greatest gravity, and with a downright belief in what they have repeated so often as to make the tale pass current even with themselves, that in such a year, and at such a place, Dr. Little removed such a man's eye, washed it, and restored it perfectly sound to its orbit, or performed similar excisions and ablutions with the liver, bowels, and brains of others. Nor do we instance these popular exaggerations merely in order to dwell upon their absurdity, or excite a smile of compassion for human credulity, but because we consider the existence of such as the best possible proof of the extraordinary boldness and success of Dr. Little as an operator.

It is much to be regretted that, with a mind stored with all that was valuable in either ancient or modern medical literature, together with a vast amount of miscellaneous information on almost every subject (for to the last day of his life, and during the busiest periods of his practice, he was an industrious reader and student), with the most acute powers of observation, an exceedingly correct and cautious judgment, a wonderfully retentive memory, which enabled him, when conversing on medical subjects, to recall the minutest details of relevant cases which had interested him twenty or thirty years before, and to illustrate his positions with a torrent of quotations, frequently in the very words of the authors,—possessing a minute acquaintance with, and an experimental knowledge of almost every modern suggestion or established improvement in each department of his profession;—it is much to be regretted, we repeat, that, with all these advantages, together with a great facility of expressing his ideas simply and clearly (as many letters in the Editor's possession

abundantly prove), he should never have contributed to the literature of that profession which he so ardently loved and successfully cultivated. The secret of his backwardness to commit himself to the irrevocable step of publication can only be explained on the ground of a morbid sensitiveness to public opinion, a weakness or a virtue as the reader may deem fit to term it, which was a remarkable feature of his character, and an apprehension that his opportunities for cultivating a minute acquaintance with morbid anatomy had been much too limited (as, in the most extensive *country* practice, they necessarily must be) to enable him to lay his views before the profession in that perfect and comprehensive style which so elicited his admiration in the writings of others of the modern pathological school of authors; and anything less than the perfection he aimed at would not have satisfied him.

As an operator it was scarcely possible that he could be excelled; and in the country he performed every form and variety of operation, amputation at hip-joint, of lower maxilla, lithotomy, hernia, ligature of all those vessels ordinarily submitted to this operation, &c. &c. He possessed great nerve and celerity, with the most astonishing aptitude and readiness in adopting, without a moment's hesitation or confusion, exactly the proper series of manipulations which more or less vary the history of every great operation.

In the year 1832, Dr. Little, having already refused the proffered appointments to the Wicklow and Longford County Infirmaries, and while in the zenith of his reputation and practice, was nominated, without the preliminary steps of solicitation or canvass, to the surgeoncy of the Sligo County Infirmary, vacant by the death of Mr. Bell, by cholera. The highly complimentary manner of this offer, and the fact that this change of residence, while it introduced him to a new and most influential circle of practice, would not materially remove him from his lucrative connexion with the county of Mayo, at once determined him on accepting this highly honourable position. An illegal election having been held in the first instance, Mr. Cooper, of Markree Castle, instituted proceedings in the King's Bench, which quashed the appointment then made, and Dr. Little was on the subsequent election appointed by a large majority. The best evidence of the estimation in which he was held during the last sixteen years of his life, will be found in the subjoined notices of his lamented death by the local Sligo papers of diametrically opposed political principles, and in the all but unanimous appointment of his eldest son, Dr. W. S. Little, to the surgeoncy of the excellent institution so long and effectually presided over by himself.

[*From the Sligo Journal of August* 17, 1849.]

"THE LATE THOMAS LITTLE, ESQ., M. D.

"WHO that has ever heard of, or been in, Sligo, will not feel that our town has lost its chief ornament and most accomplished inhabitant by the stroke of death, which selected for its victim Thomas Little? And who that hears that that stroke approached in the form of cholera but must feel that more deaths than one are involved in that blow, and will not sympathize with the inhabitants of our town, labouring under the twofold affliction, the loss of such a man, the need of such a time?

"Ardent in the pursuit of every knowledge, the Doctor's zeal in the practice of his profession knew no limit; and cholera was no sooner announced to have made its appearance in our hospitals than that zeal hurried him *unbidden* to the bed of anguish, where, as the tasked thought wrestled in vain with this dark mystery of his science, the frailer body yielded to the contamination of the disease, and he who feared no danger in the endeavour to save, has, alas! himself become the victim;—one more added to the thousands sacrificed in the service of their fellow-creatures,—service unduly estimated, too frequently ungratefully requited.

"With untiring energy, from the appearance of this fatal malady up to Monday evening, when it seized on one so valued, Dr. Little no sooner discharged his duties to the numerous subjects of his private practice, than he was accustomed to hasten to our public institutions to watch, and, if possible, to assist by his own ever able suggestions, his professional brethren in the discharge of their melancholy and dangerous duties; and having upon Monday been much engaged about his private practice, it was not till late in the day that he was able to call at Dr. Knott's to inquire how matters were going on. Dr. Lynn also happened to be passing, and seeing the Doctor's well-known gig at the door, and guessing the subject of his friend's discourse, he naturally felt an anxiety to join them. Upon gaining admission to Dr. Knott's study, great was his horror to find his valued friend, Dr. Little, already seized with the first symptoms of the disease. With difficulty he was conveyed to his gig, and driven to his own house. Everything that the anxiety and skill of his friends could suggest was immediately done, and Drs. Homan, Lynn, and Knott, together with his own son, Dr. Francis Little, were unremitting in their attention and attendance; but, notwithstanding every effort which skill could suggest, after suffering very much all Monday night, he gradually sunk on Tuesday, and at the hour of six o'clock upon that evening breathed his last, having been insensible for several hours.

"And now that he is gone, what can we, what shall we say of him? Varied acquirements, unbounded affability, and generous kindness, are attributes to which no one pen can do justice, inasmuch as they affect every one brought within their influence differently. Like sunshine, they brighten everything in its own colour; and the persons they have addressed, the hearts they have affected and pleased, have each a livelier appreciation of the individual effect than it would be possible to convey in a general description.

"The Doctor's disposition addressed itself to every class. To the invalid and sufferer he came laden with the balm of his science; while he approached the companion and acquaintance with an accomplished intelligence, ever rich in information, and softened by a certain expression of generous and brotherly feeling. Equally respected and cherished by the rich and poor, that respect and regard was only varied by the power of individual appreciation, for who ever left his society without knowing more, or feeling happier?

"Too really informed to guard with prudent solemnity the treasury of thought, the Doctor, always eloquent, plainly laid before you all he knew upon any subject, with the simple generosity of a giver, rather than the pedantic exhibition of a miser.

"But, alas! where now is that trusted physician? where that accomplished friend, with that kindly glance of recognition, attended by that unceasing play of thought and word? Reader, they are gone! Dr. Little is in his grave. Let your thoughts be with him a while there; and, though his skill may no more prolong your life, yet you may be enabled to spend that portion of it which still remains more wisely, since now more surely expecting death."

[*From the Champion, or Sligo News, of August* 18, 1849.]

"DEATH OF THOMAS LITTLE, ESQ., M. D.

"NEED we say with what sincere, what heartfelt sorrow, we announce the death of Thomas Little, Esq., M. D., of Sligo, who, for many years, so ably, efficiently, and satisfactorily filled the important situation of Surgeon to the County Infirmary? We esteemed Dr. Little for his private worth;—who did not that had the honour of his acquaintance? We looked up to him with admiration for his professional ability, because we believed it could not be excelled. As a surgeon he could not be surpassed, and some of his operations will remain on record for their boldness and their skill. His reputation was not confined to the provinces; he was known, appreciated, and respected by the entire Faculty in Ireland. To the poor he was always kind, affable, and attentive, and his loss to them will be irreparable. With a generosity, which distinguishes medical men, and gives their honourable profession a proud distinction over all others, he never refused to alleviate human suffering, if in his power, or declined to brave pestilence and death, although certain of receiving no fee or reward. He died as he lived,—died in his efforts to save the lives of his fellow-creatures. He explored the

Poor House, and the other public institutions, where the plague of cholera lurked, on Saturday last, in order to watch the progress of the malady. He caught the fatal distemper, and now he sleeps for ever in the tomb, the victim of philanthropy.

"The news of Dr. Little's illness and death spread dismay through the town. The man to whom the people looked up was carried away, and all public confidence ceased. But, heavy as his loss will prove to the public, it will be more acutely felt by his mourning family. Brought up in the lap of comfort and luxury, the Doctor's children will be ill able to bear the loss of the large emolumentary proceeds of his professional practice. We believe, however, the governors of the Sligo Infirmary will recognise the claims the family of Dr. Little has on public gratitude, and feel assured that the appointment of the son in place of the father would give universal satisfaction. We hope that medical men will have the good taste to withdraw their claims in favour of the son of the man who has done so much to promote the good of their profession."

THE END.

MEMOIR

OF

SAMUEL WILMOT, M.D., M.R.C.S.I.

Surgeon to Steevens's Hospital, and formerly Professor of Surgery to the Royal College of Surgeons, &c.

Upon several occasions during the last three years we have been obliged to stay the progress of our series of biographies of the early fathers of Irish medicine, to make room for a passing notice of some recently lost friend, or eminent member of the profession, who had passed from amongst us. These were for the most part young men just entering upon their career, or those who, having got upon the ladder of preferment, were rapidly approaching a high and honourable station, when their course was arrested, often in the discharge of duties connected with their profession, or of those dictated by friendship or humanity. It is a fact, melancholy but true, that as a body of gentlemen, occupying the middle ranks of society in this country, the members of the medical profession are not long-lived. It is, therefore, a matter of some rarity when we have to record the deaths of three or four of our senior brethren, who have died since the issue of our last Number. Of these we may mention Dr. Renny, formerly Director-General of the Army Medical Department in Ireland, the Senior Fellow, and one of the principal founders of the Irish College of Surgeons(*a*); Gerard Macklin, Esq., formerly State Surgeon, and some thirty years ago a gentleman in very great practice in this city (both of whose obituaries want of space compels us to leave over till our next publication); and Samuel Wilmot, M.D., the subject of the present memoir: all of whom have recently passed to the grave in a good old age, each having, for nearly half a century, commanded the good opinion both of the public and the profession.

Mr. Wilmot, the fourth son of John Wilmot, Esq., of the County Dublin, a gentleman of independent fortune, entered Trinity College in the year 1790, and some time after, having been called on by his father to select a profession, he unhesitatingly chose the medical.

(*a*) The Council of the Irish College of Surgeons have, with becoming taste, determined to erect a testimonial to the memory of this distinguished man.

Owing, however, to a fancy of his father's, who had a strong aversion to surgery, he was, much to his vexation, obliged to confine his studies exclusively to medicine. In the course of two years his father died, when Mr. Wilmot's eldest brother, seeing that his ardour for surgery was still unabated, bound him apprentice to Mr. Hartigan, then Professor of Anatomy and Surgery in the University, and one of the Surgeons to Steevens's Hospital. The zeal and diligence in prosecuting his studies and performing his duties which characterized Mr. Wilmot during his entire professional career, soon evinced themselves in the student. At this period there were no resident pupils in the hospital, the usual duty being performed by the externs; the visit was also at seven o'clock in the morning, in winter as well as in summer; and though he resided a short distance out of the city, which afforded an additional obstacle to regular attendance, he was never known to be absent a single morning, so that his punctuality became proverbial. As a proof of the esteem entertained for, and the confidence reposed in him, by his collegiate companions, it may be stated that he was, though still a pupil, unanimously nominated to act as surgeon to a section of the College corps, embodied in 1798.

He obtained his diploma from the College of Surgeons in 1801, was shortly afterwards appointed Demonstrator of Anatomy in the University, and, during the last two years of Mr. Hartigan's life he acted as *locum tenens* for him, thus filling the professor's chair, and lecturing on surgery and anatomy combined. The successful manner in which he conveyed instruction, and the general satisfaction his conduct gave to the Board of Trinity College, are fully attested by the presentation from them of a very flattering address, accompanied by a handsome pecuniary remuneration(*a*). In 1813 Mr. Wilmot took his degree of M. D. in Trinity College, and at the death of Mr. Hartigan, which occurred soon after, became a candidate for the vacant chair; and so strong were his claims considered, that he was absolutely congratulated and received by his friends as the Professor elect. The unsteady scales of fortune, however, turned, in an unexpected manner, against him, and another was elected(*b*).

(*a*) The following is a copy of the letter presented to Dr. Wilmot:

"*Trinity College, July* 1, 1813.

"Sir,—I have much pleasure in conveying to you the unanimous resolution of the Provost and Senior Fellows, adopted at a board held yesterday, returning you their best thanks for the liberal promptitude with which you undertook to continue the line of anatomical lectures, on the death of our late lamented professor; and also requesting your acceptance of 100 guineas, as a very inadequate testimony of their sense of the diligence and ability with which you discharged that laborious and important duty. Permit me to add an assurance of the high respect entertained for your personal character and your professional skill by the whole body, and by none more sincerely than by your very faithful

"Richard Graves, *Register*."

(*b*) It was believed by many persons at the time that Dr. James Macartney, the successful candidate, was an Englishman, and a perfect stranger. He was, however, a native of the county Armagh, as indeed his decided northern accent witnessed to the day of his death. He was a student for some time

Though disappointed at this occurrence he had soon the compensating satisfaction that his private practice was rapidly augmenting;—indeed to the circumstance of his not becoming a professed anatomist, the Dublin School of Surgery is, in a great measure, indebted for the valuable labours of Mr. Wilmot.

After Mr. Wilmot became a Licentiate of the College of Surgeons he was appointed medical attendant to a dispensary on the north side of the city; this he held only a short time when he became one of the surgeons to the Meath-street Dispensary. This latter appointment was the means of bringing him under the notice of many wealthy merchants, who at that period inhabited the Liberty of this city; and his attendance upon them and their families brought in annually a very handsome income. He subsequently became attached, successively, to the Locke Hospital, Sir Patrick Dun's, and Cork-street Fever Hospital, which latter, however, he held for only four years.

In 1807 he was nominated by Mr. M'Evoy as his successor in Jervis-street Hospital, in conjunction with Mr. Dease. The manner in which the celebrated M'Evoy handed the appointment over to Mr. Wilmot, then almost a perfect stranger to him except by professional character, is worthy of special mention. After sending for him to his house, he addressed him nearly in the following terms:—I hope you will excuse the liberty I take in sending for you, but it is to communicate to you that I have determined to make you my successor in Jervis-street Hospital; and I make this selection because I am convinced, from your high character, you will do justice to an institution which I dearly love, as it has been the instrument by which I have been raised on the shoulders of the poor to my present position(*a*). In this hospital, when he entered upon his duties, Mr. Wilmot's skill as a surgeon, and dexterity as an operator, and especially his adroitness as a catheterist, began to be appreciated: here he also performed all the capital operations, and his success in hernia operations was particularly marked. He also gave clinical lectures and bedside instruction in this institution, and delivered a private course of lectures on surgery,—a practice at that time but little

in the Dublin School, and then went to London, where he afterwards distinguished himself as a writer and a lecturer upon physiology and comparative anatomy, subjects just then beginning to engage very great attention. When elected to the Professorship of Anatomy in our University, he was surgeon of the Radnorshire Militia, and Lecturer on Anatomy and Physiology at Bartholomew's Hospital, London. He was also the writer of the articles Mammalia, Birds, Fishes, Hairs, Feathers, and Incubated Egg, in Rees' Cyclopædia, and author of the Essay on Luminous Animals in the Philosophical Transactions.

(*a*) With the precise form of the election to the surgeoncy of Jervis-street Hospital upon this occasion we are unacquainted, as the minute-book of the institution is not accessible to us, but we suppose the successful candidate's election was secured by the paramount influence of M'Evoy.

known in this city(*a*). His connexion with Jervis-street Hospital continued till 1830, when he was succeeded by Mr. Ellis. In the year 1814 he was appointed to Steevens's Hospital, in the room of Mr. Obre; and a few years subsequently was elected one of the governors of that institution. He was one of the founders of the Park-street School of Medicine in 1824, where he lectured, along with Mr. Cusack, on surgery; and after the death of Mr. Todd he was elected Lecturer on Surgery and Anatomy in the School of the College of Surgeons in 1826, as colleague with the late Mr. Colles, and afterwards, in 1828, Professor of Surgery, when that part of the subject was separated from Anatomy. He was also consulting surgeon to the City of Dublin Hospital, and surgeon to the Hospital for Incurables; besides being attached to many institutions of minor importance, which it is needless to specify. He three times filled the office of President to our College of Surgeons.

Mr. Wilmot was, as has been already stated, a very neat and adroit operator, to which the circumstance of his being ambidextered assisted. In practice his particular *forte* was diseases of the urinary and genital organs, in the treatment of which few, if any, in this or any other part of Great Britain, excelled him. The delicacy of manipulation with which he managed such cases was only equalled by the sound practical knowledge and great experience which guided him. The greater portion of his department of the surgical course, at the College of Surgeons, consisted of the description and management of those affections. As a lecturer he had invariably a full class. Stripped of everything like ornament or rhetorical display, his quiet, easy, self-possessed manner, the soundness of his doctrines, and the immense amount of experience which he brought to bear on his subject, were attractions sufficient to excite the interest and command the attention of his auditory. As a writer, he was remarkable for simplicity, clearness, and sound sense. He did not write much. Brought up in the school of fifty years ago, he had, with most of his colleagues, a terror of appearing in print, increased by a natural diffidence and excessive hatred of display; yet in latter life he has often expressed to us his regret at having written so little. There was one trait of Mr. Wilmot's character which should not be forgotten by his biographer: he was, in addition to his many other virtues, thoroughly honest; not merely honest and honourable as a man, but as a practitioner;—in him the young man found, in consultation, a *friend*, as well as an adviser. No one ever heard of Mr. Wilmot's "taking a case" from a junior practitioner.

In 1848 he resigned his Professorship, and Mr. Hargrave was elected as colleague to Mr. Porter in his stead.

(*a*) The late Mr. Colles commenced his career as a lecturer by giving a private course upon the theory and practice of surgery in South King-street. It will be recollected that at that time there were no private schools in Dublin.

He died the 7th November last, aged 75. His son, Mr. S. G. Wilmot, lately House Surgeon to Steevens's Hospital, has been elected to the surgeoncy of that institution, vacated by his father's decease.

Dr. Montgomery, in his address to the Obstetrical Society about the period of Mr. Wilmot's decease, thus spoke of his character:

"None who knew Mr. Wilmot will need to be told how much and how deservedly he was esteemed and respected, loved and honoured; not alone in the hallowed circle of domestic life and retirement, but abroad, in the wider sphere of professional duty, with the public. Few have enjoyed more entirely the affectionate regard and confidence of their patients, for the conviction could not be resisted that in him they had combined the skilful physician and the kind and sympathizing friend:

'Of manners gentle, of affections mild,
In wit a man, simplicity a child.'

"He possessed in an extraordinary degree the captivating grace of gentle courtesy, which, because it was the real spirit of the man, and not the well-feigned gloss of fashion,—the genuine radiance of Christian kindness and benevolence, and not the studied effort of affectation,—was given with equal readiness and cordiality to the junior student as to his own equal in years and knowledge,—to the maimed occupant of the straw pallet in the hospital, as to the titled sufferer on his bed of down.

"I have reason to know that through life he sincerely endeavoured 'so to pass through *things temporal* as finally not to lose the *things eternal*,' and 'to lay up treasures where neither moth nor rust doth corrupt.'—'They who were accustomed to rely upon him merely for professional aid will find it difficult to supply his place; to his intimates and his family his loss is irreparable; but his sons will inherit the inestimable advantage of their father's good name and example'"(*a*).

He was indeed admired and respected by all, even by the eccentric and sarcastic Brennan, who, while he lashed the profession, good and bad, friends and foes, in his witty, and, in some respects, unrivalled epigrams, panegyrized a few whom he particularly distinguished for their honesty and modesty; among them was Mr. Wilmot:

"_____ the last on my roll,
A man first on merit and modesty's scroll."

Mr. Wilmot did not write any separate or distinct work; he contributed the following communications to the periodicals:

Case of unusual Termination of Psoas Abscess, in the Transactions of the Medical Association of Ireland, vol. ii. 1818.

A Case of Femoral Aneurism cured by tying the external Iliac Artery, in the Dublin Hospital Reports, vol. ii. 1818.

(*a*) See Southey's Memoir of Gooch.

A Case of Hæmorrhagic Diathesis, in the Dublin Journal of Medical Science, vol. xix. 1841.

The History of a Case of Aneurism by Anastomosis in the Cavity of the Naris, with Remarks; and Observations on the Formation of Organic Stricture in the Male Urethra, with some Remarks on their Consequences and Treatment: in the Dublin Quarterly Journal of Medical Science, vol. iii. 1847, and vol. v. 1848. It was Mr. Wilmot's intention to have continued this latter subject when we were deprived of his valuable services. He was engaged upon a Memoir on the Diseases of the Prostate, which will appear in our next Number.

A Course of his Lectures on Stricture and the Diseases of the Prostate, delivered at the College of Surgeons, were published in the first and second volumes of the Dublin Medical Press, for 1839, in which he also published "Cases of painful Subcutaneous Tumours."—No. for February 20, 1839.

MEMOIR

OF THE LATE

WILLIAM GRIFFIN, M.D.,

OF LIMERICK.

EXTRACTED FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE FOR NOVEMBER, 1848.

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8

DUBLIN:
PRINTED AT THE UNIVERSITY PRESS,
BY M. H. GILL.

MEMOIR,

&c. &c.

THE icy hand of death has of late been pressing so heavily on the members of our profession,—its approaches have been so rapid and follow in such quick succession,—so many firesides have been chilled and deserted by its awful visitations,—and such an amount of misery has followed in its train,—as to sicken the heart and render it truly sorrowful. When we recount the noble spirits and the master minds which departed from amongst us, sinking beneath a pestilential scourge, and call to memory a cherished friend, or some fond companion of our early days, our spirits droop within us, and we become filled with gloomy forebodings. The serious injury which the profession has sustained in the loss of so many useful and valuable members, and the dismal tales of woe, which of late days have accumulated upon our attention, had in a measure blunted our acuter feelings, disposing us to give way to a species of fatalism, and to almost persuade ourselves, were we not able to account for it by other causes, that as a body we are doomed to destruction.

But when the announcement of Dr. William Griffin's death fell upon our ears, however apathetic or resigned we might have been disposed to feel,—whatever amount of philosophy we might have summoned to our aid,—we could not avoid being acutely sensible to so heavy a shock.

The name of Griffin carries so many bright associations with it, awakens in the mind so much purity of thought and lofty sentiment, as to claim and call forth our warmest acknowledgment. Who that is familiar with the national works of Gerald Griffin, that has not been carried away in profound admiration of his exquisite genius. The author of the Collegians may be imitated but never can be outrivalled in originality of thought, beauty of conception, powers of description, and faithful imagery. His chaste and eloquent delineations of life and character, so true to nature, and so replete with moral impulse, charming while they instruct, and instructing while they charm,—deservedly gained for him the unqualified approval of the literary world, and raised up a monument to his fame and his memory both lasting and imperishable.

To the family of Griffin has been conceded the reputation of being highly talented, and that talent, as nature would have ordained it, appeared traceable to the mother's side. William, the subject of this memoir, was the second of five brothers. He was

born in the city of Limerick, on the 25th of October, 1794; his father held the position of a respectable country gentleman, one of that class who constitute the worth and respectability of the country in the absence of the lord of the soil, who, unfortunately, in too many instances, is never heard of, save through his agent, when the rent-day arrives, or the term of the lease is on the eve of expiring. Some of his forefathers, however, had held in fee large territorial possessions, of which they had been deprived by the operation of laws, the policy, or injustice of which it is not our province to touch upon. His mother was sister to the late Dr. Geary of Limerick, a man of considerable eminence in his profession, and more particularly distinguished for his skill and great success in the treatment of fever.

He acquired a good classical education, first at the school of Mr. T. O'Brien, and afterwards at that of Mr. Richard M'Eligott, a man of much learning, and a teacher of distinction. While at school he was remarkable for capacity and quickness of comprehension. He was also very industrious, and made rapid progress in his studies. Before his education was well completed he was sent to sea as a midshipman, a mode of life at that period somewhat palatable to his taste. His prepossessing appearance, gaiety, and gentlemanly, unassuming manner, rendered him a favourite with all. Through the influence of Sir Vere Hunt, Bart., in the beginning of July, 1809, he entered as a midshipman on board the Venerable, seventy-four, the Flag Ship of the expedition to Flushing in that year, and then under the command of Sir Home Popham and Captain King. She carried out Lord Chatham and his staff, and was soon brought into action in an attack on the batteries, which William describes in a letter home, as a "very new and startling affair," but which was successful in its object without much bloodshed. The Venerable having returned to England was soon despatched for Walcheren again, and on her passage there was wrecked at midnight on the Drogan Sand, off Flushing; her masts had to be cut away, and her cannon and stores were thrown overboard. She was barely kept afloat by constant pumping until morning, when she was towed into dock by her cutters.

Being repaired at Flushing she was towed to England by the Blake, seventy-four, and young Griffin arrived in Chatham, quite tired of the sea, and sick of a seafaring life. At this early period we have to notice the beamings of those high mental qualities which were in after-life developed, in the composition of a poem, giving a full and glowing description of the shipwreck, the perils they had to encounter, and their eventual deliverance.

Having, after some consideration, determined to discontinue a seafaring life, he obtained leave of absence the following year, and shortly after had his name taken off the books of the Admiralty.

He now fixed his choice on the medical profession, but difficulties then stood in the way of his being able to fully accomplish his views, in consequence of unsuccessful speculations in which his father had been involved. Being thrown in a measure on his own resources, his natural energy and engaging address so far favoured him as to

succeed in getting himself apprenticed to Mr. Wigram, a respectable general practitioner in Holborn. In this year (1810) he became familiar with the composition of medicine, and attended the surgical practice of St. Bartholomew's Hospital under Earle, Harvey, and Abernethy. His zeal and energy soon attracted the notice of this last celebrated surgeon, who, by way of appreciation, gave him, under his hand, an unlimited admission to attend his lectures. His attendance on these lectures, and on St. Bartholomew's Hospital, continued until 1814, when he formed a connexion with a surgeon of East Grimstead as his visiting assistant, with whom he remained for a period of two years.

In 1816 he visited Brussels for the purpose of recruiting his health, which suffered from too close application to study; and in the latter part of that year, in consequence of continued delicacy, he was obliged to defer the completion of his education, and return to his friends in Ireland, after an absence of eight years. It will be remembered that this was the year in which typhus fever commenced to make such terrible ravages, among the poor especially, in the south of Ireland. The neighbourhood in which he resided soon afforded a wide field for observation, which he eagerly took advantage of, and published his views in the form of a pamphlet, which, at the time, excited some share of attention; and in reference to which he writes in an old pocket-book: "Published a little pamphlet on the epidemic fever then ravaging Ireland. Began to get a little practice without much seeking for it." His name, however, as "a skilful doctor," was spread about, and he established for himself such a reputation, that he was appointed medical attendant to the Currah Dispensary.

In the following year he fixed his residence at Adare, within eight miles of Limerick, and was appointed medical attendant to the Clarina Dispensary. In the latter part of the year 1822 he removed to Rathkeale, opened a small hospital at his own expense for the sick poor, and acquired a tolerable share of practice for the short time he remained there. These various engagements, which the nature of his circumstances made it impossible for him to decline, prevented him from fulfilling his long-cherished desire of completing his medical studies, and obtaining his diploma. His position in this respect subjected him to occasional slights, which were the more annoying to his sensitive mind, as coming from persons far his inferiors, both in education and abilities. There was no remedy, however, but to submit to them until his aim was finally accomplished. In the year 1823, on the death of his friend and relative, Dr. Enright, he was appointed physician to the Pallaskenry Dispensary, in consequence of which he resigned that of Clarina, but was permitted to retain that of Currah as it was in his immediate neighbourhood.

It was here in Pallaskenry that he made an extensive collection of facts and laid the foundation of those views, which he afterwards gave to the medical world in his celebrated work on Spinal Irritation. He now enjoyed an extent of practice equal to what our best country districts afforded, and hoped, as each new year arose, to be able to

absent himself from his duties, in order to graduate in one of the colleges. An event, however, supervened, which threw this anxious and earnest object of his mind's attention quite out of consideration for the present, and even seemed to have put it beyond his reach for ever. During the last few months of 1823 he began to suffer from a painful affection of his knee and hip, which exhibited in its course and progress all the features of hip disease. He became alarmed, and came to Dublin for advice, where he consulted the late Mr. Colles, who felt a deep interest in his case, and, after several patient examinations gave a decided opinion as to the positive existence of that affection. He recommended him to return home and put in requisition the usual remedies, such as perfect rest, counter-irritation, &c., &c.

This sad announcement, coming as it did from an authority upon which he placed so much reliance, had a most depressing effect on his spirits. On his arrival home he appeared quite overcome with anxiety and cares. The mere idea of giving up his practice, at once and entirely, never, perhaps, to resume it again, was more than the strongest mind could bear up against. One circumstance, however, remained, which afforded some consolation, and prevented the blow, heavy as it was, from being altogether so disastrous to him. In the course of his past career he had been able to save out of his income as much as was necessary to complete the medical education of his brother, the present Dr. Daniel Griffin of Limerick, who now lived with him, having already passed through his studies. A short time before, the governors of the dispensary, with feelings of the kindest sympathy for his situation, and the most earnest anxiety to contribute towards his comfort, appointed Daniel as his *locum tenens*, an arrangement which prevented the institution with which he was connected, together with the practice which he enjoyed, from passing into the hands of strangers.

After a little while his spirits brightened up somewhat, and those traits of natural energy and liveliness of character, which afterwards became so evident, would seem to be manifesting themselves. Severe though the trial was, a state of inaction with him was a perfect impossibility. Having nothing wherewith to employ himself, he turned his attention to light literature. The success and rising fame of his brother Gerald had, in all probability, turned his thoughts in this direction. While on the bed of sickness, and in the height of his sufferings, he took up his pen and commenced writing plays; and it was curious to remark that, as in the case of Cowper, who wrote "John Gilpin" in the midst of the gloomiest apprehensions, most of the productions were of a comic nature. He tried to have one of them introduced on the London stage; it was pronounced by competent judges to be possessed of considerable merit, and far above mediocrity, but merely wanting in that subordinate quality which is understood by the term "stage effect." An idea of his powers in this respect may be conceived by reference to some pieces in prose, of his composition, which were published with collections of tales by his brother Gerald; one called "The Persecution of Jack Edy," in the volume entitled "Hollandtide;" and another under the name of "The Mistake," in the "Tales of a Jury-Room."

The nature of these pieces is not by any means such as would indicate that they had been composed on a sick bed, which, however, was really the fact; and, strange as it may appear, there was hardly a performance of his of any note through life that was not accomplished either in the midst of the most harassing duty or the severest suffering. Fortunately the illness under which he was labouring did not turn out so serious as was anticipated. After a confinement of some months the second hip became affected in the same manner as the first, and both upper extremities participated in the attack. It may be imagined that this event would cast a fresh damper over his spirits, but quite the contrary occurred. The thought immediately flashed across his mind, that the assemblage of symptoms now presenting were but a diffusion of the original attack, and at last clearly revealed its true character. All anxiety and apprehension in regard to organic affection of the hip vanished from his mind, and his views on the nature of his disease were now quite altered. He summoned up an amount of mental energy really astonishing, and lost not a moment in adopting that course of treatment which the features of his case, from its present complexion and the result of past experience, could safely and with success be capable of suggesting. As the first essential and most important step, he removed to the sea side. The effect of the change was no less sudden than surprising. His strength and spirits rapidly rallied, so that in the short space of little more than two months he seemed like one who, from a nerveless and exhausted condition of body, had virtually jumped into a state of perfect health. A state of delicacy which he had long complained of, and which had at times offered serious impediments to his various undertakings through life was, in all probability, of the same nature, and taking its rise from the same cause as the present, though in its combinations, and the several forms it assumed, the idea of an organic disease frequently took possession of his feelings. When he first returned from London in the year 1816 he was seized with pain in the left side, accompanied with cough and slight expectoration. It was feared that phthisis had actually set in, but the symptoms passed off in the course of the year. After this he suffered occasionally from pains in the left side of his head and neck, and upon one occasion got a severe attack of tic doloreux in the eye-brow of the same side. He was accustomed to say he was exactly like two men put together, one of a sound and healthy constitution, and the other always ailing.

During the stages of his weary illness he never lost sight of his profession, feeling a deep and lively interest in its respectability and welfare. He had himself supplied with periodicals, and the best modern works, both on medicine and surgery; a new or important medical fact was as welcome to his ears, and seemed quite as rich a treat to him in his then situation, as in the best days of his untiring

exertions. In this way he was enabled to fan the lambent flame of research, and to keep pace with the improvements of the day. The idea of perfectly and safely escaping so trying an ordeal seemed to have inspired him with new hope, and convinced him of his great recuperative powers. In fact he felt as if suddenly and altogether endowed with new life and energy; and after taking a review of his position and the prospects before him, he came to the fixed resolution of attaining his qualification, irrespective of any obstacle that might seem to interfere with such an undertaking; and in fulfilment of this purpose he started for Edinburgh previous to the commencement of the winter session of 1825.

While there he associated himself with a few fellow-students, who, from mere acquaintances, became warm and united friends. A strong feeling of mutual attachment grew up between them, and they formed an independent group in themselves. They mixed together, studied together, and moved abroad as one body in their daily little walks during the interval of lectures, and those more expanded excursions which were occasionally undertaken by them. The leisure time thus appropriated is not to be conceived as representing hours of idle recreation. It was rather an intellectual pastime in which each gave his contribution or played some part. Griffin, the bright luminary and centre of attraction, as if too careful of himself, or perhaps being sensitive to the northern blast, generally mounted a thick drab outside coat, proof against wind and weather. It was furnished with a pair of immense pockets, all but ready to burst with voluminous notes of lectures, and other curiosities of literature. Upon one occasion, as he appeared slow in coming forth, he was rather abruptly interrogated how it came to pass that he, who had so much wisdom and knowledge within his head, could be able to carry such a weight of learned lumber about him. Without a single word in reply he unloaded himself of the Dublin Weekly Register, and read aloud one of Sheil's brilliant speeches. It was a question which he admired most,—the eloquence of the orator, or the glowing aspiration for freedom he so vehemently proclaimed; but a manly and open declaration soon set the matter at rest, by his professing his unqualified adoption of the maxim,

"Pro rege sæpe, pro patria semper."

On the subject of phrenology he was interesting without being original. He believed that there was more than "something" in its doctrines; but found fault with the nomenclature and the bumpal subdivisions. He also believed that the objections against it, in regard to its tending towards materialism, were not of much importance, for (he observed) "granting that the intellectual faculties, or thinking principles, did solely depend on the special organization of the brain, still the impress of the hand divine must ever be acknowledged; and further, the mere endowing of matter with such wonderful attributes, would be a no less display of infinite wisdom. He was in the habit of exhibiting a peculiar taste for metaphysical disquisitions, and spoke in admiration of Locke, though he considered the works of Reid and Dugald Stewart as improvements, particularly in reference to the conceptions of matter, which Locke represented in too unreal a form.

He had a passion for poetry, was an ardent admirer of Moore, and repeated the national melodies with soul-stirring emotion, at times indulging in a vein of sentimental effusion of rather a gloomy and languishing character. He also showed himself familiar with the writings of the most eminent of the British poets. But these allusions may be alien to our present purpose, so we shall advance in the usual footpaths.

In his attendance upon lectures he was regular and constant, though he conceived that in some degree they were a loss of time to him. He had always his note-book at hand, not in order to take down the words of the lecturer, but rather to select those leading facts and important truths which form the basis of skilful practice.

In hospital attendance he was most assiduous. Any case in the least interesting immediately caught his eye, and when it formed the subject of a clinical lecture he was fully informed of all its bearings. And if it should appear to him that any doubt or difficulty had not been sufficiently explained away, he did not fail to express his views or objections, whichever they were, to the lecturer. The late Professor Graham entertained a very high opinion of his capabilities, and paid in open class a very flattering compliment to his exquisite tact in diagnosis. The instance is worth recording. A woman was brought into the Royal Infirmary, with apparent symptoms of acute peritonitis, and was ordered by Dr. Graham to have leeches applied to the abdomen. Griffin pointed attention to the morbid sensibility of the skin, the inconsistent condition of the pulse, and the expression of caprice in the countenance, as suspicious of a simulating disease. Graham smilingly replied by assuring him that it was "all very fine in books, but when coming to practice matters will seem differently." A second bleeding was ordered, but before it was put in practice the patient was seized with a fit of hysteria, which at once revealed the true nature of the attack, and testified most triumphantly to the skill and abilities of the student.

The winter having passed and the lectures reaching their close, the day of trial became nigh at hand, that day whereon the twilight beamings of hope and fear doubtfully agitate the student's mind. Griffin was the first candidate to break the ice, and, as a matter of course, had no difficulty in surmounting the "primum periculum," for the medical degree. Almost contemporaneously he presented himself at the College of Surgeons, and obtained his diploma. All the heavy task being now essentially overcome, and an interval of three months having to elapse before the solemn ceremony of exhibiting in the cap of Hippocrates, brief as the period was, his native genius and enterprising spirit would allow of no rest, and, to the surprise of many, he is shortly after announced in the Edinburgh Medical and Surgical Journal as the author of an

"Essay on the Nature of Pain," a most ingenious production, ably written, and abounding with interesting anecdotes, the basis of which had formed the subject of his inaugural dissertation.

When on the eve of leaving Edinburgh he entertained the notion of fixing his residence in London, as opening a boundless range for his varied and active acquirements. It even at one time amounted to a fixed resolution, in which he was strengthened by the advice and generous counsels of Drs. Graham and Duncan, who could distinguish in him the materials for "a physician in a great city." He subsequently abandoned this project, and returned to his native soil, the sphere of his usefulness and good deeds, thrice welcome, with honours on his head, and a prospect before him bright and promising from former remembrances. Limerick was now his chief aim, as it had been his early resting-place. It would not be prudent to prematurely leave the village of Pallaskenry, but, as a preliminary, he fitted up a house in a central part of the city as an infirmary for diseases of the eye, and those incidental to women and children. The poor, whom he attended gratuitously, flocked to him in great numbers, and the institution was soon identified with his fame, and was the means of giving him a step in the ladder of promotion.

In 1830 he finally settled in Limerick, having in this year married the niece of Sir Vere Hunt, Bart., a very early acquaintance whom he had met in his boyhood days, while residing at Sir Vere's house in London, previous to his going to sea. As the fruit of that marriage he has left one son, fifteen years of age, who has already given signs of much promise. From this period his rise was steady and progressive; his income, rapidly increasing after the first few years, soon reached that amount which entitled him to the rank of a head physician.

The lamented death of the distinguished novelist, in 1840, was a source of long and enduring sorrow to his over sensitive feelings. As an instance of the love and devoted attachment which reigned in this united family, we here annex, from the Life of Gerald, published by the present Dr. Daniel Griffin of Limerick, a portion of the Dedication, to the subject of the present memoir: "whose affectionate care," he says, "fostered that talent in his youngest brother, from which the public has derived such solid pleasure," and "in memory of the deep and unchanging affection that brother always bore him."

As a practitioner Dr. Griffin was unbounded in his resources, yet withal extremely cautious, and trusted much to the powers of nature. He was sanguine to a degree, never despairing while a shadow of hope remained. He felt an intense interest in his patients, and in his anxiety to have the necessary measures faithfully carried out, he became at once the nursetender and the physician. He was connected with several of the medical institutions of his native city, and contributed largely towards their improvement and efficiency; he delivered some very interesting lectures in the board-room of the county infirmary, which were well attended by amateurs and pupils;

he also endeavoured to establish a school of medicine and surgery, but failed in the attempt, for want of active co-operation on the part of others.

In medical politics he was a reformer; and in his evidence before the Committee of the House of Commons on the Medical Charities he offered many able and valuable suggestions for their better regulation. He was a member of the Corporation of Limerick, and had within reach the highest honours that body could confer. When the question of nationality was debated he was at his post, and manfully avowed his sentiments; but he never obtruded his opinions in private, neither was he dissuaded from avowing them, when necessary, from a feeling of sickly timidity. He felt for the wrongs of his country, and sighed for her regeneration.

He was a patron of the fine arts and general literature; and he stood deservedly high in the good opinion of his profession. In the relations of social life he was bland and amiable; and he had the singularly good fortune of attaching to himself a large circle of acquaintances; his private worth and genuine philanthropy were alike proverbial; he was the esteemed of many and the favourite of all; in unpretending charity he was profuse, and in self-denying virtue unequalled; as a friend he was sincere and upright; as a man of feeling he was kind and really generous; and as a Christian he was religious without ostentation. No man could review the past with a more sterling sense of conscious rectitude, and no man could look to the future with brighter hopes of eternal reward.

In him were centred those rare intellectual excellencies which constitute the all-important attributes of a "medical mind." To the faculty of comparing and generalizing facts in the spirit of true philosophy, he had superadded the habits of close and faithful observation. The several original contributions he has made to the medical literature of his country deservedly give him place among its eminent medical men.

His brilliant career was cut short in consequence of his enthusiastic devotion to the best interests of the profession. As the result of untiring mental energy, coupled with great and overpowering bodily labours, his nervous system became quite unhinged, and in the beginning of April last he began to be affected with pain in the left side of the head. As this was no uncommon thing with him, he treated it as rheumatism, with leeches, blisters, colchicum, turpentine, &c., all the while going about and attending to business. He usually got relief on the application of remedies, and then after a week or so fell back again. After four or five weeks he consented, under the persuasion of his friends, to give up business and go to the country. He now noticed a difficulty in recollecting particular words, which embarrassed his mind in speaking or writing to patients; and his letters, though otherwise correct and to the purpose, contained several erasures or, at times, the substitution of one word for another. He used to say: "It is a most curious thing: I know as well as possible what I am

going to say, but, if I were shot for it, I cannot think of the particular word." The worst sign about him was complete absence of any sense of danger. It was now obvious that he laboured under a chronic inflammation of the brain, which, notwithstanding every possible effort that could be devised, pursued the usual melancholy course; paralysis of the right side quickly supervened, complicated with a total interruption of conversational powers; a general debility and complete languor ensued; and he continued in the same distressing and hopeless state till the termination of his earthly sufferings, which took place on the 9th of July of the present year.

We regret that the length to which this memoir has extended prevents us from alluding in a particular manner to Dr. Griffin's able writings. The following is a list of his professional publications, and the papers published by him in the different medical periodicals:

1. A Treatise on Fever. 8vo. pamphlet. 1818.

2. An Essay on the Nature of Pain, with some Considerations on its principal Varieties as connected with Disease, and Remarks on the Treatment: being the Subject of an Inaugural Dissertation delivered at the University of Edinburgh. 8vo. pp. 86. Edinburgh, Moir. 1826.

3. Observations on Functional Affections of the Spinal Cord and Ganglionic System of Nerves, in which their Identity with Sympathetic, Nervous, and Imitative Diseases is Illustrated. By William Griffin, M. D., &c., and Daniel Griffin, M. D. London, Burgess and Hill. 1834. 8vo. pp. 247.

4. Observations on the Cholera, as it appeared in Limerick in 1831-2. 1834.

5. Medical and Physiological Problems, being chiefly Researches for correct Principles of Treatment in disputed Points of Medical Practice. By William Griffin, M. D., and Daniel Griffin, M. D. London, Sherwood and Co. 1843. 8vo. pp. 356.

Dr. Griffin wrote some papers in the Medical and Physical Journal, and was a constant contributor to the Dublin Medical Journal, both in its original and in its present form. The Medical and Physiological Problems, which he afterwards published in connexion with his brother, first appeared, together with other papers, in detached essays scattered over seven volumes of our former series; and the last of his labours (a paper on abortion) appeared in the Number for May, 1847. We understand he was preparing a work on cholera at the time of his death, which is now nearly ready for publication.

THE END.

THE MORTALITY

OF

IRISH MEDICAL PRACTITIONERS

FROM FEVER.

BY

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AND

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FROM THE DUBLIN QUARTERLY JOURNAL OF MEDICAL SCIENCE, No. VII.

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MORTALITY

OF

IRISH MEDICAL PRACTITIONERS.

It is necessary to state the circumstances which have induced us to direct our attention to the subject of this paper, the importance of which requires no comment, particularly at the present crisis.

In the year 1843 the Medical Charities Bill was brought forward, and we were not without hope that some recognition of the labours and risks of our professional brethren in Ireland would appear in the Act of Parliament; for we felt that the amount of these labours, and the nature of the risks, were not known to the Government.

In common with most of the hospital physicians and surgeons of Dublin, we had to deplore the loss of many of our most meritorious pupils, who, after a brief period of country practice, had fallen victims to typhus fever contracted in the discharge of their duties; and we felt that justice required not only that the remuneration for attendance on fever hospitals and dispensaries should be fixed at a liberal scale, but that some provision ought to be made for the widows and children of gentlemen who had lost their lives in the public service. We shall shew, even from a limited and imperfect investigation, that the risk of life in the public medical service

of this country is so great, as to demand the serious attention of the Legislature.

We had long mutually lamented the hardships to which medical practitioners in this country are exposed, and we came to the conclusion, that, if a correct statement of the average mortality of the medical profession in Ireland was submitted to Government, it could scarcely fail of making a suitable impression, and exercise a favourable influence in determining the scale of remuneration for attendance on fever hospitals or dispensaries.

In order to arrive at some determinate data, we addressed a circular to a considerable number of physicians and surgeons in Ireland, to the effect,—that as the regulation of the medical charities of Ireland was a question in which the Government and the Profession were much interested, we were induced, by a sincere desire to promote the welfare of our medical brethren, to request of them to furnish us with returns of professional mortality.

To this letter was appended a number of queries, relating to the names and localities of the different medical institutions; the number of medical attendants who had been employed in them during the last twenty-five years, or since their establishment; the number of medical men who had died while serving in them; the cause of death; and the number who had suffered from fever and other infectious diseases.

The statistical results obtained from the answers to this communication shall be presently considered; but before entering on them we wish to remark on the peculiar circumstances, in relation to attendance on fever, to which the Irish practitioner is exposed.

It is an admitted fact that, from whatever cause, or combination of causes, it may arise, Ireland has, from an early period, been far more productive of continued fever than either England or Scotland. Epidemics, affecting great numbers of

persons, have succeeded one another at short intervals of time; and it rarely happens that the towns are free from fever, while minor outbreaks of the disease occur continually in the rural districts. In this way Ireland may be said to be never free from fever, which, though necessarily not arising from contagion, is propagated by it in the most decided manner.

The extent to which fever exists in Ireland, and its influence on the mortality, has been strikingly shewn by the returns of the late Census. Mr. Wilde has given a table of the mortality from fever, and the general mortality of the province of Leinster for ten years, ending in June, 1841, a period, be it observed, not characterized by any remarkable epidemic of fever. From this it appears that, while the total mortality was 317,802, that from fever was not less than 29,821, amounting, as Dr. Graves observes, "to a fraction less than one-tenth of the whole mortality; whereas, in London, the fever deaths do not amount to more than one-fiftieth of the total deaths. This difference becomes more striking from considering that deaths in Dublin from fever are actually double the deaths from the same cause in London. The last Census made the population in London amount, I believe, to one million and a half, while that of Dublin is three hundred and sixty-two thousand."(*a*)

This is not the place to enter on the question of contagion at any length; for our purposes it is sufficient simply to state that we believe the disease to originate in combinations of causes, the exact nature of which has not been ascertained. When produced, however, whether in isolated examples or in epidemics, it is propagated by contagion, and that to a degree far more remarkable than what is observed in cholera. Of the propagation of fever in Ireland by contagion we have already observed that we have no doubt, but it may be right to state, in general terms, the kind of facts on which our conviction is founded. They are:—

1st. The number of cases of the disease occurring in indi-

(*a*) Clinical Medicine, p. 46.

viduals intrusted with the medical care of the sick, including physicians, students, nurses, and clergymen.

2nd. The circumstances attending its spreading in families.

On this subject the late Dr. Whitley Stokes, in his Observations on Contagion, published in 1818, has the following important remarks. After speaking of the fact, that in a family of twelve the disease had been known to visit eleven individuals, and that thus three months had passed before the family were free from the disease, he observes:

"In the general course of the epidemic, in the district in which this family resided, one out of seven took the fever. Had the family consisted of fourteen it might have been said, before the epidemic, that if two of that family sickened they bore only the average share of the general calamity; in the family of twelve, the sickening of two would have been more than their average share, and the sickening of eleven so much more, that the chance against that event would have been nearly 189,600,000 to 1.

"I proposed the following problems to a friend particularly acquainted with this species of computation:

"Problem the first.

"An epidemic prevails so severe, that one out of seven sickens. A family of twelve is selected in a particular district, before the epidemic has visited it; what is the chance that eleven out of that family shall take the disease, supposing the sickness of one of the family does not promote the sickening of another, and supposing the family not unusually liable to disease?

"Answer; the probability against the event is, 189,600,000 to 1, if the population amount even to seven thousand.

"Problem the second.

"The same general conditions being assumed, and also that the number of the inhabitants in the district in question is seven thousand. What is the chance that in any family of twelve, within the district, eleven will sicken?

"Answer,—it is above 300,000 to 1, that no family of twelve persons in a population of 7000 will have eleven sick.

"All this according to the conditions that the sickening of one does not promote the sickening of another."(*a*)

It is admitted that the mortality of fever is much higher in the better than in the lower classes of society; and it is certain it will be found that, when medical men are attacked with the disease, it is eminently malignant. This remark applies to the cases of medical students as well as to those of practitioners. In Ireland few medical men escape fever; though, in several cases, the disease did not occur until the individuals had attained advanced age. Of this the cases of the late lamented Drs. Clifford, of Trim, and Lloyd, of Roscommon, are examples, and others might be adduced.

The opinion commonly received, that the individual who has once had typhus fever is safe from future attacks, is not well-founded. That a certain degree of immunity is thus produced, we think, is certain; but that many persons in Ireland have suffered from a second, or even a third, attack of fever, at long intervals of time, must be admitted. Our returns shew that in several instances the medical officers of dispensaries have had typhus fever more than once; so that the going through the ordeal of fever,—always, as we have already stated, a most trying one to the medical man,—has not even the advantage of assuring him against a second attack, the more serious as he will then be more advanced in life, his vital powers lower, and his moral energies more exhausted.

It is difficult to explain why the fevers of medical men should be so commonly of a bad character. That the virulence of the disease is proportioned to the dose of contagion we believe; and when it is considered that many of our brethren have been exposed not only to a concentrated contagion, but that the morbid influence has long acted upon them, we can

(*a*) These calculations were made for Dr. Whitley Stokes by the late celebrated Dr. Brinkley, Lord Bishop of Cloyne.

conceive why their fevers should be so severe. And it too frequently happens that, urged on by a sense of duty, they continue their exertions, although in the earlier stages of the disease; and, while already the marked victims of fever, they still labour to save their fellow-men.

Whatever be the cause, it is certain that the fevers of medical men in Ireland are almost always of a bad character; and this even when the epidemic is not of the worst kind. The fever is generally of a low type, with eruptions of maculæ often coming out at a late period of the case. Nervous symptoms, of all the phenomena of fever the most alarming, commonly exist to a great degree. And as a result of this condition, the use of wine, which, among the lower orders, has so happy an influence on the disease, can, in many cases, be used but sparingly, if at all; and this at a time when the debility and prostration calls for its exhibition. If to this we add the injurious influence which the knowledge of danger must have on the system of a man feeling that he is struck down by the disease under which he has seen so many sink, and tortured by the thought of leaving a young and unprovided family, we can understand how it happens that the country is so often deprived by death of so many of its best educated and most devoted servants.

Thus, the medical practitioners in Ireland are placed in a position very different and far more serious than that of their brethren in Great Britain; for while the latter have only to contend with infectious fever occasionally,—and, rarely indeed, in the rural districts,—the Irish physician has to combat it in all situations, and at all seasons; and, in consequence of the peculiar condition of the peasantry, expose himself, often under the influence of cold, wet, fatigue and hunger, to its most concentrated contagion.

The system adopted so generally in Ireland, of isolated dwellings, has an important influence on the fatigues and risks of the practitioner. The poor cottiers live, for the most part, not in towns or villages, but in their solitary cabins, on their plots of

ground, and are thus removed from many of the advantages of social life: their dwellings are hovels, and scattered over the length and breadth of the land; and when an epidemic visits the country, it is easy to see that the position of their inmates must be, to the last degree, unfavourable; their distance from the residence of the physician, or from any other means of assistance, is a cause why disease may continue for days in the family, unknown to any but its members. Want, damp, dirty habits, and bad ventilation, all concur to render the disease virulent; and by the time that the medical man visits the sick, the hovel, with several of its inmates in malignant typhus, is one focus of concentrated contagion.

The causes, then, which appear to us to account for the remarkable mortality of medical men in Ireland may be thus enumerated:

I. The constant existence of fever in the country.

II. The frequent epidemics of the disease.

III. Its highly contagious nature.

IV. The want of ventilation and cleanliness in the houses of the poor.

V. The fatigue consequent on visiting a number of houses scattered over large and often wild districts.

VI. The moral and physical depression which the repetition of these influences is sure to produce on the practitioner, particularly when he reflects on his frequent inability to relieve the victims of want and disease by whom he is surrounded.

The mortality of medical men in the cholera bears no comparison to that from fever. In Ireland the number of medical men who sank from cholera was comparatively small, and, except at Sligo, there was no important loss of life among physicians. Very few students or nurses contracted the disease; and we are fully warranted in the statement that the contagion of cholera, even in its earliest outbreak, had much less intensity than that of typhus, as it permanently exists in Ireland.

Let us now turn to the evidence afforded by the informa-

tion acquired by the returns to which we alluded at the commencement of this article.

It must, however, be particularly borne in mind, that these researches do not approach a later period than 1843, and, consequently, the calculations grounded upon them do not apply to the question of the mortality induced by the present epidemic. This will require another and a separate inquiry, to which we earnestly invite the attention and co-operation of our brother practitioners.

From the returns to our inquiries, when statistically arranged, we learn that, during the twenty-five years prior to the date of the returns in 1843, 1220 practitioners were in charge of 406 medical institutions, a number very much less than in reality exists, or had existed during that period; but the error, if error there be in these as well as the other numbers in these returns, is to be placed to the credit side of the account, for the errors have been those of *omission*, not of commission. It must also be remembered, that the entire 406 medical institutions from which returns were received have not existed for anything like twenty-five years; but this error is likewise to be placed to the same side of the account. Of the 1220 medical men who have occupied these situations during the period specified, 300 have died prior to 1843,—nearly *one-fourth* of the whole, an immense mortality, when we take into account the ages at which the deaths occurred, and consider the various other circumstances attending this calculation.

Now, when we reflect that the nearest and most accurate approach to a general average mortality in Ireland is but one in fifty-two at all ages; and when we consider that the mortality among medical men above specified must have been chiefly spread over a period from twenty-five to fifty years of age—the usual age of medical men holding dispensaries,—it makes the mortality among this class enormous. These deaths, moreover, it must be remembered, do not include those of the apothecaries, assistants, pupils, deputies, or other constituents of the medical

staff attached to these institutions; nor do these numbers include the physicians, surgeons, pupils, and apothecaries unattached to public medical institutions, hundreds of whom must have died within the period specified. Of the entire deaths, 132 died of typhus fever, or nearly in the proportion of three to seven from all causes. It is proper here to remark, that the 168 deaths from other causes, not typhus fever, include many from other contagious diseases, cholera, scarlatina, &c., also acquired in discharging the public duties attached to the institutions which these medical officers served. 568 out of the 1220 suffered from typhus fever, or forty-six per cent. of the whole; of these 568, twenty-eight had fever twice, or 1 in every 20; and nine three times, or 1 in every 63, to speak in round numbers. As we already remarked, certainly one-half of the 406 medical institutions had not been in existence during the first twelve and a half years over which the inquiry extends; and it is evident that, by lessening the periods, the mortality must be increased: these are, however, statistical speculations, in which we would rather not indulge. The cities of Dublin, Belfast, Cork, Kilkenny, Galway, Limerick, &c. (nor, in fact, any of the large towns, such as Sligo, &c.), have not been included in these returns, which have been received from dispensary and fever hospital attendants almost entirely located in the rural districts. On this account, the returns, with few exceptions, have no reference to the mortality among the infirmary surgeons and the medical attendants in the cities and larger towns, which we know to be considerable

We learn from the Census of 1841, that the proportion of deaths from fever to the mortality from all causes was 1 in every 10.59, and 1 in 3.4 of the deaths of the total class of epidemic diseases; whereas the deaths from fever among the medical profession, as far, at least, as these returns enable us to judge (and it must be remembered that they necessarily omit a great number of deaths), shew a mortality of not less than 1 in 2.29.

We are able, in part, to supply the omission of town mor-

tality of medical men from Mr. Wilde's special Sanitary Report on the city of Dublin, where we find that thirty-six medical practitioners died of fever during the ten years over which the Census inquiry extended; and that the average age at which death took place among the class ministering to health, and including physicians, surgeons, apothecaries, veterinary surgeons, midwifes, and nurse-tenders, was from thirty to thirty-five in males, and fifty-five to sixty in females; the entire number of deaths being 112 males, and nineteen females.

Some explanation seems necessary to account for the interval which has been allowed to pass since these investigations were made. The results of the first investigation gave an amount considerably beyond what even we feared did exist. This was stated in our evidence before the select Committee of the House of Commons, and we determined to repeat the inquiry. The facts, therefore, which we now place before the public and the profession are the result of a double investigation.

The following extracts from our evidence in 1843, we give, not only to corroborate the above statement, but to remove any suspicion that we had taken up the subject lightly or hastily. The period which has passed, now four years, has only increased our conviction of the truth of the returns.

In answer to a question of Lord Eliot's, as to the necessity of removing medical officers from public situations, it was answered:

"1941. It is a very delicate matter to turn an old officer out who has had an attackof paralysis, or is broken down by the hardships of the profession; and there is great difficulty in arranging matters as to the removal of an officer from infirmity. I apprehend that, the moment the board is established, there would be few appeals for even inattention; but such would happen sometimes. The greater number of incompetent persons removeable would, I think, be referable to disease, most probably acquired in the discharge of their duties. In connexion with Dr. Stokes, I endeavoured to ascertain the mortality of the profession, but

the return was so formidable, so shocking, that we were afraid to bring forward the statement we had made up, and we are trying to verify it. We were afraid to bring it forward, because the statement might be questioned."—*Mr. Cusack's Evidence, Parliamentary Report*, p. 160.

"2037. *Chairman.*] Can you state whether the salaries of the medical men in Ireland attending charitable institutions are sufficient or otherwise?—In my opinion they are not sufficient, particularly in the dispensaries; and the reason I give that opinion is, that it is a fact that in Ireland a medical officer runs a greater risk of death from contagious disease than perhaps in any country in Europe.

"2038. Have you taken any means to ascertain that?—Mr. Cusack and I have been during the last year engaged in an investigation upon that point, and it was our wish to have it completed so as to lay it before the Government, and also this Committee, but it has not yet been completed; but the results, as far as we have gone, shew a very appalling mortality of medical men; and I know the fact from my own personal knowledge, for such a number of my pupils have been cut off by typhus fever as to make me feel very uneasy when any of them take a dispensary office in Ireland; I look upon it almost as going into battle.

"2039. Is it your opinion that the fever is peculiarly fatal to the medical men in Ireland?—It is peculiarly fatal to medical men.

"2040. *Chairman.*] Do you attribute the great mortality of the medical men to the want of ventilation in the hovels of the poor which they visit?—Most cases of fever of the medical officers of dispensaries seem to be attributable to the medical man having to enter the miserable hovels of the people, and to expose himself to concentrated and violent contagion."—*Dr. Stokes' Evidence, Parliamentary Report*, pp. 166–7.

To dwell at much greater length on the facts brought forward in this communication would be unnecessary, for they speak for themselves, and sooner or later must have that good

result which ever follows the statement of a truth. The researches only come down to 1843, and refer to the previous quarter of a century; but it is our intention to carry them on so as to ascertain the amount of medical mortality for the last four years.

We have the authority of Inspector-General Marshall for stating, that from January, 1811, to May, 1814, a period of forty-one months, or three years and a half, sixty-six officers were killed in battle in every thousand, and thirty-seven died by disease, making 103 deaths from all causes, or about ten and a quarter per cent.; but the mortality of the medical practitioners in Ireland, during a period of twenty-five years, is twenty-four per cent., to speak in round numbers(*a*). When to those considerations we add the appalling fact, that of the deaths of the medical men in Ireland, one out of every 2.29 has occurred from fever, the danger which attends the discharge of public medical duties in this country becomes sufficiently manifest.

It is time that these circumstances, for which scarcely a parallel can be found, should be known and duly considered; and the Government, while it, on the one hand, seeks to remove the causes of the spread of fever in Ireland, should, on the other, provide that the poor and destitute man shall not receive inferior or insufficient medical assistance; and reward with no niggard hand, and encourage by every means in its power, the exertions of a class of educated gentlemen, we fearlessly assert, the least prejudiced, the bravest, and the most philanthropic, in the community.

(*a*) It is hardly necessary to observe that we do not make these observations with a view of proving that the medical mortality in Ireland is greater than the military mortality in a period of war. We wish only to express the facts as we have them. And it must be remembered that during the period from 1811 to 1814, when the great battles of the Peninsular war occurred, the return of military mortality is complete, while the medical mortality, as above stated, is but a portion of that of Irish medical men for twenty-five years, and is, as we have shewn, much less than the true amount.

IRISH POPULAR AND MEDICAL SUPERSTITIONS.

A SHORT ACCOUNT OF THE SUPERSTITIONS AND POPULAR PRACTICES RELATING TO MIDWIFERY; AND SOME OF THE DISEASES OF WOMEN AND CHILDREN IN IRELAND.

PART I.

MIDWIFERY.

It is scarcely necessary to inform the educated reader, that a superstitious creed, and certain mystic rites, derived from the earliest times, attach to almost every nation in a certain state of society; that some of these are of almost universal acceptation, that others belong to particular localities or races, and that their geographical distribution is a source of interesting investigation, both to the historian and the ethnologist. In many countries these rites and practices are still prevalent, and in others, more advanced in civilization, they are merely preserved in the ancient ballad, the bardic legend, or the traditional romance.

To enter into the inquiry as to the pagan, druidical, budhist, or christian origin of these, and to compare the superstitions of one country with another, would be a subject of most inviting interest, but unsuited to a periodical such as the *Monthly Journal*. The last remnant of superstition in any country, will, for obvious reasons be the medical—the charm, the herb cure, the incantation, and fairy invocation, to avert or relieve disease. In Ireland, from the character of its inhabitants, and its peculiar political, religious, and social condi-

[1] The portion of this paper relating to Midwifery, is an abstract of a communication made to the Dublin Obstetrical Society upon the 1st March, 1849.

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tion, there has up to the present time existed a wide and fertile field for the collector of folk's-lore and popular superstition. We have, moreover, a large collection of native medical manuscripts in the ancient Gaelic language, some of them of very great antiquity, in which many of our popular cures and medical practices are preserved. Of the general tenor of all these works, and of the particular merits of some, I have already given a description.[1] For the present, I may remark, that while they resemble in many particulars the books of Paulus Ægineta, an edition of which has been lately published by the Sydenham Society, they far surpass in interest to the medical antiquary the value of that work, by the quantity of local, historical, and topographical information which they contain. Many of them are, moreover, useful in a literary point of view, being good specimens of the now nearly extinct Irish language. They are, generally speaking, translations from some of the ancient classic medical authors, with commentaries by native physicians. From these works, from the legends of the last century, and from practices in vogue almost up to the present, I have, with the assistance of friends—Irish scholars, and country medical practitioners—made a large collection of general as well as medical popular superstitions, with the intention of arranging and publishing them at length upon some future occasion. The present condition of this country, the total disorganization of society, extending from the poorest to the highest, the ravages lately made by famine and pestilence, and the enormous emigration which has been and is still going forward, added to the general spread of education, and other circumstances a description of which it is here unnecessary to enter upon, are however obliterating our superstitions with such rapidity, that, in the hope of eliciting inquiry upon the subject, I have been induced to bring forward a portion of my stock without further delay.

PHILTRES.—As love or desire in some shape or another is generally the forerunner of the pregnant state, I think a detail of a few instances of love charms, philtres, potions, and incantations, administered or performed to promote desire, should properly commence this communication. These may be divided into the employment of certain herbs and medicinal substances believed to promote desire, and the performance of certain mystic rites and ceremonies of a rather diabolical nature. There are many Irish legends referring to such rites, and the old bardic traditions make frequent allusions to them. The belief in the efficacy of such means—which, I may remark, are generally resorted to by females, to excite or regain the affection of the other sex—is of great antiquity, and of very general acceptation in all half civilized countries.

[1] See the letter on the tables of deaths in the Irish Census for 1841; and an address delivered at the King and Queen's College of Physicians, Dublin, last year, and published in the *London Medical Gazette* for March 1843.

Othello won Desdemona, it is said, "by conjuration and mighty magic," and

> "—— Practised on her with foul charms;
> Abused her delicate youth with drugs and minerals
> That waken motion."

In Ireland, some years ago, there was scarcely an old herb doctress who could not prescribe something of this kind, and even yet, few years pass that we have not several instances of the administration of cantharides with the intention of promoting desire.

But that the following very remarkable, and disgusting superstition (probably Pagan), has been related to me by at least three persons worthy of the highest credit, and residing in different parts of the western country, I should be inclined to refer it to a period called "The dark Age." In this and all the following rites and superstitions, I shall, in order to economise space, relate the simple facts, stripped of their historical and topographical details.

A female, accompanied by a charm-working crone—such a *cailleagh* as would have been burnt in Scotland with the "witch's branks" in her mouth not long ago,—proceeds to a church-yard, and at dead of night (twelve o'clock), exhumes a male corpse which has been nine days buried. With a black-handled knife[1] she removes a stripe of integument a couple of inches broad from the entire length of the body—from head to heel—including if possible a portion of those parts which are usually covered with hair, as the scalp, face, breast, pubis, &c. Having restored the corpse to the grave, the strip of skin is next stretched upon a tomb-stone, and over it certain spells are cast, and certain incantations pronounced by the attendant priestess, who sprinkles it with water found in the hollow of a sacred stone,[2] and then folding it up in the form of a cross, places it over the beating heart of the credulous girl, who, under her dictation, mutters certain other incantations.[3] Thus provided, the love-sick lass returns home, and, watching a fitting opportunity, surrounds with this charmed bandage either the breast, leg, or arm of the man whose love she wishes to obtain. To prove efficacious, it must be applied and removed without his knowledge; to effect which a state of anæsthesia by means of whiskey is generally induced.

ABORTION.—Next in order we should consider procured abortion, instances of which frequently come under the cognizance of the medical man and the magistrate. Here, as in the former case, the

[1] A black-handled knife possesses particular virtues, and is used in performing several of our ancient pagan rites.

[2] It would far exceed the limits or intention of this paper, to note or describe these various formulæ in extenso, but I may remark, that water found in the hollow of an old tomb-stone or the socket of an ancient cross, is considered highly efficacious in the cure of many diseases.

[3] Except in a very imperfect way, I have not been able to procure the form of words employed. I have, however, known an instance in which this fleshy girdle was bound upon the pudendum in the hope of procuring abortion.

she-quack is generally referred to, and besides the inculcation of certain mystic ceremonies and Pagan rites, of which the foregoing may be taken as the type, she administers the most drastic purgatives and emmenagogues, of which aloes and gamboge are the chief ingredients. Certain herbs and plants, particularly rue and savine pulled in a particular manner, which I shall describe upon another occasion, are believed by the country people to effect a like end. Whether medicinal substances or herbs are employed, a certain ceremonial is likewise enjoined. Can we wonder at the ignorant Irish girl wishing to conceal her shame by the destruction of her offspring, in a country acknowledged to be one of the most moral in Europe, and where *caste* is more certainly lost by the circumstance of pregnancy before or without marriage than in any other, when in lands boasted to be the most civilized, induced abortion, even among married females, in the upper ranks of life, is spoken of in society without reserve.

Impotency and Barrenness.—The possibility of procuring either impotency or barrenness in man or woman is firmly believed by the lower orders of Irish, who think that such can be effected by a charm as well as the employment of medicinal substances. The former is most dreaded during the solemnization of matrimony, when it is believed that if a slighted lover or any person jealous of the happy couple be present, they have a power, by casting a certain number of knots, and setting a spell, of producing either impotency or barrenness. To avoid the effects of this charm, it was no uncommon thing sometime ago, for the peasant bridegroom to appear before the officiating clergyman with all the knots and various fastenings about him loosened—as his cravat, the knees of his breeches, his shoe-ties, and suspenders, &c.; and the female, who dreads such a catastrophe as unfruitfulness, retires with her attendants to undress immediately after the marriage ceremony. This is a very popular and widely spread superstition, common to Scotland,[1] and to many other countries as well as Ireland; and the casting of knots was one of the accusations frequently brought against the witches and warlocks north of the Tweed.

There are several Irish terms of very significant meaning employed in our early manuscripts, and still in use among the Irish-speaking people, to express impotency and barrenness. *Amrid*, meaning simply, barren or unfruitful, is a very common term in Munster at the present day, as well as the phrase *Fuarnd maireann agi*, meaning a man with whom it liveth not. *Meatacht*, cowardliness or failure, is also used by the country people in the same sense, and is likewise to be found in the ancient writings.[2] In

[1] See Dalziel's "Darker Superstitions of Scotland."

[2] The male organ of generation is styled in the manuscripts, both medical and general, *Erball na Feithe*, Cauda Nervorum, the tail of the nerves; but in the spoken language it is usually termed *Bod* or *Ball Ferda*, the manly member, or *Ferdacht*, manliness. *Congab*, means the parts of generation in either man or woman, but *Congna*, a horn, is applied only to the male. *Magrailte*, is the testes, and *Silne* or *Shillnay*, the seed.

The female organs are in vulgar language called *Pit*; but a more refined expression, and one used in the manuscripts, is *Tod*, signifying female purity; or *Féile*, literally "modesty," but this is occasionally applied to the organs of both sexes. The word *Féile*, modesty, is derived from a very ancient historic legend, "Fial, the wife of Luyhaidh, was a lady of strict virtue, and uncommon modesty, for she was so confounded with shame because her husband had seen her naked swimming in the river Feil, that she languished and died of grief. The stream received the name of *Inbher Féile*, from the fair Milesian, and is so called to this time."—See Keating's History. This circumstance of a death from modesty occurred, it must be recollected, a long time ago—immediately after the Milesian landing. *Bandacht*, womanhood or puberty, is another term still in use.

a very old Irish law, preserved in the manuscript collection of Trinity College, the term, *Ban beim*, literally a white blow, that is a blow that does not cut or draw blood, is employed to express procured impotency. It also means any bodily infliction which leaves no mark or scar. The passage runs thus—"What blow is it for which twenty-one cows are paid (as *eric* or *fine*)? The white blow for which the twenty-one cows are the eric, is this;—If incantation or charm has deprived the man of his hollow sinew (or nerve of desire as it is elsewhere rendered) or the woman of her sloe of desire, there are seven comhals equal to twenty-one cows to be paid for it. For every infliction is a white blow to the shedding of blood."[1] Other early Brehan laws likewise appoint certain punishments for procuring impotency or barrenness, either in man or woman.

The "Sloe of desire," alluded to in the foregoing passage, refers to the ovary or *Cnu*, the nut, so called from its resemblance in shape, and somewhat in colour, to the unripe fruit of the black thorn (Prunus Sylvestris; in Irish, *Droigheann*.)

To procure barrenness, it is even still a practice to administer some milk in which a grass mouse (Sorex Araneus; in Irish, *Luch Féir*) has been boiled;[2] and in order that a woman may not bear more children, the after-birth is buried under an elder tree and covered with a wooden bowl by three old women. I believe, however, that it is necessary

[1] See the Brehan laws preserved in the Library of the University of Dublin, H. 3-18. p. 229. For this extract as well as for much valuable assistance in arranging the Irish terms used in this memoir, I am indebted to my learned friend, Mr Eugene Curry. Indeed, without the aid of this distinguished Irish scholar, few works bearing upon Irish Archæology could now be produced.

Mr Curry has given me the terms and various passages in the Irish character, but independent of the difficulty of printing Irish, except in this country, it might appear pedantry to print them in a character so little known even to philologists. I have therefore written them with the Italian character. Those who desire to see the names of most of our fatal diseases printed in Irish, I may refer to my Nosology given in the medical memoir attached to the last Irish census.

[2] "The heart taken out of a mouse when alive and tied about the arm of a woman, prevents conception; as Sextus saith."—K'Eogh's Zoologia Medicinalis Hibernica. Dublin, 1739. p. 65. See also Bell's British Quadrupeds.

to perform certain mystic rites and incantations during this ceremony, but these I have not been able to procure, as the old women and midwives are very chary of imparting this description of knowledge.

There are several special treatises on Midwifery in our collection of medical manuscripts. There is one curious midwifery tract in particular, copies of which are preserved in at least three of our most esteemed records. In this work a great number of receipts are given, both to procure barrenness and to induce fruitfulness in man or woman, as well as to prepare the latter for conception; to expedite delivery; and to discover whether females are pregnant, &c. Of these, the following specimens out of many, may suffice to afford the reader some idea of the nature of the work, as well as its date. The vellum copy from which I have had these extracts made, was transcribed in 1496, from Fiongan MacTully's book.[1] "To burn the meal of *Darnel* and frankincense on a red stone, and let the smoke pass through a funnel under her (a woman), and that will prepare her for conception." This receipt is probably copied from one of the ancient classic authors. In the commentary to the works of Paulus Ægineta, by Mr Adams, lately published by the Sydenham Society, we read that Darnel "may be set down as the *Lolium temulentum*. Dioscorides gives the fullest account of its medicinal faculties; * * * and used in a fumigation with myrrh, saffron, and frankincense, he says, it promotes conception." Vol. 3, p. 26.[2]

"Let *Neft* be boiled on wine or on water, and let her sit on a stool with a hole in it, and let the smoke pass under her; or let it be burned on a red stone, and its smoke pass under her; or let the herb itself be placed in her *Féile;* and,—Let the blood of a hare and its runnet be dried and powdered, and drank upon some wine, or ale, or milk, after the menstrual flood, and she will conceive." The Neft was probably the Nefrin of the ancients, which modern authors think was the oriental Narcissus. The hare seems to have been not only a charmed animal, but possessed of peculiar medicinal properties among our ancient Irish authors. Its liver is still used as a cure, or rather a preventative in epilepsy, hydrophobia, and other diseases of the nervous system. MacTully's book contains, among other aphrodisiacal receipts, the following:—"To dry the penis of a hare, and powder it, and that powder to be taken by the man and the woman, and the woman shall conceive a son; but if it be the woman alone who takes it, she conceives a daughter." The testes of the boar and the roebuck, as

[1] Fiongan MacTully was one of the hereditary Irish physicians. He resided at Aughalustha, in MacDonnoch's country, on the borders of Roscommon and Sligo, in the province of Connaught. For an account of the hereditary Irish physicians and their works, see the *London Medical Gazette* for March 1848. See also O'Halloran's surgical works, and the *Dub. Quart. Jour.* for Aug. 1848.

[2] Darnel grass, in Irish *Raithléadh*, "stops the flux of the belly, the immoderate flux of the menses, and incontinence of urine."—K'Eogh.

well as the goat, together with several of our native plants, are likewise enumerated among the various receipts, either for removing or for procuring barrenness, given in this curious old work, which any of my readers, acquainted with ancient medical writers, will at once perceive was written, not only in the style, but according to the medical knowledge, of the middle ages. Besides the information which it affords as to the state of medical knowledge, it is also exceedingly interesting for the zoological and botanical information which it contains upon this country at the time in which it was written.[1]

In another medical manuscript, transcribed about the middle of the fifteenth century—a commentary upon some of the aphorisms of Hippocrates[2]—there are many curious reasons assigned for unfruitfulness in women; among the rest that of excessive fatness, by which the os uteri was said to be partially closed. The word fatness, however, means here "fleshiness." Coldness and smoothness of the womb are likewise assigned as causes of unproductiveness; and many very extraordinary receipts are given for the removal of that state, as well as to enable the practitioner to form an accurate diagnosis as to which sex the cause of barrenness exists in. Evidently the works of Avicenna and Rhazes have been the original sources of these opinions and remedies.

We are all aware how frequently barrenness depends on physical causes, susceptible of removal by art. Before midwifery was brought to the perfection to which it has at present arrived in the city of Dublin, and just before the time when Mosse, by establishing our noble Lying-in Hospital, placed the obstetric art on a sure and scientific basis—and in so doing gave a blow to quackery in that department at least—there resided in Dublin a celebrated doctress,

[1] Some years ago, Mr Eugene Curry discovered, among the manuscripts in the collection of the Royal Irish Academy, a very curious poem, probably as old as the fifth century, in which the various animals then known in Ireland are enumerated. The circumstances attending its history are these:—Finn Mac Coole is made prisoner by Cormac Mac Art, monarch of Erinn, who, however, consents to liberate him on being paid a ransom of a couple or pair of every wild animal, which were to be brought to him to the Green of Tara. Cailte, one of Finn's chief officers, takes upon himself this apparently hopeless task, and the poem is a relation of his exploit to St Patrick.

Upwards of five years ago Mr Ball made a communication to the Academy on the subject, a short notice of which will be found in the proceedings of that body for the 12th of February 1844. I am not aware of any further investigation into this matter since. Many of the animals are not now known, or at least cannot be recognized by the names given in the manuscript. It would very much have added to the interest of the subject, and perhaps have ere this been attended with beneficial results, had the poem itself, which is very short, been printed in full, as thereby persons in distant country parts, as well as those engaged in the investigation of subjects connected with early Irish history, might have recognized some of the ancient names, and decided to what animals they belonged. There is another copy of this poem in the possession of Mr M'Adam of Belfast, who, with Mr W. Thompson has, we are glad to find, been working upon the subject.

[2] Library of the Royal Irish Academy, E. 3, 30.

famed for her powers of relieving barrenness. This woman, named Mary Walker, whose advertisement in the Dublin Courant, No. 458, for 1747, says that she "arrived here from Philadelphia, Venice, Madeira Islands, London, and Liverpool," entered into engagements with several ladies to render them fruitful; and, in one of our Dublin newspapers for 1749, there is an account of a trial, in which she sued for breach of contract a lady of high rank. She succeeded at law, and recovered the stipulated sum.[1]

There are several sacred shrines, as well as supposed holy rites, still resorted to by the unfruitful in this kingdom; the most remarkable of which is a saint's bed, in the Island of Arran, off Galway Bay, to which females, even of the better classes, when hope was long deferred, were accustomed to resort, and spend a summer's night. At the Patron of Glendalough, upon the 3d of June, the pretty girls of Wicklow may still be seen embracing the large sculptured cross, opposite the western entrance of the cathedral, in order to induce fruitfulness, as well as in the belief that, by so doing, they shall "never die in childbirth."

Pregnancy.[2]—The peculiarities and popular prejudices common to the pregnant state, next in order, claim our attention. It was a popular belief among some of the lower orders, that a woman dying during pregnancy was saved hereafter in virtue of the sinless offspring which she carried. This peculiar, but not very widely spread, superstition—which I have known exemplified in this city not many years ago, when an unfortunate female was killed by accident, and great solicitude was evinced by her companions during the coroner's inquiry to ascertain the fact of her pregnancy,—appears to have descended to us from times before the acknowledgment of modern polemical dogmas; for, at present, unbaptized infants are not supposed, by some of the christian churches, to come within the pale of perfect redemption, but pass into a state of almost non-existence. Such children are therefore never buried in consecrated ground, but in graveyards set apart for the purpose.[3]

Very numerous, indeed, are the superstitions attending the preg-

[1] Several of Mary Walker's Puffs and Advertisements,—from 1747 to 1749—are before us, as also the affidavits, sworn before the Lord Mayor, of persons benefitted by her art. Among her qualifications I find the following:—"She likewise will tell, in twenty-four hours, whether it be the husband's or wife's fault that they have no children, and will make him or her be as fruitful as any man or woman in the kingdom, provided the woman be not past childbearing." Medical practitioners of the present day have acquired celebrity, if not by a like means, at least by inducing a similar effect.

[2] Pregnancy—In Irish, *Torrachus*.

[3] For some of the popular legends illustrating this belief, see the articles on "Irish Popular Superstitions," in the *Dublin University Magazine* for May and June, 1849.

nant state. The following may suffice as examples of these:—One of the most general is the belief in "Mother's Marks," which are usually supposed to be the result of accident or fright. Thus—

Seeing a hare is supposed to produce a harelip in the offspring; and, as a charm, it is recommended to the pregnant woman so circumstanced to make a small rent immediately in some part of her dress.[1] Small clustering naevi upon the face or neck are generally attributed to raspberries, bunches of currants, or other fruit having been thrown at the mother while carrying. These marks are firmly believed, even by intelligent persons, to ripen during the season when the fruit comes to maturity: an idea which receives some degree of support from the circumstance of a heated atmosphere, as in summer, always making these marks appear more red and prominent. The flat, extensive, and cutaneous nævus, which is generally of a claret colour, is believed to be caused by wine having been accidentally spilled over the same spot in the mother as that in which it appears in the child. The raised lipomatous tumour, which is usually of a dark colour, and often covered with hairs, like an ordinary mole, is popularly attributed to the fact of a mouse or rat having been accidentally seen by, or having been thrown at, the pregnant mother. To avoid the effect of frights of this description, the woman so circumstanced is directed to place her hand immediately upon some part of her body not usually exposed, in order that the mark, which it is believed will appear upon the child she carries, may be seated there; as, wherever the hand first touches when the fright takes place, there it is supposed the spot or deformity will be present in the offspring.

The various monstrosities, as well as those congenital marks just alluded to, are believed to be the result of some strong impression made upon the imagination of the mother. If a woman, while "carrying," wipes her foot or shoe in the grass of a churchyard, it is firmly believed by many of the lower orders that her child will have a club foot or *Cam Reilge*.

The numerous imaginary longings, appetites, and desires of pregnant females are too well known to require description here, and are not peculiar to this country alone.

Although the normal term for gestation in the human female is nine months, there are certain circumstances under which it is believed it may be prolonged; for instance, if a woman in "the family way" passes under the head of a mare with foal, it is a popu-

[1] These superstitions attending the pregnant state are perhaps more widely distributed, and form a more general belief, even among educated people, than any others that I am aware of. In the works of the celebrated Malblanch there is a curious relation of a female in Paris, who, having gone, while in a pregnant state, to see a man broken on the rack, was so much affected by it that her child, when born, had all its limbs out of joint. Whatever may be the cause, this is, at least, one of the earliest instances of congenital dislocation recorded.

lar belief that she will carry her child as long as the mare does her offspring.

In order to ascertain the fact of pregnancy as well as fecundity generally, there are many superstitious practices resorted to, of which the following example may suffice. At Ballymascaulan, near Dundalk, there is an ancient cromlegh of great size, the top stone of which is supported on the points of three others. This upper horizontal flag is smooth and convex upon its upper surface, so that it is with difficulty anything will rest upon it. A woman visiting this stone may ascertain whether she will ever have a family, and how many, by trying to throw a pebble on the top. If she succeeds, it is regarded as certain that she will be fruitful, and the number of stones she can lodge on the top represent the number of times she will conceive. It is no uncommon thing for the midwife or accoucheur to be asked by the friends of a recently delivered woman how many more children she will have. They are expected to be able to tell by the number of "knots" (or contortions in the vessels) which appeared in the funis.

In the ancient manuscripts, already referred to, we find some curious notices with regard to means for procuring a change of sex,—thus "to procure a change of birth in a woman who has brought forth daughters only,—to boil the testes of a wild boar (*Turc Allaidh*) upon new milk, and eat them, and drink the milk at the time of the monthly blood (*Fuil misa*)."

"The woman who brings forth daughters only, this is her cure, viz., to tie the (*Fiacail*) tooth of a stallion in a thong of seal skin, and to put them under seven masses,[1] and to suspend them at her neck." These curious receipts, to which analagous ones will be found in the old English herbals, as well as in the ancient classic authors, were once believed to be efficacious by the medical profession. It is strange but true that what is now regarded as a popular superstition, was acknowledged as science some hundred years ago. Several examples in proof of this might be adduced from the works of Paracelsus, but even many of the opinions of Sir Thomas Browne, who wrote against "vulgar errors," are at the present time believed to be erroneous, if not superstitious.

Under the head of pregnancy may be included accidental abortion, concerning which we find the following notices in the manuscripts. "Knowledge of bringing forth abortion properly,—viz., to boil *Buafalan* (Jacobea vulgaris, or rag-weed) upon water, and put it under the woman, and she shall bring forth safely."

"The seeds of water cresses (*Bilrugh*, Nasturtium Aquaticum) to be boiled on whey for a woman, and she will bring forth a miscarriage."

[1] When the peasantry wish to render any object sacred or medicinally efficacious, it is laid upon the altar under the gospel, during the celebration of a certain number of masses.

"The juice of the *Gall-biolar* (foreign water cress), to be drunk by a woman who has a dead child." Also for the same purposes, it is recommended "to put horse dung upon a red-hot flagstone, the fumes of which taken into the nostrils, are related to be highly efficacious." "For the shedding of blood of a woman, boil *Esbuc-bân* (Bellis Major, or great Ox-eye-daisy) on new milk and glorium, and let her drink it." For further information upon the virtues of these plants, we must refer the reader to the works of K'Eogh and Threlkeld.[1]

In order to procure a safe delivery, the following receipt is given. "The tops of *Briseláin* (Potentilla anserina, or silver-weed) to be broken and boiled on beef's tallow, and squeezed through a linen cloth; then mixed with wheaten meal and salt, and boiled again. Of this to eat nine bits fasting, and three at lying down, during nine nights; and it is to procure safety it is done."

MIDWIFERY.

We now come to the investigation of the more immediate object of this paper, the popular and superstitious practices employed in midwifery, under which head may be considered not only delivery but the puerperal state. In the notes to pages 4 and 5 I have already explained the meaning of certain Irish anatomical terms for the genitals. The uterus is not only in the manuscripts, but in the spoken language, termed *Macla*, or *Maclog*, literally "the place of the son;" the place or situation of the child, for the *Mac* is in this case equally applied to males and females. Another term for the womb is *Luighsheol*, the child's bed. Delivery, or the act of child-bearing, is denominated *Ces Naidhean*; but in our ancient medical writings the Latin terms are generally employed, although spelled with the Irish character.[2]

The midwifery practice among the lower orders in Ireland, and the various superstitions appertaining to delivery, would form materials for an entire essay; and many curious anecdotes and ancient legends are related of the Irish accoucheuse, for some account of which we would refer our readers to Carleton's Introduction to "The Irish Midwife," in his "Traits and Stories" of the peasantry. It is curious, however, that there is no Irish term for the word midwife.

Tedious and Difficult Labour.—In tedious labour, innumerable devices, charms, and mystic ceremonies are had recourse to. One of the most common, is that of loosening every place, person, or thing in or about the house, unlocking all the locks, unbarring

[1] Synopsis Stirpium Hibernicarum; alphebetice dispositarum sive commentatio de plantis indiginis, præsertim Dublinensibus instituta, &c. &c.—Auctore Caleb Threlkeld, M.D. Dublin, 1726.

[2] Any disease of the female genital organs, or the anus, is thus popularly expressed, "A disease between one and the ground." Prolapsus uteri is so termed, and in Irish *Taitim an Maclaigh*, a falling of the womb; or a falling of the place of the son.

doors and windows, untieing all knots, and even setting free the cows in the byre, in the hope that, by some occult sympathy, not well defined, the matrix may be induced to dilate, and the womb expel its imprisoned contents. It is also done to prevent any charm, such as the casting of knots, &c., which might have been performed by an evil-minded person, proving efficacious. But that it would lead us from our original intention, we could show that this was one of the most widely-spread of all medical superstitions.

I have known the following anecdote—a hackneyed one among country crones—related by the nurse-tender to a lady, to amuse her while "her time" was passing slowly. Among the cures and charms supposed to facilitate labour, in cases where it exceeds the usual duration, is that of placing a cuckold's hat, if such can be found in the vicinity, upon the head of the patient. In one instance, several hats belonging to the neighbours had been tried, but without success, when the groaning wife cried out in despair, "Arrah—don't be taising me any longer, but bring me Paddy's caubeen." Her husband's hat was accordingly made trial of; and, it is said, soon proved efficacious. The labour was no longer in vain; the cap fitted.

It is boasted that the Irish midwives were acquainted with the efficacy of spurred rye, or smutted corn, long before the ergot was made use of by regular practitioners. But in cases of want of uterine action, several other substances were employed, some of rather a disgusting nature. Among the rest the husband's urine was regarded as highly efficacious. To promote labour the country midwives sometimes placed the parturient woman with her hips directly opposite a roasting fire, as is the common practice in several parts of India. In some localities it was not in former times uncommon, when the labour was very tedious, to get two or three stout men to shake the unhappy patient backwards and forwards in her bed with great violence; and for some reason, which I am unable to account for, a ploughman was more frequently chosen for such purposes than any other person; but, to prove efficacious, he should be taken direct from the plough. Owing, however, to the number of country midwives that have of late years been educated at our different lying-in hospitals, practices such as those related are seldom had recourse to now.

Labour girdles,[1] as well as the cord of St Francis, were much employed in Connaught some twenty or thirty years ago, in order to ensure a safe delivery. They were even had recourse to by

[1] The first of February or Candlemas day is a high festival among the lower orders in the South and West of Ireland. Among the various rites and superstitions then performed, is that of setting a charm for a labour girdle. This latter is either a ribbon, or a band, or scarf, which having been duly incanted, is hung upon a line or hedge in some exposed place during the night. If, upon examination next morning, it is found to have increased in length, it betokens length of days; but if it has got shorter, it indicates an untimely end to the person who performs the charm. At all events, it becomes endowed with peculiar virtues, and is ever after called the *Brat Brighde*, or St Bridget's Garment, from its having acquired its peculiar powers upon the festival of that Saint.

persons in the middle ranks of life, particularly, before any manual interference was permitted. Not only was the patient encircled with the sacred girdle, but she was also surrounded with several other charms and amulets. Those round or ovoid stones which we sometimes meet with in grave-yards and ruined churches, by the sides of holy wells, and on the rude stone altars in the extreme west of Ireland, are believed to possess certain obstetric virtues, and are carried a considerable distance and laid in the bed of a woman in labour. In the vicinity of Clonmacnoise, a friend of the patient is despatched, in any case of tedious labour, with directions to embrace the large stone cross, which still exists among the ruins of that sacred spot, so that the points of the fingers may meet around it; and if, from the shortness of the hands or arms of the person so employed, it is impossible to effect the desired object, then a handkerchief or some article of dress is made use of to complete the span. Upon the return of the messenger, who may be either male or female, the woman in labour is embraced by him or her in the same manner, and in this way the "knot of childbirth" is immediately unloosed. Some of the old midwives pretend to effect the like object by knotting and then untieing over the patient a number of ribbons, on which they had previously pronounced certain prayers and incantations. It was also customary in the west, to attempt to procure a safe delivery, by counting nine articles of clothes (men's if possible), over the woman "during a pain."

The midwife generally consoles the mother under her sufferings by assuring her, that in proportion to the amount of pain she experiences, so will be the love and affection of her child. A very popular belief which midwives rather encourage than otherwise, and to which many witty allusions are made by the people, is that these practitioners possess the power of transferring the pains of labour from the groaning wife to a man;—to any person they wish. The husband is generally the person selected, but old bachelors are said to be, above all others, objects of the midwives' vengeance; on which account, as well as the quizzing which they generally get upon such occasions, these celebats are seldom seen at the houses of the peasantry when the woman is "in the straw."

If we turn to the manuscripts, we find some curious receipts given to hasten delivery. "The milk of a hound and of a ewe, and wine; equal quantities to be taken as a drink, and she shall be immediately delivered." "For a woman to bring forth a child without danger, let the following words be written on vellum, and tied on her abdomen, viz. [1]Maria peperit; Christum peperit; Anna peperit; Maria, Elizabeth, et Johannem, Celestium Remegium. Satur, Arepo,

[1] These words, written in the form of a square, with crosses between them, form a charm of very ancient date, and described in most books of magic.

Tenet, Opera, Rotas.'"[1] And in later times, K'Eogh, from whom we have already quoted, in enumerating the virtues of the hare, says, "the eyes drawn entire out of the head of a hare taken in March and dried with pepper; one of these being so tied to the belly that the sight of the eye may touch it. This will facilitate labour in women, but the child being born it is to be removed, lest the womb also comes out." Need we wonder at popular superstitions long remaining in a country where this was gravely put forward by a Bachelor of Arts, and Protestant Chaplain to the Baron Kingston of that day!

Unnatural Presentations.—In cases of cross birth women used actually to be turned upside down, and while thus suspended by the feet shaken violently in order to alter the position of the child. This custom, however, is now very rarely resorted to. Notwithstanding, I am informed, that a death actually occurred from its employment not many years ago, near Gweedore, in the county of Donegal.

Spontaneous evolution was, it would appear, known to the early Irish midwives. I have heard several old physicians state that they had been informed of the fact by country nurse-tenders long before my friend Dr Douglas's valuable essay appeared. In Gabelhover's book of physic printed in 1559, there is a receipt given:—"To cause a childe beinge ether alive or deade, to revert or directlye turne itself agayne in his mother's bodye lyinge therein indirectly turnede," (p. 235). The same work contains many curious receipts on subjects connected with midwifery similar to those which I have quoted from the Irish manuscripts.

The rude interference of some of the country midwives, particularly in the province of Connaught, caused frightful consequences in former times. I have heard my father, who was in extensive practice in that part of the country, say that he had known midwives constantly attempt forcible extraction of the fœtus, with the hook of an ouncel or steel bar; and I am informed by practitioners residing in the county of Galway still, that some years ago, when any difficulty or delay occurred in the child's head passing through the external parts, the midwives used to cut or lacerate the perinæum with a sort of curved knife called a "*meadog*," formed out of the point of an old reaping-hook.

The belief in the virtues of the caul or membranes as a preservative against fire and water prevails in this country, as well as in England, yet I have never read or heard of one being advertised in our public newspapers, a practice of rather common occurrence in England.[1] Even the caul of a calf, or some domestic animal, is looked upon by our peasantry as efficacious, provided it is expelled unbroken. It is generally preserved and thrown over the collar-beam of the

[1] See a very entertaining little book, 'Popular Superstitions,' published in the Series of London Anecdotes, p. 122.

house. May not the virtue attached to unbroken membranes have had its origin in the sage advice of some observant practitioner, inculcated for the purpose of preserving them unruptured to the last?

In dividing the funis, the midwives always leave a longer portion attached to the abdomen of a male than to that of a female child.

To predict the sex of a woman's next child, it is only necessary to observe the following rule. If the woman's last child, or even abortion, was born when the moon was on the increase, it will be a boy; but if on the decrease, a girl.

Hemorrhage.—In cases of flooding a number of popular remedies are employed; some medicinal, others partaking of the nature of a charm. A very old one, and now nearly obsolete, is to bury a harrow pin in the ground and leave it there till the woman's safety is insured. It is also a common practice to include the wrists, ankles, fingers, and toes in tightly drawn ligatures in order to arrest the return of the blood. In menorrhagia it is usual to tie worsted thread upon the fingers, particularly on the last phalanx of the thumb. I have seen very injurious consequences arise from the constriction employed in such cases. Not only in uterine hemorrhage after delivery, but in that which occurs in connexion with the menstrual function, a very popular remedy some years ago consisted in the administration of a few drops of the discharged fluid, mixed with a weak solution of the sulphate of copper. Where the hemorrhage occurred in the unimpregnated female, it was customary to bury, without the patient's knowledge, some of the discharges. Burned cork is still a very popular remedy.

In the manuscripts, yarrow is recommended to be mixed with some fluid and drunk as a styptic. The various popular remedies for hemorrhage generally which I shall describe hereafter, are also made use of in that occurring during childbirth;—among the rest, pig's dung, which is believed to be highly styptic, and consequently applied as a poultice to the abdomen.

Management of the Placenta.—In cases of retention of the after-birth, it is even still a practice to force a piece of mould candle down the patient's throat. It is possible that, by inducing vomiting, it may prove efficacious in causing the uterus to expel its contents. But in almost all instances among the lower orders in the remote districts, where the placenta has been retained for an unusual length of time, the cord is either tied to the patient's thigh, or held fast by one of the attendants. I remember having been sent for to a case of this description in a distant part of the country; I found the midwife on her knees at the bed side with a firm grip of the funis in her hand, which she exultingly displayed to me, observing, "Doctor I never let it out these five hours." It is a popular belief that if the funis was let go, it might slip back into the uterus and be for ever lost sight of. I have known more

than one instance in which eversion of the uterus was produced by the midwife forcibly dragging the funis.

The human placenta is either destroyed by fire or buried; generally the former. When buried it is usual to place it under a hedge, or in some locality where its grave cannot easily be polluted by the foot of man or beast.

After-pains are said to be relieved by eating plentifully of boiled cabbage.

The subject of the puerperal state, as well as the diseases of children, will be considered upon a future occasion.

In the foregoing recital I have, from the nature of the subject, been obliged to employ a more homely phraseology than is usual in professional writings. To many the description of these popular superstitions may appear uninteresting, and even useless; but, independently of all other considerations, I think it is of importance that young country practitioners should be made acquainted with the popular practices in use among those with whom they have to deal;—practices that are generally had recourse to before the aid of modern science is called in—which physicians ought by all means to counteract, but which in many instances will be resorted to the moment their backs are turned.

END OF PART I.

ON

THE ANCIENT LIGHTHOUSE OF CORUNNA,

FORMERLY KNOWN AND DESCRIBED AS

THE PHAROS OF HERCULES.

Mr. Wilde prefaced his observations by stating that he had already published an account of this celebrated building, which is situated at the extremity of the peninsula, on which the town of Corunna stands, wherein he had cursorily mentioned, that independent of the architectural beauty of its structure, its inestimable value as a beacon to mariners crossing this portion of the Bay of Biscay, and its marking the common entrance to the harbours of Corunna and Ferrol, what added "still greater interest to it in the eye of the traveller, was the fact of its enclosing within its massive walls one of the most interesting monuments of antiquity—the Pharos of Hercules—the oldest existing specimen of this kind in Europe, and amongst the very few now anywhere to be found."*

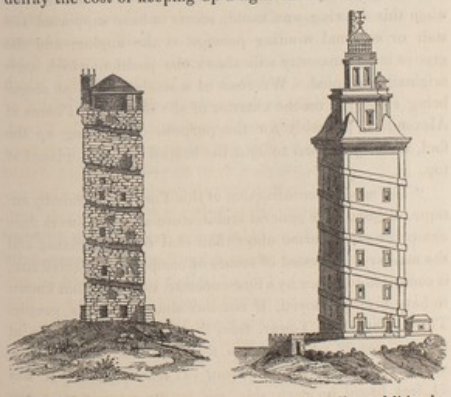
These observations were those of an ordinary traveller, who had no particular theory to support, and no peculiar object in view, save that of eliciting truth, and recording, with fidelity, what passed under his notice. Since then Sir William Betham having, in his "Etruria Celtica," questioned some of the statements put forth in this quotation, and finding, as he states, some incongruity between the accounts given by Mr. Wilde and Laborde, appears to have come to

* Narrative of a Voyage to Madeira and the Mediterranean, 2 vols. 8vo. 1st edition, 1840, pp. 12–14.

the conclusion that the ancient Pharos is *not* included, as is stated, within the walls of the modern Tower.

Mr. Wilde went on to say, that "being about to republish the original notice of this building, and feeling somewhat piqued at the assertion of Sir William Betham, who, never having seen the locality, laboured, I conceive, under such disadvantages as hardly entitled him to criticise, although, it must be said, in the most kindly spirit, the description which I had given from a personal examination on the spot, I have, however, to thank him for having noticed the subject, even in the manner which he did, for it has led to the discovery of a most interesting manuscript and two drawings, the only ones, I believed, in existence, of the ancient and modern Towers, which I beg leave to lay before the Academy, and which I procured in the following manner:

"When Sir William's book appeared I wrote to the British Consul at Corunna, requesting him to procure me some information upon the subject of the 'Hercules Light,' as well as plans or drawings of the ancient and modern tower; and also to have made for me a copy of, or extracts from, any work or archive, either in manuscript or print, which might be still extant at Corunna, Betanzos, or Brigantia, or any of the towns bordering the splendid harbour of Ferrol, and where such a record would be most likely to have been preserved; at the same time, from the present unsettled state of Spain, and the various revolutions with which that unhappy country has been visited, I hoped for, more than anticipated, a favourable answer to my communication. After the lapse of a considerable length of time I have received the most confirmatory proof of my original position in these two drawings, together with the Spanish manuscript, which I now exhibit to the Academy, and which were discovered in the bureau of an old architect in Corunna. This document, entitled, '*Copia de la representacion y mas documentos que con fha de* 16 *de Marzo de* 1786, *dirigio, esta Junta de Gobierno condor Planos al Ecmo Sr. Marques de la Sonora,*' appears to be a Report presented to the Marquis De La Sonora by a Government Commission, empowered to inquire into and report upon certain improvements destined to be put in force in the harbours of Corunna and Ferrol, in 1786. In this '*Memoria Sobre la antiquedad de la Torre de Hercules,*' it is recommended to repair the ancient Tower or Pharos standing at the extremity of the peninsula, 'the only notice of which,' says the writer of this Report, 'is, that it was in existence at the beginning of the fifth century,' and was originally intended for the same purpose, namely, a signal for the ships going to England. It may be remarked, that so advantageous was the post considered, that in 1684 the Consuls of England, Holland, and Flanders, entreated of the Spanish authorities to have the building repaired, and stated that their Governments would, at their own expense, defray the cost of keeping up a light on it.



"The preceding representations faithfully exhibit the

condition of the original Tower, as it stood in 1786, and also that of the present modern casing of granite with which it is surrounded.

" The wood-engraving to the left represents the original ancient Pharos, a square, hollow tower, surmounted by a rotundo, which was crowned by a large flag, bearing evident marks of the long-continued action of fire upon its surface. At each of the corners there was a small square turret; one of these is represented as still existing when this drawing was made, but evidently of a much more modern construction than the rest of the building. At foot of the drawing we find the following inscription: '*Fecit Trueva Alumnus Academiæ ex Civitate portus Brigantini, anno* 1797.'

" An external winding staircase led to the top, and permitted ingress to its internal apartments, through the small apertures still existing in the tower. A small square buttress at each corner, portions of which were in existence when this drawing was made, seems to have supported the stair or external winding passage at the angles; and the groove in the masonry still shews the position which such originally occupied. We read of a similar mode of access being employed on the exterior of the celebrated Pharos at Alexandria, probably for the purpose of carrying up the fuel, which was used to light the beacon that was placed at top.

" The mode of construction of this Tower is decidedly antique, although the general architecture and stone-work does not point out a period older than that of the Romans; and the masonry, composed of stones of comparatively small size, is cemented together by a lime-concrete, similar to that known to have been employed, if not introduced, by this people. The height of the Tower, from the base to the rotunda at the top, was 82 royal Spanish feet, and the rotundo itself was 11 more, making in all about 132 feet English. It was 31 feet broad on each side, and in the interior were two walls crossing in the centre, each 4½ feet in thickness. The

Tower was divided into chambers or compartments by three stone floors, originally without any apertures in them, so that these apartments could only have been entered from without. The outer winding stair having been removed at some period long prior to the date to which we now refer, apertures were made in these stone floors, and ladders leading from one flight to another, enabled persons to ascend to the top from within. It is stated in this Spanish document that the outer staircase was pulled down to build a convent in the neighbourhood, but at what precise period history does not record. The small Towers at the top are believed to have been erected subsequent to the removal of the outer stair, perhaps in 1684, when the British, Dutch, and Flemish Consuls relighted this wide-spreading beacon.

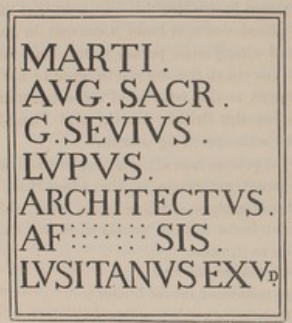
" With regard to the precise date of its destruction, all that we can learn from Spanish authorities is, that when Molina De Malaga wrote his description of Galicia, in 1549, this staircase did not exist; for in this old poetic work we find some rhymes referring to it, thus:

Pues la Corũna tampoco la deso,
Gran Puerto do numa fortuna le corre.
Y hablo de aquerte por sola una Torre
Antiquo Castillo que llaman el Vieso;
Aquerte es do dicen que estaba el eyrep,
Mas es fabuloso sabido lo que era
Estaba cercada de grand escalera
Que quien la deshiro no tubo consep.'

Of which the following exceedingly rough, but literal translation, may afford the English reader some idea:

But Corunna I do not like,
A Great Port where no fortune runs.
I speak of this only on account of a Tower,
An ancient Castle, which was called le Vieso (the old);
This is where they say lived the witch,
But it is a fabulous saying—whatever it was
Was surrounded by a large staircase,
Which whatever mounted could not find its way down.

"The origin of the original Tower, and its name, are involved in much obscurity. Galician tradition assigns it to the workmanship of Hercules himself. Some characters, scarcely legible, on one of the stones, says the writer of this Spanish manuscript, states that it was erected in honour of some of the Cæsars. Near its base was discovered a stone bearing the following inscription: the translation of which is attended with some difficulty from defacement, as well as the number of contractions of the text. In any attempt at doing so it should be compared with the inscription at p. 10. Baron Humboldt states that Laborde, who furnished him with a copy of these lines, likewise informed him, I suppose from the inscription, that 'this Pharos was constructed by Caius Sevius Lupus, architect of the city of Aqua Flavia (Cheves), and that it was dedicated to Mars.'



"Strabo, indeed, affirms that Galicia had been peopled by Greek colonies, and according to an extract from the Geographies of Spain, by Asclepiades, the Myrlean, an ancient tradition, stated that the companions of Hercules settled in these countries. Very few Spanish authorities mention this ancient '*Torre del Pharo*,' or, as it is sometimes called, The Iron Tower; and the appearance which it must have presented when originally built, accords precisely with the descriptions which we read of the ancient Pharos at

Messina, and also that at Alexandria, around which we know there wound an external spiral staircase, so broad and so gentle in ascent that it is recorded a car and oxen could with facility pass to the top. The Spanish manuscript, which I now lay before the Academy, refers its construction (in all likelihood) to the time of Trajan, because none of the geographers who lived before this emperor mention it, not even the accurate Mela, who alludes to other particularities on this coast. This, however, is but a negative proof; and even among later geographers the same silence is preserved. There is, however, one record extant in a stanza to be found in the old Spanish geographer Ororio, or Orosirus, who lived in the beginning of the fifth century, to this effect:

'Ubi Brigantia Calletee Civitas Sita
Altissimum pharum & inter pauca
Memorandi operis ad speculam Britanice
Erigit . . . .'

"Here we have the first notice of one of the purposes for which this Tower was supposed to be erected, and also of the ancient tradition, existing both in this country and in Spain, of the British Isles being seen from the Pharos of Hercules. Without, however, attaching any weight to the story of our island being seen from this Tower, it may be remarked, that if the ancients sailed directly *northward* from it they would, owing to the concavity in the Bay of Biscay in which the harbour of Corunna is placed, arrive at Cape Clear, instead of Cornwall.

"The early writers upon Irish history and Irish traditions have made frequent allusions to this ancient structure, as the 'Tuir Breoghan.' It is mentioned under this head in the Leabhar Gabhaltas, or Book of the Conquests, a translation of which was made by Henry O'Hart about the year 1686, and the original, which is now in the pos-

session of Sir William Betham, contains this notice of it: 'Then Lughaigh, the son of Ith, went to Tuir Breoghan, or Corunna, and shewed his father's dead body unto the posterity of Breoghain,' &c.; and from this Breoghain is, in all probability, derived the name of Brigantia, one of the oldest cities in this part of Europe.

"Sir William Betham has, with great labour and ingenuity, searched out and recorded, in his 'Etruria Celtica,' the various Irish authorities that refer to this building, and says, that he has discovered references made to it in the Eugubian Tables, which, he believes, speak of the early navigators steering by the fire set up on the land when the ship left the coast of Spain for the Turn or Carne; and in the same passage the triple-pointed hill of Cape Ortugal, the next most prominent headland, appears to him to be referred to.

"In another place Sir William Betham says: 'The name of Corunna and the Groyne are both derived from the river upon which the town stands,—Garonne, the rough or boisterous river, as the Garonne of France.' On this passage, however, I may remark, that I cannot agree with my brother Academician, for Corunna *does not stand on any river*, and the only one in its neighbourhood, and that too at a considerable distance across the harbour, is not the Groyne or Garonne, but the Rio Burgo. The term Groyne, however, is constantly applied by the early Spanish writers to the Bay itself.

"The term Corunna, or Colonna, may have been applied in after-times by the Romans, from the circumstance of finding the Tower or Column upon this headland, in the same way that the appellation of Cape Colunna has been applied to the island in the Grecian Archipelago on which was erected the celebrated Suniam temple, the remarkable columns or pillars of which are still standing.

"Again: 'There is,' says Sir William, 'some incongruity between the accounts of Mr. Wilde and Laborde. The

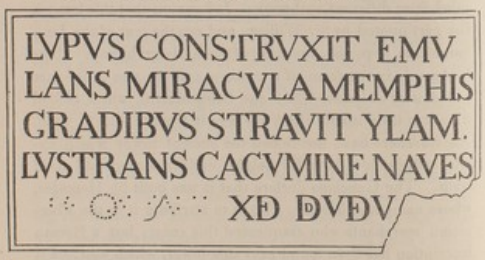
latter says, the lighthouse is situated "upon a very high mountain, a league from the harbour;" and Mr. Wilde has stated its position to be "about a mile to the S. W. of the town, on a rock by the water's edge." Any one, however, at all acquainted with the locality, knows that there is no such mountain in this vicinity as that described by Laborde, and the position of the Hercules Tower can easily be ascertained by those who have not seen it by referring to any of the Admiralty's charts of the coast; and, moreover, a light on "a very high mountain a league from the harbour" would be of little service for nautical purposes.'

"I find, however, on again referring to the work of Laborde, that it consists of two parts—an itinerary, or journal, which appears to have been written from personal observation, and a running comment, in the form of notes, and printed in a smaller type, on the population, commerce, administration, natural history, &c. &c. of the countries visited, and which is evidently derived from other sources, and compiled from different authorities. It happens that this latter is the part quoted by Sir William, and not the text of the Journal, where, at p. 435, speaking of the harbour, he says: 'The harbour is in the form of a crescent; at the two points are the castles of Sainte-Clare and Saint Martin, which defend it, and a little island which shelters it from the north wind. All travellers have mentioned the ancient tower which excites admiration from its height, and its strong and solid walls. The Galicians declare that it was built by Hercules, whose name it still bears; this is to attribute it to the Phœnician merchants who frequented this coast; but a Roman inscription has been found near this tower, which ascribes it to the god Mars. If it is really the work of the Phœnicians, as its antiquity and the tradition lead us to believe, this account may be reconciled by supposing that the Romans, wishing to preserve this monument, and in gratitude for their

victory over the Carthaginians, who sprung from the Phœnicians, consecrated it to their tutelary deity.'

"As this was a matter of some popular interest in connexion with the antiquities and early history of this country, Mr. Wilde quoted several extracts from what Sir William Betham has put together upon this subject, from Giolla Keavin, an Irish poet, who lived about A. D. 1072, in a poem called Reim re Riogh, or the Race of Kings—from the Annals of the Four Masters—and from the Book of Ballymote; from all which it would appear that the Irish poets and annalists were well acquainted, not only with the existence of this Tower, but with many of the ancient bardic traditions assigned to it: such as its being built as a watch-tower by Breogin, the son of Braha, who is also said to be the founder of the city of Brigantia, &c. &c.

"In the Spanish manuscript it is recorded that a stone bearing the following inscription was found built into the wall of an old house in the town of Corunna.



"The writer of the manuscript thinks that the dilapidation of the Hercules commenced in the middle ages, when it was converted into a castle or fortress belonging to the Archbishop of Santiago; that the stones and material of the

outer staircase were at this time removed, and that some trace of them may still be found in the fortifications of the old town.

"The result of the commission to which allusion was made at the commencement of this notice, was, that the Spanish Government determined to leave the ancient Pharos in existence, but to envelope it within the present modern granite building, which was commenced in 1797, and is represented in the right-hand figure of the engraving at page 5. It is a handsome square tower, built of close-grained white granite, and not only contains between its massive walls the original Pharos, but is made to resemble it as much as possible; and on its exterior a projecting band of masonry exhibits the line of the original external staircase.

"No doubt can now any longer exist with regard to the position and preservation of this most interesting remain, the Pharos of Hercules. At foot of the drawing which Mr. Wilde exhibited, the following inscription is decisive: '*Perspectiva que de muestra el estado de la terre antiqua llamada de Hercules quando de emprendio sure edificacion y revestimento de canteria por orden del Real consulado du la Coruna.*"

"To establish this fact, and to record some additional notice regarding the traditions and early history of one of the most interesting structures at present remaining in Europe, must apologize for this lengthened notice."

THE END.

CONTRIBUTIONS TO THE HISTORY OF MEDICINE IN IRELAND.

SOME NOTICES

OF

THE IRISH MESMERISTS

OF

THE SEVENTEENTH CENTURY,

GREATRAKES, COOK, AND FINAGHTY.

BY

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SOME NOTICES,

&c. &c.(a)

The first person in this country who performed cures by stroking patients with the hands, is commonly supposed to have been Mr. Valentine Greatrakes, who flourished in the reign of Charles II. That supposition, however, is erroneous; a much more remarkable performer of this kind figured in Ireland in the troubled times of the Commonwealth, as well as after the Restoration. An account of his "wonder-working practices" exists, drawn up with great care and critical acumen by a contemporary having a personal knowledge of the man, his pretensions and performances; indeed, it would be difficult to find, even in the Critical Dictionary of Bayle, a subject, curious in its nature, or for the authenticity of the testimony on which the facts relating to it are supported, treated with more acuteness or subjected to a more searching inquiry.

In the following notice of it some interesting particulars and remarkable statements of facts in relation to practices analogous to those of modern animal magnetisers, will be laid before the reader, and it is for him to make his own deductions from them.

It may be well to state that this account of the performances of Greatrakes and his precursor is given without any intention of furnishing arguments either for or against the belief in mesmerism.

Those who set about building up systems before they have collected sufficient materials for the projected structure, begin at the wrong end of their undertaking; and, perhaps, the disposition to demolish everything newly raised, from a fear of novelty that exaggerates defects, may lead to the untimely end of beginnings that might, possibly, have grown into something good or useful, had the work proceeded.

In things that are strange and new, every failure in the performance of them is accounted by some persons a proof of impos-

(a) [It is our intention not only to continue our series of medical biographies, but also to give, from time to time, some notices of rare Irish medical works, as well as accounts of Irish medical manuscripts, of which the Royal Academy and the University possess so many valuable specimens. We likewise purpose devoting an occasional chapter to the record of some of the superstitions connected with medicine, and would gladly receive any information on this subject which our country friends can afford us. On the present occasion we avail ourselves of the peculiar knowledge and ability of our distinguished countryman, already so favourably known to science, literature, and humanity, to present our readers with some notice of a subject partly medical, partly superstitious, and partly mesmeric.—Ed.]

ture, and in others a great number of failures fail to excite any suspicion of the power or probity of the performer. In debating societies, the question, exceedingly vexed and perplexed by much discussion, whether Cromwell was a hypocrite or a fanatic, remains always to be disputed and never to be resolved. The fact is, those who are the dupes of their own zeal, as their credulity increases, become unscrupulous with regard to the means they employ to acquire notoriety, to inspire confidence, and to lure others into their opinions, real and professed.

This was essentially the case with a late very eccentric lady, remarkable for her opinions respecting the occult sciences! "Hypocrisy," says Hume, "quite pure and free from fanaticism, is perhaps as rare as fanaticism entirely purged from all kinds of hypocrisy." Of other kinds of enthusiasm and imposture, as much may be said. It is rare to find one quite pure and free from the other, and the fervour of the former entirely purged from all mixture of the latter. Evident attempts to deceive may justly bristle up all the faculties, and put reason on its guard against imposition; but sound criticism will scrutinize with patience all subjects and phenomena presented to it, and even where there is much to excite suspicion, censure, or disgust, will leave nothing, however ill-accompanied, unnoticed, that has any claim to attention, or right to a candid judgment.

The account of the career of one of the "performers" referred to, stands peculiarly in need of those observations.

Before entering on the subject of the first wonder-working non-professional practiser of the healing art I have referred to, the principal circumstances that are known of Greatrakes require to be briefly noticed. He was born, by his own account, in 1628, at Affane, in the county of Waterford; educated in the free school of Lismore; and "perfected his studies in humanity and divinity in England," in the house of his maternal uncle.

The breaking out of the rebellion had caused the flight of his family, and the embarrassments of the latter led to his return to his native land. Afflicted at the deplorable state of the country, and disgusted with the unnatural differences then existing, he retired from the scene of strife and sought seclusion in the Castle of Cappoquin. "There," he says, "I spent a year's time in contemplation, and saw so much of the madness of the world that my life became a burden to me, and my soul was as weary of this habitation of clay as ever a galley-slave was weary of his oar." In 1649 he obtained a commission in Lord Broghill's regiment, then on service in Munster; and in 1656, when a part of the army was disbanded, he retired to his estate at Affane, and shortly after was appointed a justice of the peace. About 1662, when he was thirty-four years of age, he says he had "an impulse, or a strange persuasion in his mind (of which he was unable to give any rational account to another), which did very frequently suggest to him that there was bestowed on him the gift of curing the king's evil."

This conviction he concealed for some time, but at length communicated it to his wife, who endeavoured to persuade him it was "some strange imagination;" whereupon he made his first experiment in her presence on a youth afflicted with the evil "grievously in the eyes, cheek, and throat."

"Then I laid my hands on the places affected, and prayed to God, for Jesus' sake, to heal him, and bid the parent bring the child two or three days afterwards to me again, which accordingly he did, and I saw the eye was almost quite whole, and the node, which was almost as big as a pullet's egg, was suppurated, and the throat strangely amended; and to be brief (to God's glory I speak it), within a month discharged itself quite, and was perfectly healed, and so continues, God be praised."

He now proceeded on his career of healing by means of prayer, friction, or stroking the affected parts, and his fame extended over the country and even beyond its shores.

In his own account of his proceedings after his first return from England, he mentions having lived in a state of seclusion for a year, in the Castle of Cappoquin.

We find in Smith's Waterford a very curious account of Robert Cook of Cappoquin, a kind of Pythagorean philosopher, who, "for many years before he died, neither eat fish, flesh, milk, butter, &c., nor drank any kind of fermented liquor, nor wore woollen clothes, or any other produce of an animal, but linen. This man had a considerable estate in this part of the country. During the troubles in King James's time he removed to England, and lived sometime at Ipswich, but returned to this country, where he died about the year 1726."(a) In 1691 he published a very remarkable paper in the form of questions and answers respecting his tenets, wherein, giving his reasons for the customs he adopts and the faith he holds, he calls himself "a Christian and a Protestant," whose religion it is "to fear God and to keep His commandments,"—"to abhor evil and to do good, and have fellowship therein with all in every sect, or gathered or scattered people,"—"to hearken to the Spirit of Christ, which is the law of life in man," "the divine swift witness," which reproves for sin and overcomes all evil inclination: to follow the example of James the Just, that holy apostle Eusebius writes of, "the brother of our Lord, who eat not flesh nor fish, nor drank wine, nor used woollen clothes, but linen;" "which cannot give any just man offence;" the object of it being "to keep out of wrath and violence," and to avoid things like "wine and strong drink, which are hot in operation and intoxicating," and, as he thinks, "needless as tobacco to him," finding water, bread, and vegetables, most healthful, and linen and other issues from vegetable fibres "cleanest and wholesomest;" and thus to free himself "from most of the cumbers, labours, and toils, both of body and mind, a few things being sufficient in this way of

(a) The Ancient and Present State of the County of Waterford. By C. Smith, M. D. 8vo. Dublin, 1774, p. 370.

living, and bringing easily into contentedness and true thankfulness to God."

This remarkable man lived to upwards of fourscore years.—his opinions were refuted by the Athenian Society, and Smith disposes of them more contemptuously than he was justified, perhaps, in doing. Cook was not above fifteen or eighteen years younger than Greatrakes. It is probable the opinions of both were derived from a common origin.

In 1665, at the request of the Earl of Orrery, Greatrakes went to England "to try his hand on the head of the Lady Conway, of Ragley, in Warwickshire," who had long laboured under some cerebral affection. He remained at Ragley some weeks, and totally failed in his efforts to cure or relieve that lady; but "several marvellous cures performed (in Warwickshire) by the stroking of the hands of Mr. Valentine Greatrakes," are related by Dr. Stubbes, a medical practitioner of Stratford-upon-Avon, in a letter containing an attestation of several other cures by "the miraculous conformist,"—as the poor Irish gentleman was called,—given by Mr. Foxcraft, M. A., a Fellow of King's College, Cambridge(*a*).

In Stubbes' letter, he speaks thus of the performances he witnessed: "filling with admiration the most learned and suspicious beholders. In truth, they are such that he is not at all obliged to the ignorant for the esteem he hath acquired, nor is it possible for the most tender or superstitious and censorious zealots to destroy his repute. He is a man of a graceful personage and presence; and if my phantasy betrayed not my judgment, I observed in his eyes and mien a vivacity and sprightliness that is nothing common."

The writer proceeds to describe him further as a man of good life, of benevolent principles, "conforming to the doctrine and discipline of the Church of England, yet without that censoriousness whereby some signalize themselves," modest and humble, thinking well of others, and "seeming by his faith and by his charitableness, to include some grains of the golden age, and to be a relic of those times when piety and miracles were sincere."

In his attempts, however, to give a natural solution of most of the cures effected by Greatrakes, he makes mention of his long and continued frictions from one to two and three hours; and Dr. Smith, in his History of Waterford, reminds his readers of Bacon's observation in his History of Life and Death,—that motion and warmth (of which true friction consists) draw forth into the parts new juice and vigour, and conduce much to longevity. "How far the imagination" (in those alleged cures), he adds, "might contribute to the cure, is uncertain."

The fame of Greatrakes reached the court of Charles II., "who invited him to Whitehall, to exhibit his powers." The Earl of Arlington was the bearer of the King's commands. The merry

(*a*) The Miraculous Conformist, or an account of several Miraculous Cures performed by Mr. Greatrick. Oxford, 1666. 4to.

monarch might have been somewhat jealous of the renown of a successful rival in the practice of manipulating patients for the cure of scrofula. One of His Majesty's first public acts after the Restoration was "touching for the evil," which Evelyn thus describes: "July the 6th, 1660, His Majesty began first to touch for the evil, according to custom, thus:—His Majesty sitting under his state in the banquetting house, the chirurgeons cause the sick to be brought or led up to the throne, where, they kneeling, the King strokes their faces or cheeks with both hands at once, at which instant a chaplain in his formalities says, 'he put his hands upon them and he healed them.'" This the good old Evelyn details in his usual quaint, quiet manner; and having described the patients getting a piece of money strung on white ribbon put round their neck by His Majesty, he adds: "the chaplain, each time the King put on one of those ribands, repeated: 'That is the true light who came into the world.' The Gospel was then read, prayers for the sick offered up, a blessing pronounced, and the King washed his hands after having stroked above six hundred."(*a*)

Greatrakes undertook the journey to England without expectation of fee or reward; and after he had been at the palace of Whitehall, where it does not appear he attracted much attention, he took up his abode in Lincolns-Inn-Fields, "where incredible numbers of all ranks and sexes flocked to him respecting the restoration of their health."

"All he did was only to stroke the patients with his hands, by which all old pains, gout, rheumatism, and convulsions, were removed from part to part, to the extremities of the body, after which they entirely ceased; which caused him to be called the stroker: of all which he had the testimonials of the most curious men in the nation, both physicians and divines."(*b*)

In the memoirs of Lord Orrery, in manuscript, *anno* 1669, cited by Harris, Mr. Love states that Greatrakes failed to relieve him of a pectoral and rheumatic disease, but he was witness of his curing the falling sickness, beyond credit; and further, that the Royal Society, and other modern philosophers, not able to dispute the fact, found words to define it, and called those strange effects "a sanative contagion in the body, which had an antipathy to some particular diseases and not to others."

In the Philosophical Transactions, No. 256, p. 332, the celebrated Ralph Thoresby gives several remarkable instances of cures effected by Greatrakes. He mentions the practice adopted by him in the case of his own brother, suffering from violent pain in the head and back, "who obtained immediate ease to his head, by the former only stroking it with his hands; he then fell to rub his back, which he most complained of, but the pain immediately flew from his hand to the right thigh, thence he pursued it with his hand to his knee, from thence to his leg, ankle, and foot, and at last to his great toe. As it

(*a*) Grammont's Memoirs, p. 435. (*b*) Smith's Waterford, p. 366.

fell lower it grew more violent, and when in his toe it made him roar out; but upon rubbing it there it vanished." He gives another case, of white swelling of the knee, of six or seven years' standing, also cured. "He stroked both the knees of the patient, and gave her present ease, the pain flying downwards from his hand till he drove it out of her toes, and the swelling in a short time wore away, and never troubled her after."

He gives a third case in the same Transactions, of a person cured of deafness and pain in the ears, and mentions several other cures. "He adds, that when Mr. Greatrakes stroked for pains, he used nothing but his dry hand; if ulcers or running sores, he would use spittle in his hand or fingers; and for the evil, if they came to him before it was broke, he would stroke it, and ordered them to poultice it with boiled turnips, and so did they every day till it grew fit for lancing, &c." "Such as were troubled with fits of the mother, he would presently take off the fit by laying his glove on their head; but he never perfectly cured any, for their fits would return." But Mr. Thoresby mentions that he cured many of falling sickness, provided they remained with him, so that he might see them in three or four fits, else he could not cure them.

Some of his failures in England caused a clergyman of the name of Lloyd to write a book against him, entitled, "Wonders no Miracles, or Mr. Valentine Greatrakes' Gift of Healing examined." London, 4to. 1666. The latter vindicated himself in a publication named, "A brief Account of V. Greatrakes, and divers strange Cures by him performed; in a letter to the Hon. Robert Boyle, Esq." London, 4to. 1666. Lloyd's severe reflections on the reputation of "the Miraculous Conformist," seem to have borne down his reputation in England; and on his return to his own country nothing foreign was requisite to bear out in his case the truth of the old adage that "no man is a prophet in his own country." The last time that any mention is made of him by his contemporaries was in 1681: he was then living in Dublin, "but how long he lived after," says Dr. Smith, is uncertain.

In 1673, when Peter Walsh, the Franciscan, produced his History and Vindication of the Irish Remonstrance, Greatrakes appears to have sunk into obscurity. Walsh says, that no sooner had a Catholic wonder-worker made his exit, "than Greatrix, an *English* lay Protestant, started up to supply the former's place, by making people believe he himself, too, had a gift from God to cure all diseases by praying and stroking; even also at London, whither he came at last to cheat the world, as the former was thought to have done. What became of this Greatrake I neither know nor care; only this, I know that, not long after his practises on folks in London, he went out like the snuff of a candle, just as Finaghty did."(*a*)

(*a*) Walsh's History of the Irish Remonstrance, p. 736.
[In addition to these notices of Greatrakes, we beg to refer our readers to our preface to the Number of this Journal for Feb. 1846, pp. iii. iv. v. See also Walter Harris's translation of Ware's "Writers of Ireland," where we have one of the earliest accounts of "Valentine Greatreaks, an estated Gentleman, born at Affane, in the county of Waterford, in 1628." Besides the writings of Boyle, Stubbes, Thorsby, Lloyd, Charles Smith, Walsh, Love, Wichcot, Cudworth, and Patrick, where the question of Greatrakes' cures are considered, we also find him mentioned by Dr. Henry Moore; and the ingenious novelist, Mr. St. Evermond, made him figure as the hero of a romance called "The Irish Prophet," to which we have already alluded. The first volume of the Dublin Penny Journal, p. 401, likewise contains a brief memoir, with a portrait of this remarkable personage, as also a letter from Lord Conway, about his "sanative virtue" and "natural efficiency."

Dr. Beal about this time communicated to the Royal Society the following statement with respect to practices somewhat similar to those of Greatrakes, and several of which, especially those enumerated under the fourth head, are still employed by persons of high rank and station at the present moment in Ireland: "1st. That he could make good proof of the curing or killing of a very great and dangerous wen, that had been very troublesome for two or three years, by the application of a dead man's hand; whence the patient felt such a cold stream pass to the heart, that it did almost cause in him a fit of swooning. 2nd. That upon his brother's knowledge, a certain cook in a noble family being reproached for the ugliness of his warty hands, was bid, by his lord, to rub his hand with that of a dead man; and that his lord dying soon after, the cook made use both of his lord's advice and hand, and speedily found good effect. 3rd. That a gentleman who came lately out of Ireland informed him of an aged knight there, who, having great pain in his feet, insomuch that he was unable to use them, suffered a loving spaniel to lick his feet, mornings and evenings, till he found the pain appeased, and the use of his feet restored. This, saith the relator, was a gentle touch and transpiration; for he found the spirits transpire with a pleasing kind of titulation. 4th. That he can assure of an honest blacksmith, who caused vomitings by stroking the stomach, *gave the stool by stroking the belly*, and appeased the gout and other pains by stroking the parts affected."—Vide Philos. Transact. Numb. 12. p. 206.—Ed.]

Walsh, when Procurator of the Franciscans, was called on, in 1666, to lay before the National Congregation assembled in Dublin "a detailed account of all he had either heard from others, or by his own experience known, of that good father, the far-famed, wonder-working priest, father James O'Finaghty." It is to be borne in mind that Walsh had taken a prominent part in the affairs of the Catholic Confederation, against the Cardinal Rinuccini, and in favour of the Viceroy Ormond, and, by his own admission, Finaghty had been of the opposite "nuncio party in the late troubles of the nation." Ormond, again filling the same office in 1666, patronized Walsh, who was on very intimate and confidential terms with him; and after the departure of the latter from Ireland, so little were the tendencies of Father Walsh towards superstition or enthusiasm in religious matters appertaining to his Church, that in England he finally obtained some appointment in connexion with the Protestant Cathedral of Winchester, which did not render his services in a clerical way indispensable. There is another point, probably, that requires attention. Father Walsh professes over and over to have made his researches and report in a spirit of the utmost im-

partiality and candour, with a desire to do the fullest justice to the pretensions of the subject of his inquiries. But a cautious reader might be inclined to say, "methinks the gentleman doth protest too much:" nevertheless, bearing these things in mind, how the reporter was circumstanced and disposed, his account of the performances of the wonder-working priest is drawn up with singular judgment, care, and industry.

The first time and place that Father Walsh heard of this singular personage was in 1657, in London, during the reign of Cromwell. In a letter from an Irish Jesuit to one of his order in London, there was an account of one James Finaghty, a secular priest, who formerly had charge of a parish in the archbishopric of Tuam, apparently raised up by Providence, in those times of trouble and calamity, to confirm the people in their religion; and for this purpose "extraordinarily gifted with a true miraculous power of dispossessing devils, and curing too all sorts of other ills, even the most natural diseases, so that he drew the world after him, and not only Catholics but Protestants. Insomuch, that he had often a thousand, sometimes fifteen hundred, nay, two or three thousand, who followed him even through bogs, woods, mountains, and rocks, and desert places, whithersoever the people heard him to have fled from the persecution of Cromwell's officers and governours; that priests enough could not be had (though many accompanied him on purpose) to hear the confessions of the great multitude drawn to repentance and resolutions of a new life by the example of his life and wonder of his works: that, therefore, he was justly and principally, next after St. Patrick alone, esteemed another Thaumaturgus, or wonder-worker of Ireland," &c. &c. Readers, who may feel particularly disgusted at accounts of superstitious practices or occurrences in Ireland, and disposed to relinquish all research when these are met with in their own country, even in the chronicles of events of two centuries ago, may be reminded of the doings of Mr. Thom,—the new Messiah,—and his followers, in the vicinity of the principal cathedral town of England in our own times; and may be assured that a great deal more interest attaches to the performances of the Irish thaumaturgist, than does to the phrensied exploits, impious pretensions, and tragic catastrophe of the Canterbury prophet.

There are matters of interest, even in a medical point of view, in the singular effects produced on the imaginations, and, as it is alleged, on disease itself, in many instances, by the practices of Finaghty; and, notwithstanding his frequent failures and evident attempts to impose on the superstitious and weak-minded, it is a question of more than mere curiosity whether his practices of a curative kind were identical with those which Mesmer is commonly supposed to have been the originator of.

It is certain that practices similar to those of the animal magnetisers were in vogue with the Pagan Irish, and were condemned by St. Patrick; but, notwithstanding the condemnation, were still observed after Christianity was established. One of the first Irish

scholars of the day, Mr. Eugene Curry, recognises, in a pagan practice,—called in Irish, *Teann Lae*, or "The Enlightenment,"—a performance of a mesmeric kind.

The earliest account of this practice was found by that gentleman in an ancient Irish manuscript, where the affairs of Ireland are treated of during the interregnum between the death of Edirsgel More and Conaire More, about the year of our Lord 20.

The evils arising from the delay attending the election of a king, after the death of Edirsgel, led to a great assembly of the princes and chiefs at Tara, and there it was determined to practise the *Teann Lae*, to ascertain the will of heaven respecting the succession. "The enlightenment" was, accordingly, performed in the usual manner. A young man was selected by the Druids; some raw meat was given to him to eat; a great number of solemn rites were performed. One of these consisted in breathing on him, and these operations continued till he was put into a deep trance; and while thus entranced, he was questioned as to the person who was destined to succeed Edirsgel. He then returned intelligible answers, describing the person spoken of. The young man was kept entranced till the Druids sent to a place some six or seven miles distant, which had been named by the young man, and there they found the person described and sought for, and they forthwith proclaimed him monarch.

In 1662, the Duke of Ormond being again Viceroy, Walsh, on his return to Ireland, heard once more of Father Finaghty working great wonders. He was commissioned, immediately after his arrival in Dublin, by his Grace of Ormond, "to look particularly and singly after him (the same Father Finaghty), and see he allured the people no longer, by going about so like a mountebank, cheating all the nation, nay and bringing his countrymen also into suspicion of some bad design among them; and this neither unjustly nor at all ungroundlessly, if his procession about the kingdom, and the multitude everywhere flocking to him, be considered."

Walsh, then, was appointed not to inquire into the truth or falsehood of Finaghty's pretended powers, but "to see that he allured the people no longer;" so that we are more likely to find in his report what was unfavourable to the pretensions of this man, in the result of his performances, than such things as might seem to give any support to them. Yet there is no *apparent design*, in the inquiry instituted, to deal unjustly or unfairly by the person who was the subject of it.

Walsh at once entered into communication "with the most judicious of all kinds, both ecclesiastics and laics, from all parts of the kingdom, at Dublin," some of whom were of the county of Galway, where Finaghty had his ordinary residence, who had seen him practise on themselves and others. The result of his inquiries was:

1. That in 1662, previously to Ormond's arrival in Ireland, Finaghty had obtained a pass from the authorities "to go freely where he pleased in Ireland," and had gone from province to province, and had drawn after him great multitudes of people, "some expecting

to be healed of their infirmities ; others, incomparably the greater number, to be satisfied in their curiosity."

2. That he had blessed and hallowed a great number of wells in various places, and given them special titles; and, as the people imagined, had given them part of his own efficacious supernatural virtue for the cure of diseases.

3. That he had made a triumphant progress through several countries, till he came within five miles of Dublin, and was in all places "received, entertained, reverenced, honoured, and admired, not only by the common people, but by the gentry, nobility, knights, lords, ladies, and clergy also; and by many also presented by gifts, which he never refused."

4. That at Cluansillah, five miles from Dublin, such vast numbers of people of the city and adjacent country thronged about him, that many were trodden almost to death.

5. That from thence he returned to his own country, practising everywhere, "as his manner and delight was to practise in the open fields, amongst great multitudes, dispossessing of devils from such as he himself alone was pleased to judge possessed, and curing, too, or at least with pretending and attempting to cure all other diseases by prayers and exorcising, *and touching, and crossing, and stroking, and (sometimes also for some diseases) by blowing vehemently and laboriously into the ears of the diseased party.*"

6. That some Protestants, also, had gone to see him, others of them to get his helping hand; but amongst them many, and likewise amongst the Catholics, who returned extremely unsatisfied, looking on all his feats as impostures, while others cried them up for miraculous performances; "and from the former dissatisfied persons the information given to the Lord Lieutenant had proceeded."(*a*)

A Galway man well acquainted with Finaghty told Walsh, that the former had in his youth been a servant "to one Father Moor, an old, venerable Jesuit, and skilful exorcist," from whom he had learned his art and knowledge of exorcising. Subsequently Finaghty, when questioned on this point, denied the assertion. There was no Jesuit on the Irish Mission named Moor. There was one named Moor living in Drogheda in 1642 and 1649 ; he was superior of his brethren in Galway—then a septuagenarian—a man of great repute in his order(*b*).

Father Melaghlin, a Franciscan, who had a personal knowledge of Finaghty, spoke of him to Walsh as "a very illiterate, undiscerning person," who never had studied natural or rational philosophy,

(*a*) [It is a very remarkable fact, that while the Roman Catholic clergy of Ireland, either from their own common sense, owing to the habits of strict discipline in which they are educated, their reverence for established authority, or their love of orthodoxy, have kept aloof from all modern quackery,—very many of the Irish Protestant clergy have been, of late years at least, the warmest advocates and most devoted apostles of Hydropathy, Homœopathy, Phrenology, Phreno-Magnetism, Mesmerism, and such like delusions.—Ed.]

(*b*) See Dr. Oliver's Jesuit Biographies, p. 259.

and very little divinity, or rather none at all, fit to make him a discerner of spirits," and yet he pretended that he knew a large portion of his countrymen and co-religionists were possessed by devils. Moreover, the Franciscan asserted that those whom he pretended to have cured were observed very soon to relapse into their former state.

Walsh could meet with only "two grave Catholic gentlemen," Geoffrey Brown and Richard Bellings of the Kilkenny Confederation, who could speak from their own knowledge of cures effected by Finaghty. These gentlemen "were no bigots." Bellings assured him that Finaghty had "a wonderful gift from God, of curing by exorcisms and prayers." Brown told him he had been present when a cripple, well known on the way, who had been always without the power of his lower limbs, "going upon all fours, with the aid of two short crutches, half a foot high," had been cured in the presence of a great multitude in the following manner:

The cripple being laid down at the feet of the Father, the latter prayed over him, signed him all over with the cross, and after some time bid him get up, "which the cripple did not;" but one of the assistants raised him up by main strength from his crutches, and held him up for some time with difficulty, the cripple crying out vehemently that he was in torture all the time. Then Finaghty had him laid down again, repeated all the former operations, and bid the assistant rise him up once more. The cripple was no sooner raised up than he stood without assistance, walked before all present, gave God thanks, and found himself perfectly cured; and the following Sunday attended a hurling match, "to the extream wonderment of all who had known him before." Mr. Brown, however, "would not determine whether what he saw was a true miracle or no." Mr. Bellings, some time after, in Walsh's hearing, solicited the Duke of Ormond for a pass for Finaghty. The Viceroy offered him one for Dublin, where, if he came and performed only one miracle, he should be honourably received and lodged even in the Castle. But he cautioned Mr. Bellings against allowing Catholics to be laughed at for their credulity.

About a year later Walsh received accounts of Father Finaghty, then in England, performing very wonderful cures, both on Catholics and Protestants, at the Portuguese Ambassador's in London, and at the Queen's at St. James's. It appears that he was sent for to London to cure the lady of a Portuguese nobleman, then staying with the Queen, who had lost her sight; and "Father Taig M'Eochny," *alias* Captain Power, an Irish Dominican, afterwards Bishop of Clonfert, was sent from the Court with money for father Finaghty. The mission was in vain, the money was lost,—the attempts of Finaghty to give sight to the blind countess proved a failure. Nevertheless, he maintained his credit with his friends, though the jealousy of some minister caused him to decamp from London. "He was thence honourably conveyed in a coach drawn by six horses, accompanied by an English Catholic gentleman,

through Oxford, to Chester and Holyhead. He remained in Wales for some days, with Lord Dillon and Mr. Garrett Moor, two great admirers of his, and then returned to Dublin.

The higher order of Catholics of the capital were said to have been rather scandalized by the circumstance of Father Finaghty having come accompanied from England by a Lancashire woman, whom he described as a demoniac. But while he remained in the capital "he performed" at the house of the Lord Fingall, and a great number of persons, both Catholics and Protestants; amongst the latter, the Countess of Antrim, conducted thither by Father Peter Talbot. The great feat promised on the occasion was to dispossess the Lancashire woman of a devil. Father Talbot, not unreasonably, required a dispossession *in signe visibile* for the satisfaction of the standers-by. Finaghty made no objection; however, he said it should be done by *visible sign;* he commenced his exorcism, and "falling again to his adjurations, failed manifestly, before all the people." It is worthy of observation, though Walsh passes over the fact unnoticed, that whenever Finaghty failed he never seemed in the least disconcerted, nor did he vouchsafe to attempt any apology for the failure. Walsh now set about "a last and most vigorous inquiry;" and the result of this new inquiry was as unsatisfactory, and the testimony as conflicting, as on the former occasion. All the Church fathers, regular and secular priests, seemed against Finaghty. They accused him of taking presents of horses, watches, gold, silver, pieces of woollen and linen cloths, &c. One venerable old Franciscan, in the convent of Clane, Father Dempsy, told Walsh the custom of Father Finaghty was, to assemble a multitude in an open field, and single out before the people some young maid whom he was wont to say was possessed by the devil. If the girl denied it, "he would box her and bang her lustily," until, being confounded with shame, she would confess whatever was required of her. He had acted thus at Downadea, at Sir Andrew Aylmer's; and the maid selected by him on that occasion, and buffetted into an admission of "possession," came to father Dempsy soon after, and confessed to him that she had been compelled by shame to give the answers required of her, but never had been possessed, to her knowledge, by any devil. At Castletown, in the diocese of Dublin, at Lady Dangan's, Walsh was informed that he had healed a lame man, and given sight to a blind one. But the parish priest of Castletown "seemed not thoroughly satisfied of the miraculousness of what was done there," for, besides praying, exhorting, touching, and crossing, he lay down on the cripple, stretched out the sinews of the legs, and straightened the knees forcibly; while at Lady White's, at Leixlip, where he restored the sight of a blind man, "with his fingers he forcibly opened the eye-lids of the blind man," yet neither could be said to be perfect cures; "the *blind man* did not see clearly, nor did the cripple go even then strongly and confidently."

Walsh at last had the good fortune of (being in Dublin when Finaghty was there) meeting with him; but previously he found

that some Protestant officials "had come to a resolution of bringing Finaghty before the Bishops' Court, for a wizard or an impostor;" but Dr. Loftus had interposed, and objected to that proceeding, "till Walsh's arrival or the Viceroy's return to Dublin."

The Roman Catholic clergy, on the other hand, had assembled, and discussed the propriety of prohibiting any further practices of his in Dublin, and to command him to depart, "as an impostor or a brain-sick man." The Franciscans alone continued to countenance him; and a young Protestant Irish gentlewoman, they informed Walsh, had been cured of "some inward disease in one of her limbs by him." The lady herself also informed him of the same fact, and of her having been subsequently "reconciled to the Roman Church." This was the only cure which Walsh could learn had been effected by him, and he attaches little importance to it.

He then proceeds to give the result of his own communication with Finaghty, whom he first met at the chapel of Father Aylmer, a secular priest, in Owen's-arch (Audoen's-arch?), when the latter was preparing for the altar, and was on his knees when Walsh entered. The substance of his answers to the different queries of the latter were: that he had formerly, he believed, the good opinion of all the clergy; that the Jesuits of late, both in England and at home, had opposed him; that he never denied, as Lord Clancarty had asserted, the power of curing natural disorders; that he had never learned modes of exorcism or curing from Father Moor; that whatever had been done by him was the gift of God, and the end of his performances was to manifest the truth of his religion; that he had informed Lord Aubigny, the Queen's Almoner in England, that he would undertake to cure as many sick as might be brought to him, after being duly examined by an expert physician, after the clergy of the Court had failed to heal them by their prayers; but that his challenge had not been accepted; and finally, that he again offered to do the same in Dublin, and commissioned Walsh to make that offer to the Lord Lieutenant and Council; that he feared no trial, and for once he had failed that he had succeeded a thousand times; that God had bestowed his gift of healing on him before he entered into orders, and that his first essay was with a book of exorcisms in the case of his own brother, one prayer from which book had caused the devil to restore some clothing Satan had stolen from that brother. After visiting him several times, Walsh at length had an opportunity of seeing him practise on twenty or thirty poor country people. Their ailments were aches and pains in various parts, weakness of sight, and deafness. One was a boy apparently blind, and another a girl of thirteen or fourteen who "was troubled with fairies."

He began with prayer and exorcism; these were very short. Having driven the pain, as he said, or the patient asserted, from one part to another, he followed it from place to place, "crossing and praying and conjuring;" and after two or three attempts "the patient, being questioned by him, answered, he or she was cured."

Then he bade the person return, kneel down, and return God thanks. In this way he proceeded from one to another, but occasionally varying the practice. In some cases "he used to blow very long and very strong into the ears of such who complained of deafness or pain in the organ, laying his mouth on the affected ear, or blowing so vehemently hard thereinto, that it must have been both painful to himself, and naturally (without any miracle at all) in some measure effectual to work in the organ some alteration." The practice of blowing into the ears of cattle, especially of horses, is an old popular arcanum, well known to cattle doctors and several veterinary practitioners in this country,—a practice much older than Walsh or Finaghty, and which has been revived with some notoriety within the last ten or twelve years.

Finaghty's repeated efforts to restore the sight of the blind boy were wholly unsuccessful; "yet he very carelessly, and without any further ceremony or notice taken thereof (the failure), giving over and turning away from the blind boy, passed on to some other of those who expected their turn, but who had no visible disease or evil, and practised upon them."

A poor woman from Crumlin, with the child "troubled with the fairies," next approached.

Finaghty said he must speak with the girl apart, and he led her away to another room, and "remained (alone) with her for a pretty while," Father Walsh thinking it odd that he had not been asked to be present at this conference. At length he allowed him and the others present to enter the room where he and the girl were. The latter was seated opposite an open window, the former was standing over her, praying and exorcising, crossing the head and forehead; and, according to the girl's account of her shifting aches, he pursued the pains from limb to limb, crossing and exorcising the affected part. Sometimes she said the pains were gone; then "he boxed her, said she lyed, and re-commenced his operations, *pursuing the pains in the same method till he comes down to her feet, then rubs hard, or rather strikes or strokes hard her foot, with his own over it in a sloping manner, so that her toe was the last he touched with his sole, as pretending to drive out the devil* from that last habitation or retreat of his into her toe."

Then he bade her look out of the window and see how many people passed, and when she demurred he menaced her, and this had the effect of getting answers from her. He asked her if she saw a high mountain afar off, with a great fire on the top, and a multitude of black-looking people fighting, slaying, and throwing one another into the flames. She answered, "yes." He finished his exorcism by calling on a hundred thousand devils to come from hell and carry off their companion who possessed God's creature then present. But, strange to say, the girl having repeated her former declaration that she was cured,—Finaghty said again, "she lyed," and, turning to the beholders, said, "she is yet strongly possessed, she must be brought to me again."

Yet, after this scene, Father Walsh called on him in Kennedy's-lane, and finding him on his knees at his devotions, requested to be touched by him from the crown of the head to the soles of the feet, "for a little spice of the scurvy," which he had for many years. But though no great benefit appears to have been derived from the operation, he was resolved "to suspend his judgment till the great public trial before the Viceroy came on, which he (Finaghty) had demanded. The Viceroy gave some very excellent reasons to Walsh for not complying with this demand, but Father Walsh prevailed on him "to let the man have his will."

Finaghty came to Walsh one day, and complained of having been kept six weeks in town waiting for the Duke's license for the trial. Walsh informed him it had been granted; a number of sick would be sought out, and there should be a few Protestants amongst them, by the order of the Viceroy; and the trial should take place in two or three days. Next day Finaghty came by appointment to Walsh's abode (in Kennedy's-lane also), and said mass privately there in the oratory of the latter. Two grave and distinguished gentlemen of the Court came in "unexpectedly," as Walsh states; one was the famous physician and great traveller, Sir William Petty; the other Sir Robert Southwell, one of the clerks of the Council at Whitehall, who had lately been Envoy Extraordinary at the Court of Portugal. Sir William Petty had been charged, jointly with Dr. Yarner, to examine the sick persons who were then in town in readiness for the trial. Finaghty was sitting at the fire when Walsh, pointing to him, told the gentlemen that was the "far-famed, wonder-working priest, Father James Finaghty." Sir William Petty spoke to him in very courteous terms, saying, with respect to his wonder-working powers, his own mind was as a sheet of blank paper; he had no impression for or against them: "You may write in my soul what you please as to the way of worshipping God, if you attest that way by plain miracle. And, therefore, if you do, by your prayer, remove this wart which you see on my finger, I will presently declare myself of your religion." Finaghty objected to the proposal, or to any deductions that might be drawn from its failure, if accepted; so it was withdrawn. Sir William then said he laboured under a troublesome infirmity; he was purblind or near-sighted, and if Father Finaghty would cure him, he would humbly and gratefully acknowledge "God's merciful and wonderful hand therein." Father Finaghty rose up and said, "let us try." He then turned his face to the wall, knelt down, and seemed to prepare, by private prayer, for the attempt. Sir William and his companion, who resolved to second the operator's efforts as much as in them lay, knelt down likewise and prayed, as did also Father Walsh. When Finaghty arose he put a stole about his neck, and sprinkled them all with holy water; then placed Sir William between him and the light of the window, "said a prayer proper for the eyes," and repeatedly crossed the eyes of the learned physician. Then he put a Bible in Sir William's hand, and asked him could he read it bet-

ter than formerly. The latter, in his hopefulness of an improvement, at first thought his sight "mightily amended," but, soon finding his error, he told Father Finaghty how it was. The operation was repeated, with the same result, a second time. "Father Finaghty, without further attempt or ceremony, or word spoken by him, turns aside, pulls off the stole, puts on his hat, and takes his former seat at the fire, with his back turned to us, as unconcernedly as might be." Sir William put on his hat also, and asked Walsh if he knew any thing of necromancy, for he knew a book that treated of that science, wherein every word of the prayer used by Father Finaghty was to be found. The book, he stated, was said to be written by "Frater Petrus Lombardus Minor." The book was then shewn to Walsh (for it strangely appears Sir William had it in his pocket), and Walsh acknowledged there was no material difference between the two forms of prayer. "Sir William, before he took his departure, said, in a solemn way, he had a proposal to make: Let the gentleman (Finaghty) assemble in a field a multitude of sick people, as he is wont to do, and he, Sir William, would bind himself in a sum of £100, to be paid in gold to Father Finaghty, to cure by his own practice as many as Father Finaghty should cure by his. Then he and Sir Robert Southwell went away, without so much as saluting or noticing in any way Father Finaghty."

"This was the last experiment I saw of that good father," says Walsh. Next day the latter, by the Viceroy's orders, intimated to him all was in readiness for the proposed trial. "The poor gentleman (at this intimation) discovered, even in his countenance, his inward anguish and extreme trouble." It was evident he never expected the permission of the State would be given for such a trial. He immediately said he could not stay; he must set out next day for Connaught; he was weak in body; his health had been impaired in Dublin; he suffered from night perspiration, which had been brought on by the labour of mind and body attending his performances; he must go to the country to recruit his strength, then he would return and perform all he had promised. All remonstrances were, for a length of time, in vain. The plea of ill health, he was reminded, was untenable; he eat and drank, and slept well. The world, if he fled, would set him down for an impostor. At length Finaghty said, "he would then stay, and appear without further delay." Poor Father Finaghty was put by the wily Viceroy and his astute agent "in a fix." Shortly after his assent was given to the recommendation of Walsh to stand his ground, he said: "Oh! that I had those two possessed women which the Jesuits brought me the other day."

Walsh now kept a sharp look out after the thaumaturgist. The night before the appointed trial he caused him to lodge in his house. Finaghty retired to bed very confident in his manner of success on the morrow. At day-break, when Walsh arose according to custom, he was surprised to see Finaghty enter his room accoutred for a journey, and state to him that he had been perspiring all night (probable enough), he was sick, he could not stay, he had a horse ready for his departure; and to have him beg also to make his excuses to the Viceroy.

A sick man, setting out on a long journey on horseback, in the depth of winter, seemed somewhat strange to Walsh. Finaghty was called on to sit down and write to the Viceroy his reason for abandoning the proposed trial. Finaghty said he was a poor master of the pen; he could not presume to address a Lord Lieutenant. Walsh replied, the excuse was an idle one; he could write very well, and good sense too, when he pleased. It was diamond cut diamond. Finaghty would not commit himself on paper. The menaced prosecution in the Bishop's Court was not abandoned, only suspended. Witchcraft was a felony, punishable at the stake, and Finaghty had more ambition to do miracles than to suffer martyrdom.

Walsh gave him some money for his journey; charged him to make no further attempts at healing or exorcising on his route to Galway; he bore himself submissively, "and, two hours after, before he left town, he sent me (says Walsh) a little printed English book in 12mo or 16mo, an account of his own miracles lately done in England." Here ends Father Walsh's report to the lords and fathers of his order in congregation assembled.

It appears, by a note to the document in question, that, subsequently to his flight from Dublin, he still practised on maids and women in Connaught; and some of the latter, whom he declared demoniacs, he shut up in Portumna, and, by discipline and fasting, drove almost mad. The reader may, probably, recollect the similar result produced by similar means on the nuns of Loudon in France, about the same period, that ended in the judicial murder of Urban Grandier. The Archbishop of Tuam finally took Father Finaghty to task for practising exorcisms by wholesale, and declaring multitudes of women demoniacs, "and for further saying, that all the women in Ireland were possessed, i. e. by the devil specially possessed." He was forbidden to practise any more in Connaught, and his feats everywhere else were generally opposed and prohibited. "He went out like the snuff of a candle," as we are told by Walsh. "He made a great noise," we learn from Dr. Smith, "both before and after the Restoration, for curing all sorts of diseases (which he held to be the effect of possession), by exorcisms and stroking, and was followed for some time by vast numbers of people. But at last he was discovered to be a mere impostor." This is all that Smith condescends to say of him, yet his career has more in it to excite curiosity and attention than that of Greatrakes, to whose performances he has devoted some pages.

Whether Finaghty, the far-famed wonder-worker, was a mere impostor, a mere fanatic, a compound of both, or a man who performed some cures, which neither a mere fanatic nor a mere impostor could have effected, and, whether those cures were made alone by an influence exercised over the imagination, or by practices productive of phenomena (of whatever nature they may be) similar

to those produced by mesmeric operations, the reader will determine.

In conclusion, it may be observed that practices analogous to those of animal magnetizers, for the cure of diseases, may be traced in many works of antiquity, and the popular modes of cure by *the medicine men* amongst some tribes of American Indians, the *hakims* in the East, the *fetish* people in Africa, and the *handling doctors* in some parts of Ireland.

The simple practice of handling or stroking with the hand, in all probability, preceded the use of the magnet for the cure of disease. Lessing erroneously ascribed to Paracelsus the use of the magnet, as a remedial operation. Œlius, who flourished A. D. 500, making mention of it, says: "We are assured those who have the gout in their hands or feet, or convulsions, find relief when they hold a magnet."(a)

Paracelsus, who surpassed all the wonder-workers of antiquity, and believers in marvellous scientific practices, even in the possibility of making "homunculi" by them, particularly eulogized the use of the magnet for the cure of disease: fluxes and haemorrhages, and various other maladies, he tells us, were curable by magnetic influence.

In the fifteenth century Marcellus speaks of the use of the magnet for the cure of tooth-ache, and Leonard Camellus, for the same disorder, speaks of its application to the head. Kircher mentions the use of magnetic beads worn round the neck; and Ambrose Parè speaks of the employment of the magnet in some surgical operations. In 1770, Father Hehl, a Jesuit professor of astronomy, in Vienna, Beckman states, communicated to Anton Mesmer the wonderful effects produced by magnetized steel plates; and in 1798, Perkin's magnetic steel tractors obtained a temporary notoriety; but the *modus operandi*, both with Mesmer and Perkins, as far as regards the mere manipulation, imposition of hands, passes, or friction, was the old popular practice that has been already referred to,—the handling or moving of hands over the sick,—of those operators, in various countries, who professed to cure disease by the combined power of magic and medicine, or superhuman means alone, with the influence, real or supposed, of the magnet superadded to it.

(a) Ap. Beckman's Hist. of Inventions. London ed., vol. i. p. 44.

IRISH ASTROLOGERS.

In our Preface to the present series of this Journal, we mentioned the name of "Isaac Butler, Surgeon, Astrologer, Almanac-maker, and Botanist," and, moreover, Satellite to the Physico-Historical Society in 1744.

This genius, of whose birth or lineage history has not informed us, was employed by this society to make inquiries after rare plants, and to travel in search of fossils, simples, and such other curiosities

as were mentioned in the society's proposals. He was also required to produce, from time to time, lists of the names and localities of all the indigenous plants then in blow in the vicinity of Dublin. He procured specimens of mineral waters both for the societies and for Dr. Rutty. He furnished the Physico-Historical Society with a catalogue of plants and minerals found in various parts of the kingdom, which is still preserved in the minute-book of this body in the library of the Royal Irish Academy. Besides Butler's knowledge of the sciences, natural and unnatural, visible and occult, chemical and astrological, it would appear that he was somewhat of an antiquary, and was at one time employed by the Dean and Chapter of St. Patrick's to collect materials for a history of their cathedral. Butler died on the 7th December, 1755. In the minute-book of the Medico-Philosophical Society we find the following entry on the 7th of December, 1756:

"Proposed that the Eulogium upon Isaac Butler, drawn up by a Member of this Society, be inserted in this book." A portion of this is as follows:

"On Tuesday last, at 7 Min. four Sec. past Three, *Post Meridian*, descended to the *Antipodes* or *Nadir*, at his Lodgings under the Sign *Leo*, in *Taurus*, or Bull Alley, the *Umbra* or *Penumbra*, of Mr. Isaac Butler, *Ptolomean Philomath, judicial Astrologer*, Discoverer of Losses, *Botanist*, and Calculator of Nativities, having passed the *Meridian* of Life, and his grand Climacteric, in the 66th Year of his Age.

"He had been formerly a Student under, and for several late Revolutions of this Globe, was Successor to the late truly *Adept*, Doctor John Whalley, Professor of the celebrated Astrological Art of the Doctors *Lilly* and *Partridge*, of *Bickerstaffian* Memory, which Dr. *Whalley* did for many Years calculate and publish the principal Almanack in Ireland, at a time when *judicial Astrology* was held by Philosophers in such Reverence, that they thought it rather supernatural, than a Science founded on *Sidereal Influences*. The like learned *Ephemeris* and Predictions, since his Master's *Culmination* to the *Medium Cæli* below the *Horizon*, have been annually set forth by Mr. *Butler*, who was a kind of *Gymnosophist* and *Rosicrusian* well skilled in the Occult Sciences, and all the Wisdom of *Ptolomey, Erra Pater, Cornelius Agrippa*, and *Tycho Brahe*, which, besides the Changes that were to happen in our Atmosphere, and other the usual Furniture of Kalenders, contained the Geocentric Courses, Revolutions and Aspects of the Planets, calculated for the Meridian of this Hon. City of Dublin.

"He also inherited from his Master many physical Secrets, and gained such a Knowledge in *Botany*, that he not only collected Simples for the Curious, and Officinals for the Sick, but he also taught several Tyroes in Pharmacy to know most of our indigenous Vegetables.

"December 7th, 1755, this truely greatly *Adept* departed this life; having hastened his end by Laudanum taken in Brandy, which he prescribed for himself, in order to dye like *Socrates* and other antient Sages.

"John Smith, by Trade a Weaver, by Profession a Quaker, being trained up at the feet of our celebrated Gamaliel, and many years his Disciple, succeeded to the Great Honour of being his Successor, in constructing of Almanacks, in Botanical Researches; and being also Beadle to the Company of Apothecaries; and was also chosen Sattelite to a Society of Virtuosi, to which his Master belonged, but being no Conjurer, he has not meddled with Fortune-Telling."

A more lengthened eulogium, in the same strain, appeared in the *Universal Advertiser* of Saturday, December 11, 1755.—Ed.

VEGETABLE PHYSIOLOGY;

(OR, PHYTOLOGY*.)

TREATISE FIRST.

ANATOMY OF THE CONSERVATIVE ORGANS OF PLANTS.

Introduction.

Plants, whether regarded as individuals, or as grouped in the garden, the field, and the landscape, are objects of universal interest. The beauty of their forms; the delicacy, harmony, and splendour of their colours; the fragrance which they exhale; the refreshing verdure, and the convenient shade which we owe to them, besides their more important uses in contributing largely to our raiment, our sustenance, and our lodging; connect our interests, and even our existence, with theirs: whilst the examination of their conformation, and the observation of their functions, as organized living beings, expand and elevate the mind, and raise its contemplations in wonder and in gratitude to the great Source of all life. This important subject is divided into two parts; the first comprehending the structure of those organs on which the growth and preservation of the plant depend; the second, the structure of those organs by which the continuation of the species is insured. The former part, treating of the *Conservative Organs*, makes the proper subject of this Treatise. But it is necessary, first of all, to explain the substances of which the organs, whether conservative or reproductive, consist.

Chapter I.—*Of the Elementary Components of the Organs of Plants—Fluids—Membrane—Fibre.*

All plants, however different in form and other qualities, are composed of solid and fluid parts. The solid parts are generally permanent; that is to say, the organs which they constitute, when once perfected, are not subject to that waste and repair which the animal solid is supposed to undergo during life; but the fluid parts are changeable, varying continually both in mechanical admixture and in chemical composition.

The primitive solid components of the vegetable textures are *membrane* and *fibre*; from which are formed the common organic structures, the cellular and the vascular tissues*, and the varied combinations of these in the bark, *parenchyma* (or spongy, porous parts,) wood, pith, and medullary (or marrow) rays. The fluid elements are watery solutions of the soluble materials of the soil; from the decomposition of which, and the recombination of their ultimate components, by means of mechanical and chemical agency influenced by the principle of life, all the solid components, textures, and secretions are formed.

Vegetable Membrane is an exquisitely thin, transparent, colourless film, which resists the action of water and watery solutions in the living plant: but, when life ceases, is quickly acted upon by water, and reduced to mucilage. Du Hamel, a French philosopher of just celebrity, has asserted that vegetable membrane is composed of small organic fibres, arranged parallel to one another, and united by a glutinous substance: but no such structure can be detected by the microscope; on the contrary, it resembles a simple pellicle, or the film of a soap bubble, varying in transparency in different parts of the plant. In

* *Physiology*, from the Greek, a discourse of nature.
Phytology, also from the Greek, a discourse of plants.

* Tissue, a web, is the name for the soft and flexible parts of animals and plants—the cellular tissue is divided into cells, the vascular into vessels.

its simplest state it forms the sides of the cells of the cellular tissues; a little more condensed, those of the sap vessels; and still more condensed, the general covering, epidermis, or outer skin. It has also been supposed to derive its origin from minute globular bodies, found in the elaborated sap, which are dilated into vesicles to constitute the cellular tissue. There are other globules of a smaller size and more regular form, found in the interstices which frequently exist between the cells; and which, besides being the rudiments of future cells, according to M. Keiser, a distinguished German naturalist, are the cause of the different colours of the elaborated sap. It would be absurd to attempt a serious refutation of these hypotheses: we have only to recollect that plants are living bodies; that these globules are most probably merely nourishing matter, being found in great abundance in seeds, and wherever much nutriment is wanted; and that it is as easy to explain the most complex operations of structure, as to assign a satisfactory cause for the simple dilation of these particles into organic vesicles.

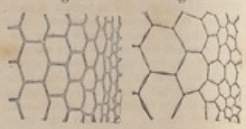
Vegetable Fibre is not so easily demonstrated as membrane, and is evident in one of the vegetable organs only, the spiral vessel, which is composed of one or more threads, twisted in a spiral manner so as to form a cylindrical tube. It is probable that these filaments owe their origin to the union of minute fibres, which can be detected in the elaborated sap and in all the proper juices of plants: this opinion, however, is also hypothetical; and it is not impossible that all the vegetable textures are modifications of membrane.

To enable us to examine the intimate structure of plants with advantage, the aid of a powerful single microscope is requisite; and the objects to be examined should be placed in a drop of clear distilled water. If we wish to examine the component parts of the plant, the portion containing them should be plunged in nitric acid, and the phial placed in boiling water, which must be kept at the boiling point for twelve or fifteen minutes. By this treatment, the parts composing the vegetable tissue lose their cohesion and become transparent, which greatly facilitates the investigation of them; the boiling, however, must not be carried so far as to disorganize the tissue; but, whenever the transparency is produced, and the parts separate of themselves, the boiling should be stopped, and the parts disjoined by pincers, under distilled or filtered rain water*.

Chapter II.—*Of the Elementary Parts composing the Organs of Plants—Cellular Tissue—Vessels.*

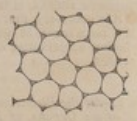
1. *Cellular Tissue.*—If a thin transverse slice of the stem of any plant be put into a drop of pure water, and placed under the microscope, it will be seen to consist chiefly of cells, more or less regular, resembling those of a honeycomb; as represented in *fig.* 1 and 2, in which the cells are magnified 260 times. This

Fig. 1. *Fig.* 2.



is the most common appearance of the cellular tissue when it is neither lax, nor compressed; but the form of the cells varies in different parts of the same plant, and also in different plants. The simplest form of the cell is the globular; the next is that of a twelve-sided figure, produced by a moderate pressure of six surrounding cells upon one, as displayed in *fig.* 3, the greatly magnified transverse section of the stem of Nasturtium (*Tropeolum majus*); but,

Fig. 3.

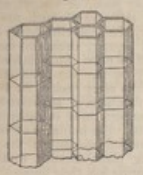


when the pressure of the surrounding cells is considerable, from each cell being stretched to the utmost, and the whole confined within a certain limit,

* See *Recherches Anatomiques et Physiologiques sur la Structure intime des Animaux et des Vegetaux, &c., par M. H. Dutrochet*, p. 9.

the form of the cell is necessarily hexagonal. In a *vertical* or upright section, the cells are generally longer than they are broad, and appear to be double six-sided pyramids with their points cut over. (See *fig.* 1.) In some plants, however, they seem to be six-sided figures transversely divided, or ranges of small cylinders, as in the Sugar-cane (*Saccharum officinarum*) (*fig.* 4.); whilst in

Fig. 4.



others, as, for example, the Banana (*Musa Paradisiaca*), they are flattened, and so arranged as to leave large triangular interstices between them.

In the greater number of plants, the form of the cells in the bark and in the pith is nearly the same. In annual and herbaceous plants, the cells are almost all uniform in figure, when viewed in a transverse section of the stem; but in a vertical section those of the exterior part of the bark, and those surrounding the vessels, are longer and of a more tubular character than the others; and resemble in some respects short pointed close tubes united obliquely at their points. Oblong cells are always found surrounding the vessels, both in succulent annuals, and in trees and shrubs; and it is probable that this arrangement is connected with the change which the sap undergoes in becoming the proper juice of the plant. These elongated cells, disposed in bundles, and crossed with the horizontal cells of what are termed the medullary rays, form the whole of the inner bark (or *liber*); and, with the addition of sap vessels, they form also the wood. In the medullary rays, which are those diverging lines seen by the naked eye running from the centre to the circumference, in a transverse section of a *ligneous* or wooden stem, and commonly termed *insertions*, the cells resemble those of the pith; but they are much smaller, and nearly disappear, from compression, in the old wood.

The size of the cells varies in different plants, and in different parts of the same plant. In general they are smallest in the leaves, larger in the roots, and largest in the stems of the same plant; and they are larger in annual and succulent plants than in trees and shrubs. In ligneous plants, the cells of the pith are larger than those of the parenchyma, or porous, spongy substance, and are visible to the naked eye; but in some plants, and some parts of plants, they are so minute as to require a million to cover a square inch of surface*.

If each cell be a distinct vesicle, the partitions between the cells must be double; and this is rendered evident, under a powerful microscope, by the interstices which are apparent at the angles of the cells, when these are not fully distended, as in *Nasturtium*, (see *fig.* 3.) These interstices, or intercellular canals, as they are termed by some vegetable anatomists, vary greatly in size. In some plants, as *Calla Ethiopica*, they surpass the cells in magnitude; whilst in others, as *Sassafras*, they are scarcely visible. In both states, M. Keiser asserts that they contain proper juices; and, also, that they are the channels through which the sap rises; but, it is not probable that a function so important to the vegetable economy would be allotted to such casual organs. The conjunction of the cells with the vascular system differs according to the nature of the contiguous vessels, as will be afterwards explained.

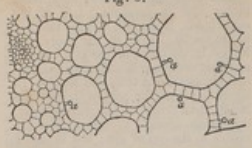
The cells are empty, or rather filled with air, in some parts of plants; but, in other parts, they receive and transmit fluids. In aquatic plants, in which there are large reservoirs of air, the cells of the parenchyma inclose bundles of vessels, whilst those which answer to the pith in other plants contain air only; and in trees and shrubs, although the cells of the pith contain an aqueous fluid, in the young or succulent state of the twig, yet they contain only air at a later period, when the twig becomes woody.

The air-cells, or rather reservoirs of air, of aquatic plants, are separated by partitions of cellular tissue, as is well illustrated in the greatly magnified section of the stem of *Calla Ethiopica*,

* Hooke's *Micrographia*, p. 114.

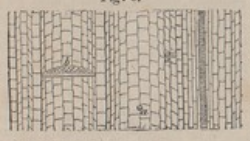
(*fig.* 5.) They resemble short cylinders

Fig. 5.



or tubes divided by cellular diaphragms at irregular distances; see *fig.* 6, in

Fig. 6.



which *b* represents the diaphragm in one of these air tubes, in a vertical section of the same stem. Air tubes and cells are most frequently found in the centre of stems and in leaves, rarely in roots, and never in the woody part of plants. Their interior surface is sometimes smooth, as in the Banana; sometimes rough, as in grasses; in a few instances, they are filled with small cells, formed of an extremely thin membrane, and containing air; and, in others, as *Calla*, globular and radiated bodies, supported on footstalks (*a*, *figs.* 5 and 6.) are seen rising from their sides, and pointing towards their centres. Small air-cells, similar to those found in the air reservoirs, are also sometimes observed in the large vessels.

Such is the cellular tissue: it enters as a component into almost every part of the vegetable structure; and some of the less perfect plants seem to be altogether composed of it. It is highly probable that the most regular form of its cells, the hexagonal, arises from the pressure of the original globular vesicles upon one another: a fact which may be easily illustrated by agitating a solution of gum in a phial only one-third full: the air is involved in the mucilage and produces a froth; the cells of which are hexagonal, owing to the limits opposed to their expansion by the sides of the phial. We also observe in the spawn of the frog, the ova or eggs of which are deposited in reservoirs close to the termination of the oviducts, that the gelatinous cells, which surround and form a covering to each egg, assume the hexagonal figure, from dilating in a limited space. The cellular tissue, besides containing water, other fluids, and air, is the repository of mealy, sugary, resinous, oily, acid, and saline secretions: it is the medium also by which the descending proper juice, or elaborated sap, is diffused sideways through the plant; and many changes, effected by electro-chemical agency, occur in the juices which fill its cells. Such, indeed, is the simplicity of the vegetable structure, that there is every reason for believing that the functions of secretion and nutrition are performed solely by the cellular tissue. The influence of vitality is thus beautifully displayed: the cells of the living plant, swollen with fluids, retain, during life, their figure; change the fluids they contain into others of the most opposite quality; and constitute a sufficient barrier to prevent them from mingling together: but, as soon as life is extinct, the sides of the cells yield, the secretions mingle, and, if circumstances be favourable, decomposition proceeds, permitting the chemical affinities, which had been controlled during the life of the plant, again to exert their influence.

2. *Vascular Organs.*—If the branch of a vine, or of any other tree, be cut transversely early in the spring, the sap will be observed to sweat out from numerous points over the whole of the cut surface, except that part which the pith and the bark occupy; and if a twig, on which the leaves are already unfolded, be cut from the tree, and placed with its cut end in a watery solution of Brazil wood, the colouring matter will ascend into the leaves, and to the top of the twig. In both these instances, a close examination, with a powerful microscope, will demonstrate that the sap perspires from the divided tubular portion of the stem, and that the colouring matter rises to the top of the twig, through real organic tubes: these are the sap, or conducting, vessels of the plant. But if we examine a transverse section of the vine, or of any other tree, at a later period of the season, we find that the wood is apparently dry, whilst the bark, particularly that part next the wood, is swelled with

fluid. This is contained in vessels of a different description from those in which the sap rises: they are found in the bark only, in trees, and have been named *proper vessels:* but they may with more accuracy be termed *returning vessels*, from their function of carrying downwards the sap, after its elaboration in the leaf.

From the nature of the pith in trees and shrubs, no vessels are requisite in that part, and none are found in it; but they are found in every part of herbaceous plants. Thence we ascertain that the oldest and most compact plant, (as Hedwig, a distinguished naturalist, of Leipsic, who died in 1799, remarked,) is but a collection of vessels and cells, which have nothing of the character of a solid, except the thin membranous coats by which they are formed.

The general figure of the vegetable vessels is cylindrical; but the vessels are so minute that the greatest of them is scarcely visible to the naked eye. Hedwig measured the largest vessel in the stem of a gourd; it appeared $\frac{1}{75}$th of an inch in diameter, under his microscope, which magnified 290 times, so that its real diameter was the 3480th part of an inch; and Leuwenhoeck, a citizen of Delft, who died in 1723, and was an accurate microscopic observer, reckoned 20,000 vessels in a morsel of oak about $\frac{1}{10}$th part of an inch square. Notwithstanding their minuteness, however, the characters of the vegetable vessels can be tolerably well ascertained by the aid of the microscope.

The vessels of plants are generally collected in bundles or *fasciculi*, each containing from three to a hundred or more vessels. They occasionally, however, apparently ramify, but not like the vessels of animals, out of greater into less; for the ramification, if it can be so termed, is of the same diametrical size as the trunk of the vessel. It is also commonly supposed that they do not open into one another by what anatomists term *anastomosing**, even when the end of one vessel seems to open upon the side of another; but, nevertheless, a true union of this kind has been observed in the vessels of leaves.

In describing the structure of the vegetable vessels, we may arrange them, first, according to their functions, or as Conducting vessels, and Returning vessels; and, secondly, according to their similarity in point of structure.

A. *Conducting Vessels.*—The first of these vessels which was discovered is the simple spiral. It was described nearly about the same time by Malpighi, a professor at Bologna, who died in 1694, and by Dr. Grew, an English physician, and secretary to the Royal Society, who died in 1711; and it has lately been supposed by Keiser to be the original of all the other varieties of vegetable vessels, which he asserts are merely changes of the spiral. This opinion receives considerable support from the fact, that spiral vessels are found in all young plants; and that they are the only kind observed in some of the inferior tribes of vegetables. But there is another kind of vessel, the *annular* or ring-shaped, which exists as early as the spiral vessel, in many young plants, and, therefore, cannot be a transformation of the spiral: indeed, Keiser's theory of the manner in which he supposes this change to be effected in the annular vessel is the least satisfactory part of his excellent work†. We are, therefore, satisfied that there are two primary forms of vegetable vessels, the *spiral* and the *annular*, of which all the others are modifications or varieties.

A. *a.* 1. The *Simple Spiral.* If a leaf-stalk of Dogwood (*Cornus sanguinea*), or of the Elder (*Sambucus nigra*), or if the fleshy scale of any bulb, as, for example, that of the White Lily (*Lilium candidum*), be cautiously broken, and the parts drawn asunder, the spiral vessels will be seen, like screws, partially unrolled. They are formed of one or more opaque, silvery, shining fibres, turned in a spiral manner, generally from right to left, so as to form a hollow cylinder, as represented in *fig.* 7. The spires are

Fig. 7. *Fig.* 8.



* From a Greek word, signifying to open the mouth.

† *Mémoire sur l'Organisation des Plantes, &c.* 4to. Haarlem, 1814.

generally in contact, and the vessels are cylindrical, except when many of them are compressed together, in which case they are irregular. It has been supposed that the fibre forming the spiral vessel is hollow; but, when we consider that the diameter of the vessel itself, as Hedwig has ascertained, is less than the 3480th part of an inch, this is not very probable. In some plants, also, as the Reed *(Arundo donax)*, the fibre is evidently flattened. The spiral is sometimes formed of one continuous fibre, sometimes of several parallel fibres adhering together; the numbers varying from one to nine, as in *fig.* 8. The fibres are tenacious and elastic; for, when forcibly stretched, they contract and again roll themselves up, on the stretching power being withdrawn. The spiral vessels are the smallest of the conducting vessels; and differ in size in different plants, and also in the same plant at different periods of its growth. The less perfect the plants are, the smaller these vessels are found to be. They are larger in annual and in succulent plants than in woody plants; in some of which, for example, Guiaic *(Guaiacum officinale)*, and the Fir tribe *(Pinus)*, they are very small. They are smaller in grasses than in succulent herb and in some plants, as *Chara*, Grass-wrack *(Zostera)*, Duck-weed *(Lemna)*, and Hornwort *(Ceratophyllum)*, they have not hitherto been detected. In the young plant of the Balsam *(Impatiens balsamina)*, they have not at first the diameter which they acquire as the plant advances in age. They differ also in size in different parts of the same plant, being generally largest in the stem, and in the footstalks of leaves.

The spiral vessels are found in the earliest stage of the growth of the plant, even in the plantule or embryo in the seed. They stretch through the whole length of the plant, from the roots to the leaves and flowers, following the various curvatures of the stem. They are generally disposed in fasciculi or bundles, the smaller vessels of the group being always those next to the pith. The cells in the vicinity of these bundles are smaller in the ratio of their proximity; but there is no evident direct communication between the cells and the spiral vessels. In succulent plants they are found involved in the cellular pulp or the parenchyma; in woody plants, they always surround the pith, in the young shoot; and they form the greater part of the midrib of leaves and its ramifications, or what are erroneously termed veins and nerves, in leaves. They are also found in the *calyx* or flower-cup; the *stamens*, the *pistil*, and the other parts of the flower; and in the *cotyledons* or lobes of the seed.

A. *a.* 2. The *Reticulated Vessel* is a modification of the simple spiral, in which, the spires having become distant, the interstices are filled up in part with new fibres that pass diagonally from one turn of the spire to another, as if a branch from the original fibre; as in *a b c*, *fig.* 9. The whole of the spaces,

Fig. 9.



however, between the spires are not filled up by branched fibres; and therefore clefts or openings are left, which, from the *reticulated* or net-like aspect they produce, have given rise to the name of the vessel. Reticulated vessels are not found in young plants, being the result of a change produced by the advanced growth of the plant. They are found in a few plants only; but in some, as the Balsam *(Impatiens balsamina)*, at its full growth, they are the only kind of vessel contained in the root, in which part they occur more frequently than in the stem. In the fasciculi of vessels in which they are found, their situation is towards the bark.

A. *b.* 1. The *Annular Vessel* is a primary form of vegetable vessel, named from its being formed of fibres like rings, instead of one continuous spiral fibre. According to Keiser, this vessel is an accidental production, caused by the tearing of the spires, which fall into simple rings, between each of which a membrane is formed. But independent of the fact already noticed, that the annular vessels are found as early in some plants as the spiral vessels, we ourselves have traced them from their earliest appearance, and are satisfied

that the rings never formed parts of a spiral vessel.

The annular vessel consists of a simple transparent membranous tube distended by rings, which are retained in their places by minute needles, which can be separated from their vessels in Spider-wort *(Tradescantia)*, and some other plants. These needle-like bodies, or *raphides* as they are termed, are about $\frac{1}{50}$ of a line in length; and are found in other parts of the plant besides the annular vessels. *Fig.* 10 exhibits the

Fig. 10. *Fig.* 11.



earliest formation of the annular vessel, at a time when the rings exist separate in the cellular mass, without the membranous tubes; and *fig.* 11, the perfect vessel. The rings are generally separated from one another only by a space equal to their own diameter; but they are occasionally at a distance of six or eight diameters. The annular vessel is found in many plants; and is particularly distinct in Spider-wort and Balsam.

A. *a. b.* 1. The *Punctuated Vessel* derives its origin both from the simple spiral and the annular vessel. When the spiral is its original, the spires are separated, and the intervening space filled with a connecting membrane, which is thickly studded with round oval dots, as displayed in *figs.* 12

Fig. 12. *Fig.* 13.



and 13. When the annular is the original, the membrane covers the rings, which can sometimes be moved within the tube as in the Reed *(Arundo donax)*: see also *fig.* 11. The dots, which surround the vessel in parallel rows, appear, in some plants, to be pierced in the centre, and it is probable that this is the case in all. The membrane in the spiral punctuated vessel is not present in the young plant, and does not form until the leaves of the plant are in their adult state. In both varieties of the vessel it is at first transparent, and becomes opaque by age. It is the largest, in respect of diameter, of the vegetable vessels; and, in the fasciculi of vessels in the stems of herbaceous plants, it is always the nearest to the bark. It is present in the root, the formed wood of stems, in branches, leaf-stalks, and the midrib of leaves. In old and hard wood, as of the oak and the chesnut, the punctuated vessel appears as if it were branched.—(See *fig.* 12.)

A. *a. b.* 2. The *Beaded Vessel* is a modification of the punctuated and the reticulated vessels. It resembles a chain of oblong ovate cells, or beads, (*fig.* 14.) whence it derives its name.

Fig. 14.

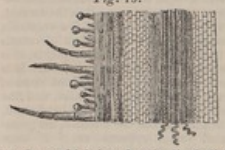


It is found only in the knots of the stem, and the tubercles of the roots; and seems to be intended for uniting the other vessels with one another.

Sometimes two or more modifications of structure are seen, at the same time, in the same vascular tube. This arises from the natural tendency of the simple spiral vessel to change into the punctuated vessel; and both this and the reticulated into the beaded vessel. If the stem of a gourd be examined at different periods of its growth, or in different parts of the plant, between the root and the top of the stem, we shall find that, in the young plant, or at the newly unfolded extremity of the old plant, the

vessels are all simple spirals. As the plant advances in age, each of the vessels already formed becomes punctuated, and new spiral vessels appear on the opposite side of the fasciculus; and this transformation of spiral into punctuated vessels proceeds until all the vessels, in the oldest part of the stem, that are next the root, are punctuated vessels. This is well illustrated in the two portions of the stem of the same gourd represented in *fig.* 15, and *fig.* 16. In

Fig. 15.



the first, which is a longitudinal slice, taken near the top of the plant, the vessels are few, and all simple spirals;

Fig. 16.



in the second, taken near the root, the number and magnitude of the vessels are greatly increased, and they are all punctuated, except the innermost, which is spiral. This illustrates the remark that the vegetable solid is permanent; for, by the growth of the plant the original spiral thread is stretched, and the intervening membrane is added to form the altered vessel. As a proof, also, that the spiral and the annular vessels are not varieties of one another, Keiser, whose accuracy of observation can be relied upon, asserts that the punctuated and the reticulated vessels are never found in the same plant.

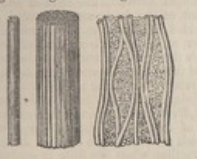
We cannot here enter into a minute investigation of the functions of the vegetable vessels; but it may be proper to state, that the most contradictory opinions regarding them prevail. It is undoubted that, in early spring, and in autumn, fluid is found in all the vessels; and even those persons who maintain that the spiral vessels are *tracheæ (wind-pipes)*, or air-vessels, have been forced to admit that they occasionally carry sap. The great difficulty rests, undoubtedly, with the spiral vessels; for those which have membranous sides can be intended for no other purpose than to carry fluids. Whilst the subject remains undetermined, the following hypothesis may be hazarded:—that the spiral vessels are intended for conveying upwards the sap, in young plants and shoots, and that they accomplish this with a very moderate impulse, owing to the easy contraction of the fibre, lessening the diameter of successive portions of the vessel, and thus raising the sap forced into it by an impulse communicated in the radical fibrils; but that, as in the more advanced age of the plant the strength of the coats of the radical fibril increases, no contracting power in the coats of the vessels becomes requisite, and all that is necessary is a sufficient strength of the coats of the vessels to resist the pressure of the ascending fluid, which receives its impulse in the roots, and ascends as if it were through dead tubes. The nature of this impulse, and the effect which it produces on the progress of the sap, (for there is no circulation of that fluid) will be fully explained in the treatise on the *functions* of plants.

B. *Returning Vessels.*—It has been already stated, that as soon as the leaves begin to appear, the sap ceases to flow from the wood if it be wounded; but that this does not proceed from the sap not continuing to rise, but, as Dr. Hales has expressed himself, 'from the attraction of the perspiring leaves being greater than the power of *trusion* (a thrusting) from the column of water.' The bark, however, at this time, is full of fluid, which is evidently descending, a fact which was first noticed by M. de la Blaise, and has since been confirmed by Mr. Knight*; and this fluid is carried downwards in vessels which are situated near the inner margin of the bark. They run, in straight parallel fasciculi (or bundles), close to the wood; but, as a new layer of these is added every year, and the former layers are pushed outwards, those at a distance from the wood separate from one another, and produce a mass of network,

* Mr. T. A. Knight, President of the Horticultural Society.

the meshes of which are filled with cellular matter. Each vessel is a simple entire tube, of a small size. The vessels in the bark of trees and shrubs, which have a copious, thick juice, are arranged around reservoirs of this juice, in the same manner as the oblong cells are arranged around the other vessels; but, in herbaceous plants, those in which the vessels are distributed, in distinct bundles, through the parenchyma, they form part of each fasciculus, in conjunction with spiral or annular vessels. In figures 17, 18, 19, is represented

Fig. 17. *Fig.* 18. *Fig.* 19.



each of these states of the returning vessels.

CHAPTER III. — *Of the Compound Organic Constituents, or Common Textures of Vegetables—Epidermis —Bark—Wood—Pith.*

By the terms *Compound Organic Constituents* and *Common Textures* are understood those parts of the plant into which the elementary organs enter as components; and which, nevertheless, are themselves only components of the vegetable members. They will be described in the order in which they are found in the trunk and the branches of trees, proceeding from the exterior or outward skin to the centre of the plant.

1. The *Epidermis*, or vegetable cuticle (*Epiderma cuticula*), is an extremely thin membrane or pellicle, which, variously modified, extends over the surface of every part of the plant, from the spongy fibril of the root to the delicate petal of the flower, and even to the fruit; interposing a barrier between the living organs and all extraneous substances. It is furnished, in leaves, and in some stems, with extremely minute vessels, which spread over it like network, the form of the meshes differing in different plants, but, in leaves, all terminating in spiral vessels at the edge of the leaf. In herbaceous plants, and in young and succulent twigs, the epidermis is transparent, and, with a few exceptions, colourless, receiving its apparent colour from the parts which it covers. In old trees, however, it appears to be coloured not only in different plants, but in different parts of the same plant: thus in the Birch (*Betula alba*), it is white on the trunk and brown on the young branches; but this colour probably belongs to the *cutis*, or inner skin, which it covers. In young and annual plants, it is applied so closely over the cellular tissue as to be scarcely separable from it: but, in perennial plants, it is annually reproduced, and the old epidermis is pushed outwards. The doublings of layers thus accumulated has led to the erroneous opinion that it consists of several layers. Before it separates, it becomes opaque and apparently coloured. The new epidermis also is perfected before the old exfoliates; and in this manner the parts which it is intended to cover are always protected.

The epidermis is generally supposed to be perforated by the organic pores which are found on some parts of the surface of the plant; but it is probable that it enters these pores as a lining membrane, instead of being perforated. These pores, which shall be particularly noticed when leaves are described, are not found in all plants; they are not present, for instance, in the Lichens, nor in many mosses, nor in all plants which grow under water; neither are they to be discovered in every part of the same plant; never on the trunk, except when the plant is devoid of leaves, and never on the root. They are found on both sides of the leaf in grasses and in many other plants which have erect leaves; on the inferior side, or disk, only of the leaves of trees and of shrubs; on the upper side only of floating leaves; upon the *calyx*, but seldom upon the *corolla* of flowers; and on the stamens and the style in a few plants. They are found also on the outward rind or skin coverings of fruits, and of seeds; and on the cotyledons or seed lobes. They differ in size in different plants; but in the same plant their dimensions are always the same. The hairs, prickles, and glands, which are present in stems and in leaves, are merely extensions of the cellular tissue, covered with epidermis.

The epidermis is probably intended for the protection of the cellular tissue from the direct action of the atmosphere; and, in some instances, to limit the growth of parts. When it is accidentally destroyed on the succulent twigs of perennial plants, it is quickly regenerated; but in annual plants, and on the leaf and the flower, it is never renewed. It gives free passage to moisture, and exhales or gives out vapour, and absorbs or sucks it in; and it performs the latter function independently of the pores already noticed, which cannot be detected on the absorbing surfaces by the most powerful microscopes. Some vegetable physiologists, among whom is M. Mirbel, have regarded the epidermis as merely condensed cellular membrane, altered by exposure to air and light: but the majority more correctly admit that it is a distinct organized membrane.

2. The *Bark (cortex)* comprehends four very distinct layers or parts—the epidermis, which has been already described, the *cutis*, (inner or thick skin,) the cellular integument, (or covering,) and the inner bark, or *liber*, each of the three last of which we shall separately describe.

a. The *Cutis* consists of two layers, the outer of which is the pellicle or epidermis, already described, and the inner a composition of transverse cells which stretch betwixt the epidermis and the cellular integument. But this structure varies in different plants; thus, in the Horse Chesnut (*Æsculus hyppocustanum*), these cells resemble transverse vessels opening upon the surface of the stem; in the Lesser Periwinkle (*Vinca minor*), there are three series of such cells; whilst in the Laburnum (*Cytissus laburnum*), there is only one irregular layer. In young succulent shoots, the cutis is generally colourless and semi-transparent, transmitting the green colour of the cellular integument which it covers; but, in some instances, it is coloured; for example, white in the Birch (*Betula alba*), and yellow in the Japonica (*Aucuba Japonica*); and, as we have already remarked, it varies in colour in different parts of the same plant.

b. The *Cellular Integument* (*stratum cellulosum*) is composed of oblong hexagonal cells, ranging vertically, and varying in regularity in different plants. These cells are commonly filled with juices, which become greener the nearer they approach to the light; and it is the transmission of this colour through the cutis and epidermis, which gives the green colour to the succulent twig.

c. The *Liber*, or *inner bark*, is of a whitish hue, and the texture fibrous to the naked eye: but, when it is examined by a good magnifying glass, it seems to consist of fasciculi of longitudinal fibres running in a waving direction and touching one another at certain points, so as to form oblong meshes, which are filled with cellular tissue; see *fig.* 19. These longitudinal fibres, under a powerful microscope, are found to be fasciculi of returning or entire vessels, situated between the cellular integument of the bark and the wood, and divided into meshes by the medullary rays, which extend horizontally from the pith through the wood into the bark; and there push between these fasciculi, to reach the cellular integument. This tubular texture has been termed *cortical fibres*, from the supposition that it is of a ligneous nature, an opinion which received some support from the fact, that when the liber is soaked in water, the intercellular part dissolves, and the oblong fibres remain unaltered: but no doubt is now entertained that these apparent fibres are hollow tubes, the vessels which convey the elaborated sap downwards, to increase the solid diameter of the tree. When the liber of the Lace-bark tree (*Daphne lagetto*), is soaked in water and afterwards beaten, it forms a beautiful vegetable gauze, which might be worn as an article of dress. Oak bark, when it has been long exposed to the weather, exhibits a reticulated aspect resembling the above-mentioned gauze. The whole of the bark is annually reproduced, and the old layer pushed outwards. When it cracks vertically, there are formed the rough furrowed coats of the Elm, the Oak, and many other trees; when transversely, the multiplied layers of the Birch and the Currant; and when the crack is irregular and in both directions, the flakes which are annually thrown off by the Plane. Du Hamel demonstrated this fact, of the annual regeneration of the bark, and the pushing outwards of the old layers, by passing a silver wire through the young bark, in the middle of its thickness, and finding it some years afterwards in the decayed bark.

Neither spiral nor annular vessels, nor any of their varieties, are found in the bark: but its vessels are the reticulated already described. The whole of the cells of the liber contain secreted fluids; and it is this portion of the bark, therefore, that yields the various products which render certain barks useful in medicine and the arts.

3. The *Wood (lignum.)*—If a young shoot of any tree or shrub be cut through transversely, there is perceived under the bark a cylinder of greater firmness than the bark, inclosing a spongy or cellular mass: this is the wood. If the tree, or the portion of it which is cut through, be several years old, several cylinders of wood are observed inclosing one another, or forming concentric layers around the cellular column or pith, and occupying the space between it and the bark. The outermost of these layers is always more succulent than those are which are within it, and is named *alburnum*. It is this part which, in deal, has a whiter colour, is more spongy and less durable than the more perfect, or *heart wood* as it is termed. These concentric layers are also perceived to be traversed by rays or lines diverging from the centre of the stem to its circumference, and which are evidently of a structure different from the other part of the ligneous circles. On a closer inspection, aided by the microscope, this ligneous part of the tree is discovered to be formed of longitudinal fasciculi or bundles of vessels surrounded with oblong cells, which are traversed horizontally in various places by flattened masses of cellular substance, separating the bundles of vertical tubes and oblong cells, so as to display a reticulated appearance, when a perpendicular section of the stem or shoot of any tree or ligneous plant is examined. The wood, therefore, consists of two distinct parts, *concentric layers* and *medullary rays*, as represented in *fig.* 20.

Fig. 20.

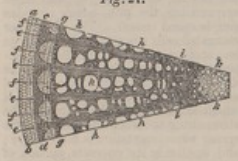


a. The *Concentric Layers* (*strata lignea.*)—The vessels of which these consist are the punctuated, or the reticulated, or, under certain circumstances, the beaded, except in the first circle surrounding the pith, which contains simple spiral vessels. The oblong or elongated cells are arranged parallel to one another, except where they are separated by the medullary rays. The vessels in each concentric layer of wood are always larger in that part of it which is nearest to the centre of the stem, owing to their being formed in the spring when vegetation is most active; and smaller in the opposite portion of the layer which is formed in autumn; but in the vascular fasciculi of herbaceous plants, in which there are no concentric layers, the smaller vessels are always towards the centre of the stem; although in Palms, which have also no concentric layers, the larger vessels are found in those fasciculi nearest the centre. The oblong cells contain fluids in the young or succulent state of the wood; but as this advances in years, they are filled with thickened secretions; and these becoming drier, and consequently harder, produce much of the solidity and firmness of wood.

b. The *Medullary Rays* (*radii medullares.*)—The flattened masses of cellular tissue, which compose these, consist of oblong cells resembling the oblong cells which surround the vessels; except that they are horizontally arranged. These rays stretch from the first layer in the centre to the surface of the wood; and are there opposed by others situated in the *liber* or inner bark. In these rays the cells are more numerous in the middle of the mass, so that in a vertical section of a stem they appear to be of a lozenge shape. (See *fig.* 19.) The cellular texture of the medullary rays has led them to be regarded as processes of the pith, and hence their name, the pith being as it were the marrow (*medulla*) of plants. But that this is an error seems evident, for the first layer of wood, the one next to the pith, has no medullary rays traversing it, although every subsequent layer is crossed by them. But this central layer differs from the other layers in several respects. It consists

of small oblong cells, imbedding a circle of simple spiral vessels, and a cellular lining or sheath which is interposed between the pith, and the spiral tubes. In herbaceous plants no medullary rays are perceptible until the plants have produced seed, and become woody, when they are evident; as displayed in *fig.* 21, the transverse section of the

Fig. 21.



stem of the French Bean (*Phaseolus vulgaris,*) in which *a b* represents the bark, and *c d* the termination of the medullary rays, *e e e e*, between which the spaces within the semicircles *f f f* are filled also with the cells of the bark: *g g* are the vascular bundles, consisting of large punctuated vessels *h h h h h*, and small spiral vessels *i i* close to the pith *k k*.

4. The *Pith* (medulla) is composed entirely of cellular tissue, which is at first, in the succulent state of the plant, filled with watery fluid; but gradually exchanges this for air, becoming dry before the first layer of wood is perfected, except near the final bud, or where branches are given off, in which places it retains its moisture. The cells of the pith in young stems and twigs are more regularly hexagonal than in other parts of the plant; but this alters, owing to different circumstances, as the tree acquires age. The pith is usually white, but in some instances it is coloured; as, for example, it is yellow in the Barbary (*Berberis*), pale brown in the Walnut (*Juglans regia*), fawn-coloured in the Sumach (*Rhus*), and pale orange in yellow-flowered Horse Chesnut (*Æsculus flava*). The diameter of the pith in many herbaceous plants, and in the majority of trees, continues of the same diameter in the full-grown plant as it was in the twig or the young plant: but in the Sunflower (*Helianthus annuus,*) and a few other plants, it increases in diameter after the spaces of the stem between the leaves cease to extend. The cavity which contains the pith is circular in the majority of plants; but it varies in shape, being furrowed, oval, triangular, quadrangular, pentangular, and hexagonal in many trees. It is also, in general, longitudinally entire; but in some trees, as in the Walnut, it consists of a succession of transverse diaphragms* intersecting the hollow cylinder of the wood, with the intervening spaces empty. See *fig.* 22.—In many herbaceous plants it is a mere lining sheath.

Fig. 22.



Such is the nature of the general components of the vegetable structure; et us next examine the members and organs into which these enter. They may be divided into two distinct classes: 1. The conservative members and organs, or those on which the life of the individual depends. 2. The reproductive members and organs, or those by which the species is perpetuated. The former comprehend the *root*, the *stem*, the *leaves*, and the *appendages* of these parts; the latter comprehend the *floral envelope*—the *productive organs*—and the *seed*.

Chapter IV.—*Of the Structure of the Root—its Divisions—Mode of branching—Rootlets—Capillary Fibrils.*

The root, *Radix*, as commonly defined, is that part of the plant 'by which it attaches itself to the soil in which it grows, or to the substance on which it feeds, and is the principal organ of nutrition†.' There are, however, some exceptions to this definition; some roots are not fixed to any thing, but float loosely in water, as Duck-weed (*Lemna*), and some have no roots at all, but absorb their nutriment from the air by their general surface, as the genus *Tremella*. Roots, as they grow, generally assume a determinate form; and botanists have arranged them accordingly; but we must refer our readers to the subject of

* From the Greek word, signifying a fence or separation, or skreen.

† Keith's System of Physiological Botany, vol. i. p. 33.

Botany, both for an account of the forms of roots, and of their relative direction in the earth.

The mature root consists of three distinct parts; the *body* or *caudex*, which is often divided into branches; the *rootlets*, which issue from the caudex and branches; and the fibrils, occupying the top and sides of the rootlets.

The roots of trees so closely resemble the stem in structure, that they have been named *subterranean trunks* and *descending stems*; and, on this account, we may refer to the description of the stem for information respecting the general anatomy of ligneous roots, at least as far as concerns the caudex and branches. In herbaceous plants this analogy is less close. When the root is *annual*, the caudex consists of a cuticle and a thick cellular bark, which constitute a large proportion of the diameter of the root; and a central part, composed of oblong cells and vessels, disposed either in separate fasciculi, or in rings, or in rays as in the transverse section of the root of the Sweet-pea (*Lathyrus odoratus*), represented in *fig.* 23. The cortical cells are all hexagonal;

Fig. 23.



the sap vessels are the punctuated; those in the centre being generally the smallest; and they occupy the place of the pith, which is seldom found in annual roots, except near the top, where the root changes into the stem. In those annual roots which secrete a white or a proper juice, all the cells are tubular, and arranged with great symmetry; and they appear to be conductors as well as reservoirs of the proper juice. The root of the White Poppy (*Papaver somniferum*), a few of the cells of which are represented in *fig.* 24, affords a beautiful example of this structure. A contracting power might be suspected to exist in these cells, as the exudation of the juice from a transverse section of the root is much greater than could be contained in the range of divided cells; and on examination we find the cells of several successive ranges empty and shrunk; but in this case the exudation rapidly thickens, and favours the emptying of the entire cells, a fact satisfactorily accounted for by the theory of M. Dufrochet, which shall be explained in the Treatise on the Functions of Plants.

Fig. 24.



In *biennial roots*, the disposition of the parts is more varied than in annual roots. In the first season of its growth, the biennial root consists of a cuticle and thick cellular bark, surrounding a large central part composed of short hexagonal tubes, variously arranged; but often in rays proceeding from the centre to the circumference. These generally contain *mucus* or proper juice. The sap-vessels, even the smallest and most recently formed, are punctuated: they are larger in diameter than the tubular cells; and variously arranged in different plants, sometimes in rays through the central part, as in Burdock (*Arctium lappa*); sometimes in fasciculi, as in Hemlock (*Conium maculatum*); and, in other instances, in circles. The mucus in the tubular cells being appropriated for perfecting the flower stem, the flower, and the fruit, is absorbed as the fructification of the stem advances; and, as these are perfected, the cells are emptied and their sides become ligneous. It is this which renders the turnip, the carrot, and other eatable biennial roots unfit for the table, when the plants have flowered.

Perennial herbaceous roots are still more varied than either the annual or the biennial, in the proportion and relative position of parts: they may, however, be all described under two heads; those composed chiefly of *tubular cells symmetrically arranged*; and those composed of *common cellular tissue*.

If the root of Dandelion (*Leontodon taraxicum*), in the first year of its growth, be taken as an example of the first division, we find that a transverse section of it consists of a cellular pith, *a* (*fig.* 25.) surrounded by ten fasciculi of sap-vessels *b*, *b*, *b*, which are punctuated with oblong dots; a thick pa-

Fig. 25.



renchymatous layer, consisting of oblong or short tubular cells arranged in rays through which run numerous fasciculi of reducent vessels *c*, *c*, *c*, disposed so as to form concentric circles; and a bark *d*, consisting of hexagonal cells, and covered with a thick cuticle. As the root advances in age, new vessels are added to the fasciculi of sap-vessels; and as these continue to increase, the original pith is so compressed, that the centre of the stem assumes the aspect of one vascular mass. New layers of cellular tubes and reducent vessels are also added on the exterior, the old vessels becoming opaque, whilst the cuticle with the cellular bark cracks, and both are annually pushed outwards; until, at length, the root appears, in a transverse section, even to the naked eye, to consist of a central vascular part, surrounded with concentric circles, alternately opaque and transparent. The vessels are variously dispersed in different plants; but, in all of this division of perennial herbaceous roots, the tubular cells are symmetrically arranged, and constitute the greater part of the root. If the root of Deadly Night-shade (*Atropa belladonna*) be taken as an example of the second division, we shall find that it is composed chiefly of oblong cells not symmetrically arranged, with one large fasciculus of punctuated sap-vessels in the centre, and several smaller fasciculi interposed, so as to form nine or ten indistinct, interrupted rays. In the second year, additional sap-vessels surround the central part; and, as the root advances in age, it resembles the ligneous stem in structure, having a pith, concentric circles of wood, diverging rays, and a bark.

Herbaceous roots are all originally spindle-shaped; but they sometimes become forked, in which case the sap-vessels of the caudex are divided according to the number of the forks, as if a skein of thread was divided into two or three parcels. In truth, this division differs from branching, inasmuch as branches are new productions with vessels of their own, which may unite with, but are not a part of, those contained in the caudex. When any thing opposes the extension of the tap-root, or destroys a portion of it, then branches shoot out sideways; and this is probably owing to the addition in the extension of roots being always made at the point.

Rootlets (radicella), whether of ligneous or of herbaceous plants, project at right angles with the surface of the caudex, or the branch on which they are seated. Some rootlets are productions of the bark or of the alburnum of the stem; and are shot forth whenever the part is placed under the ground, or is surrounded with moist earth. Thus, if the branch of a tree or a shrub be bent downwards until it touch the ground, then pinned to the spot and slightly covered with earth, rootlets will be sent out from the under part of the branch; and if the branch be then separated from the tree, it will grow and become a tree similar to the parent: or, if a ring of bark be removed from a branch, and the part surrounded with moist earth, in the manner of grafting, rootlets will be emitted from the upper portion of the divided bark. Rootlets also come from the knots in the stems of grasses and similar plants, whenever they are brought into contact with moist earth: thence the advantage of rolling young wheat and grass; for whenever these rootlets are produced, additional stems also spring from the knots. The rootlets, which issue from the caudex of the root and the branches, proceed from the medullary sheath, and are united with the vascular fasciculi of the ligneous part of the root; but from whatever part they originate, rootlets consist of one large fasciculus of punctuated sap-vessels, generally arranged in rays, and inclosed in a cellular bark.

The *Fibrils* (*fibrillæ*) comprehend two parts,—the thread or capillary ramification of the rootlet, whence their name, and the *Spongiets* (*spongiolæ*), which are seated upon their sides. The *fibrils* consist of a central fasciculus of vessels, inclosed by a cellular cortex and cuticle; the *spongiets* are oblong, oval, spongy bodies, very minute, and found only on the fibrils; (*a*, *fig.* 26, represents one greatly magnified.) When examined under the microscope, they are found to consist of a porous cuticle, inclosing a circle of hexagonal cells, *b*,

(*fig.* 26.) surrounding a fasciculus of vessels, *c*, which anastomose with, or open into those of the fibril. They shrivel up in a few seconds after the root is taken out of the ground, and lie so close to the fibril as to be scarcely visible (see *a*, *a*, *a*, *fig.* 27.); but, if the fibril be placed in water, they as rapidly expand again, swell, and project from its sides (*b*, *b*, *b*, *fig.* 27). The

Fig. 26. *Fig.* 27.



smallness of these bodies prevents their structure from being more fully developed. Some late experiments of M. Dutrochet, which have been already mentioned as important, have thrown great light upon the functions of these minute bodies: they render it probable, that these fibrils imbibe the fluid from the soil through the cuticle, aided by electrical influence: and the cells, swelling, push the fluid into the vessels, through which it rises, forced upwards by the impulse given to it from the continued imbibing of the swollen cells, and the resistance opposed to distension by their sides and those of the vessels through which it rises. Some families of plants, instead of this capillary fibril furnished with spongiets on the rootlets, have a spongy knob at the extreme point of the rootlet; and, in some floating plants, as Duckweed (*Lemna*), and Callitriche, there is a small coif or hood at the extremity of the root, as represented in *fig.* 28, in which *a*, in the small figure, is the floating plant, *b* the rootlet, and *c* the coif. The structure of these parts is displayed in the dissections *a b c*, magnified figures (*fig.* 28.); and the cause of the floating of the body of the plant, or the leaf, as it may be termed, is rendered evident by the air cells of its cutis, and the two large air cells in its substance, which are represented in the magnified figures. These spongiets of the capillary fibrils are the real nourishing organs of all plants; and as they are found only on the fibrils at the extremities of the rootlets, the reason is obvious why

Fig. 28.



small plants thrive better close to trees which have parallel roots than at a little distance from them; the earth being less exhausted in the neighbourhood of the larger roots, than where the rootlets spread. It is a curious fact, that coloured fluids, which never pass through the cortical pores, pass readily into the spongiets.

Chapter V.—*Of the Structure of the Stem and Branches.*

All stems, as far as regards structure, may be arranged into three classes:—

1. Stems which display, internally, an apparently *homogeneous mass, inclosed in a simple cuticle.*
2. Stems composed of *bundles of vessels, apparent woody fibres, variously distributed in a cellular parenchyma, inclosed by a simple cuticle.*
3. Stems composed of *concentric layers of conjoined vessels, connected woody matter, surrounding a column of pith, and inclosed by a bark.*

1. The stem, in the first of these classes, appears to the naked eye as if composed of interwoven fibres, forming a felt-like texture; but, when examined by the aid of a good microscope, these fibres are found to be oblong cells arranged parallel to one another, (*fig.* 29.)

The Mushroom tribe (*Fungi*), the Lichens and the Flags (*Algæ*), afford

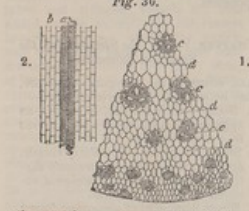
Fig. 29.



the best illustrations of this description of stem.

2. The stems of the second class are composed of two distinct parts, a vascular or ligneous, and a cellular, variously arranged, according as the stem is solid or hollow. If we take the sugar-cane (*Saccharum officinarum*), as an example of the solid stem of this class, we shall find it to consist of vascular cords (*fig.* 30., 1: *c c c*), interspersed in a cellular parenchyma (*d d d*), inclosed within an epidermis, which adheres closely to it. Both the cellular matter and the vessels are larger, and the vascular cords thicker and more distant from one another, in the centre of the stem than towards the circumference. The cells are short, hexagonal tubes, placed above one another: (*fig.* 30. 2. *b*. and *fig.* 4.) and each ligneous cord is composed of spiral or of punctuated vessels, (see *fig.* 30. 2. *a*.) closely encircled with narrow oblong cells. In some instances,

Fig. 30.



the vascular cords run in straight lines; in others, they have a zig-zag course. In the knots of articulated solid stems of this description, the vascular cords send off branches, which meet and touch in arches before they are distributed to the leaf, which generally is given off at the knot, sheathing the basis of the new articulations. Stems of this class have no medullary rays. If the plants are *monocotyledons* (or plants whose seed has *one* seed lobe only), the stems increase in length, but, with the exception of the Aloes, Yuccas, and Dracena, they never augment in breadth. The Palms, the stems of which are of this kind, all rise, sometimes to the height of 200 feet, with a cylindrical columnar stem, notched with the bases of fallen leaves, and terminated with a magnificent crown of foliage: and as the vitality of this description of plants depends on the herbaceous part, if the terminating bud or cabbage, as it is termed, be cut off, the whole plant will immediately die. The White Lily (*Lilium candidum*) closely resembles the Palms in its developement and growth. If the plants are *dicotyledons* (with *two* seed lobes), or *polycotyledons* (with *many* seed lobes), the proportion of the cellular matter of the stem greatly exceeds that of the vascular. Thus, if we take white Bryony (*Bryonia alba*), as an example, we shall find that the stem consists of a mass of cellular matter, involving fourteen vascular fasciculi, and inclosed in a bark composed of a cuticle and three distinct cellular bands. See *a*, *fig.* 31. The cells are chiefly oblong hexa-

Fig. 31.

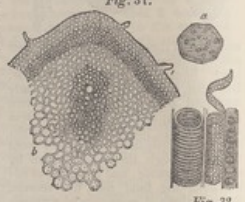


Fig. 32

gons, which are larger in the centre of the stem, (*b*, *fig.* 31.) and, as the season advances, become empty and almost resemble pith. The vascular bundles contain three distinct kinds of tubes; the *punctuated*, which is the largest and always in the centre; the *spiral*, with the fillet punctuated; and the *annular*, (see *fig.* 32.) Such is the general structure of herbaceous dicotyledonous stems of this class: they resemble monocotyledonous stems in having distinct fasciculi of vessels; but the presence of the bark is a sufficiently characteristic distinction.

In *hollow* stems of this class, the cavity is surrounded by a mass of hexagonal cells, involving fasciculi of vessels symmetrically arranged. If we take the Gourd (*Cucurbita*) as an example, we find ten fasciculi. The vessels vary in size and number according to the age of the stem: at first they are simple spirals; then some annular vessels appear; and, ultimately, they assume the character of the punctuated annular. In some plants, as Balsam (*Impatiens Balsamina*), the

vessels are spiral, annular and reticulated. The bark is cellular, and contains proper vessels. The cavity is in many instances interrupted at the knots (*nodi*) by a diaphragm; and it has been supposed, although with little truth, that each articulation may be regarded as a distinct individual, which takes its origin from one knot and terminates in another. If we examine the culm or stalk of Wheat, which is an articulated stem of this kind, we may perceive, by placing a longitudinal slice of one of the knots under the microscope, that the vessels of the lower articulation *a*, *a*, *fig.* 33, as soon as they reach the dia-

Fig. 33.



phragm, which separates the lower from the next articulation, give out the vascular cords *d*, *d*, which, traversing the diaphragm, rejoin the original cords in the leaf *b*, *b*; whilst the vessels of the new articulation *c*, *c*, seem to rise out of these, traversing the diaphragm *e e*. There can be little doubt, therefore, that the articulated culm is one individual; for although the vascular cords of each articulation terminate in the leaf of that articulation, yet the vessels of the new joint seem to be merely branches of that below it.

The Palms, Irises, Orchises, Grasses and Rushes, afford excellent illustrations of this description of stems.

3. The third class of stems, as has been already stated, is composed of three distinct parts, *bark*, *wood*, and *pith*. These are variously arranged, as the plants are woody or herbaceous.

The structure of the woody stem is exemplified in all trees and shrubs. If we take a transverse slice of any twig of the growth of one year, we find the *pith* in the centre inclosed by a ring of *wood*, and this surrounded by a circle of *bark*. If we take a longitudinal slice, we find another part, the *medullary rays*, transversing the wood. The general structure of each of these parts has been already sufficiently described. A layer of bark and of vascular or woody matter, *alburnum*, is added every year to the diameter of the tree; and the functions of both the bark and the wood are chiefly carried on by these new parts, which are, therefore, whilst young, endowed with more irritability than any other part of the plant. Both the bark and the wood are formed from a gelatinous (jelly-like) secretion, named *Cambium*, which is deposited partly from the reducent or returning vessels of the bark, and partly from the medullary rays, between the wood and the bark. It appears, however, to be principally prepared in the leaves and transmitted through the bark; for when the leaves of a tree or a shrub are destroyed, scarcely any new wood is formed in that season; and if the bark in the trunk of a tree be gnawed off by sheep, or otherwise removed, the portion of the wood above it continues to augment in diameter, because it is supplied with the elaborated, nutritious juices prepared in the leaves, while the portion below the wounded bark ceases to grow, owing to all communication between it and the foliage being cut off: See *fig.* 34,

Fig. 34.



in which *a*, the part above the gnawed portion is considerably thicker than *b*, the part below it.

Without prosecuting further this physiological discussion, it is sufficient to know, that it is from this elaborated sap that the new liber and alburnum are formed, by the organic power, or vital principle inherent in the plant, transforming this gelatinous fluid into cells and vessels, the diverging layers being formed at the same time as the concentric. Neither is it requisite, here, to inquire into the functions of the different kinds of vessels, which enter the composition of the concentric layers; we may only observe, that it is not yet ascertained, whether the simple

spiral vessels transmit fluids; but there is very little doubt that the punctuated vessels are those through which the sap is transmitted from the roots to the leaves. The layers of wood acquire hardness as they advance in age; but this is not the consequence of the mere loss of fluid parts, but of the deposition of woody matter, and other secretions in the cells; and this continues until the wood attain its final degree of hardness, which does not occur before the tree has arrived at its full growth. Hence the superiority of a tree felled at this time, to that of one cut down at any earlier period.

The *pith* is swollen with fluid, in the young twig or stem; but it becomes, afterwards, dry and spongy, and is slightly compressed by the swelling of the internal woody layer, during its process of hardening. The form of the pith is regulated by that of the cavity which it fills; and this, although for the most part circular, yet differs in different trees: thus, for instance, it is oval in the Ivy, furrowed in the Oriental Plane, triangular in Oleander, quadrangular in the Oak, and hexangular in Dogwood. It varies, also, in diameter in the same tree, even when young, being smallest at the base of the stem, larger in the middle, and smaller again at the summit; and these variations are observable in the growth of each future year.

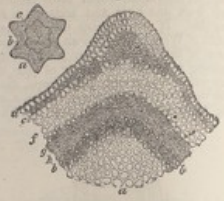
In most trees, the pith is entire and uninterrupted all along; but, in some, as the Walnut, it is intercepted by empty spaces (see *fig.* 22.); in a few, as the Magnolias, the column is broken by ligneous partitions; and in others, as Woodbine, it is merely a spongy sheath, lining the interior of the cavity of the stem and branches. Many conjectures have been hazarded respecting the use of the pith; it has been supposed to be the nervous system of plants, to give origin to buds, and to serve as a reservoir of moisture for the supply of the leaves, whenever an excess of perspiration requires it. But, it is most probably intended merely to afford the surface necessary for the formation of the first layer of wood; and to give, by the bulk of its swollen cells, a degree of firmness to the succulent stem and recent shoot, which they would not otherwise possess, before the bark and the alburnum require sufficient consistence for that purpose*.

* See Thomson's Lectures on the Elements of Botany, vol. i.

The structure of Herbaceous stems of this class is well illustrated in the stem of Madder (*Rubia tinctorum*). In a transverse section, we find, 1, a bark, *a*, (*fig.* 35.) easily separated from

Fig. 35.

Fig. 36.



the parts beneath; 2, a vascular layer *b*, somewhat resembling the first concentric woody circle in ligneous stems; 3, a cellular pulp, *c*, which gradually becomes dry, and assumes the appearance of pith. The bark is covered with a thin, transparent cuticle *d*, (*fig.* 36, a highly magnified section of one angle,) which transmits the colours of the green proper juice contained in the outermost layer of cortical cells *e*, immediately beneath it. Within this are several layers of hexagonal cells *f*, containing a pale-yellow watery fluid, which deepens towards the interior of the bark, where we find its source, the proper juice, filling a range of narrow oblong cells, *g*, situated close to *h*, the layer of returning vessels. The outside vessels in *h*, which may be termed the ligneous layer, are large and punctuated; the inside are smaller and spiral, composed of three distinct filaments, and both are bedded in a green pulp. There are many modifications of this structure in herbaceous stems of this class; but the difference is chiefly in the arrangement of the vessels, which approaches more or less to that in ligneous stems. Thus, in the stem of Thorn-apple (*Datura stramonium*), which is an annual, the distribution and character of the parts so closely resemble those of trees and shrubs, that it may be considered a soft ligneous stem, demonstrating the great diversity, with respect to induration, in wood; whilst, in the Lettuce (*Lactuca sativa*), the sap-vessels are in distinct fasciculi, like those in the stems of the second class, but arranged in one circle; and the vessels in each fasciculus are disposed

in diverging rays, separated by condensed cellular divisions.

But the most interesting circumstance connected with stems of this class is the origin of branches. When a bud protrudes to form a branch, the perpendicular vessels of the part on which it appears, separate to permit it to pass between them, and afterwards meet again (see *fig.* 37.), to pursue their original direc-

Fig. 37.



tion; a circumstance perfectly consistent with the fact, that branches, although attached to the parent, are truly distinct individuals; the lateral, or viviparous progeny of the stem, or of the older branches, on which they are produced. All branches proceed from germs formed in the earliest unfolding of the parts in which they appear, although the buds produced from these germs may not be protruded until the tree be greatly advanced in age. In the twig, yet inclosed in the bud, the rudiments, or germs of branches to be formed upon it, can already be perceived. It first appears as a simple vesicle, filled with a greenish fluid; apart from the permanent members of the plant, and enveloped by cellular tissue, filled with mealy particles. The organization gradually advances; and, if circumstances be favourable, the embryon branch becomes conspicuous in the spring, rising apparently, but not actually, from the medullary sheath of the parent twig, into the vessels of which the spiral vessels of the embryon branch open; and bundles of these are distributed to each of the new leaves, yet scarcely visible to the naked eye, and compressed within the scales of the bud. By degrees, the bud lengthens and swells; and, the scales giving way, the young branch is protruded, clothed with its leaves, each bearing in its axillæ, bendings, the germ of a branch destined to become, in its turn, the parent of another series of branches. Let us pursue this investigation.

Before organization commences in the germ, the embryon branch is an insulated vesicle connected with the parent merely by cellular matter. The effect of the organic power is the addition of new matter to this living vesicle (or *punctum saliens*), and the evolution of new parts; till gradually extending in the direction of its axis, it unites with and becomes a permanent part of the parent plant. In the germ thus situated, and supplied with nutriment from the mealy granules contained in the cellular tissue surrounding it, the organization of the branch commences as from a centre. The first part which can be distinctly recognized is the pith; surrounding this, we next perceive lines which are the first traces of the spiral vessels of the future branch, running in a direction from the centre of the parent branch to the peak of the gem: indications of the separation of the cellular matter into scales are next perceptible: but the whole bud or gem is still a truly insulated body, and continues so until circumstances favourable to its complete evolution occur, however distant from the period of its formation. No determinate period, therefore, is fixed for the protrusion of the germ into a bud; but at whatever time this may happen, its course is traceable from the medullary sheath to the surface on which it appears, by a pale stream of parenchymatous matter traversing each annual, concentric, ligneous layer (see *a a*, *fig.* 38.) But this parenchymatous track

Fig. 38.



only marks the advancement of the vital speck or germ to the surface of each annual belt of wood; and is altogether useless as far as regards the germ, except in the belt on the surface of which it is seated, with the life of which, indeed, its vitality is intimately

connected. Destroy this, and the germ becomes extinct (see *a*, *fig.* 39.); augment its vital energy, and the germ is

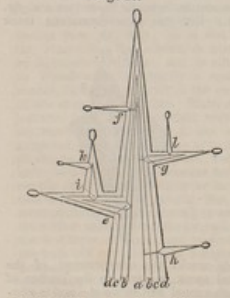
Fig. 39.



unfolded into a perfect bud and branch, but leave things as they are, and the germ will advance to the surface of the next year's belt of wood; and so on progressively, until it be ultimately unfolded, or perish with the destruction of the tree. The twig, therefore, which appears on the surface of an old hollow trunk, is still to be regarded as having originated in the first year of the growth of that part of the trunk, however old it may now be, and its progress is traceable through the shell of wood, which still remains free from decay.

A very clear idea of the origin and connection of branches may be conveyed by the aid of a diagram. Thus, if we imagine the successive years of the growth of a tree to be represented by the cones *a*, *b b*, *c c*, and *d d*, *fig.* 40, it is evident that the germs furnishing the branches *e f g h*, although all generated on the surface of *a*, in the spring of the first year, are, nevertheless, un-

Fig. 40.



folded at different periods of the growth of the tree. In the first year, *e* only becomes a branch, on the surface of which *i* is generated which in its turn generates *k*: in the second year *g* is unfolded and generates *l*: the third year brings forth *h*, and the fourth *f*. In these branches the age of each branch is clearly indicated, from *g*, which is one year old, to *e* which is four: but although this is the case, and *f*, which has sprung from an apparently adventitious bud, is not older than *h*, a secondary branch from *e*, yet the germs of all were generated on *a*, and consequently of the same date with the first developement of the trunk.

It is a curious fact, not generally known, that the germ, if not yet unfolded, will not advance through any belt of wood, not actually belonging to the stem on which it originated, however intimately connected with it; or that the specific action necessary for perpetuating the germ, cannot be begun in any one of a succession of concentric circles, when it has not originated in the first of the succession. Thus, in the section of the trunk of a willow, ten years old, represented in *fig.* 41, cut a little below

Fig. 41.



the joining of two branches that have grown together into one, we find the bud *a* moving onwards in a direct line from the centre of the trunk; but *b*, as soon as it touches the belt *c*, where the coalition occurs, turns aside; and, instead of being protruded at *f*, which would have been the case, had it kept its direct course, appears at *b*. In this section, *d* marks the last independent belt of the branch, and *e* that of the trunk: the other zones, common to both, are the result of alburnous matter furnished by each in particular.

It is proper to remark, that the foregoing theory of the origin of branches differs from all those usually received; and in particular is at direct variance with the opinion of Du Hamel, supported by Mr. Knight, that every alburnous layer is capable of giving origin to buds and branches. But the truth of it is demonstrated in every bud and branch,

in a state of natural growth; and, although a bud may be artificially produced from any layer of alburnum, yet, such is not the course of nature. As far as regards the origin of branches, therefore, the following conclusions may be safely adopted.—"1. That every branch originates in a germ. 2. That every germ is a distinct, insulated individual, the lateral progeny of the plant, generated at the period of the developement of the stem or the branch on which it appears as a bud. 3. That every adventitious bud, or bud appearing on an old stem or branch, originates in a germ generated at the developement of the stem or branch on which it appears, however long it may have remained latent. 4. That every latent germ is, annually, carried outwards in a horizontal direction through every concentric layer of wood, intermediate to the pith and the surface on which it shall sprout into a branch, leaving behind it a white mark crossing every ligneous belt, by which its progress can be traced. 5. That every branch when fully developed displays the same structure as the stem."

Chapter VI.—*Of the Structure of Leaves—in the unexpanded State—in the expanded State—Cuticular System.*

The leaf, generally speaking, is a temporary part of the plant, originating at the same time as the branch of which it forms an appendage, flourishing during spring and summer, and perishing towards the close of autumn. Some plants, however, preserve their leaves through the winter; and even those the leaves of which fall in autumn, are not, strictly speaking, devoid of leaves in winter, for the new leaves are already formed and inclosed in small pyramidal bodies, either seated on the surface of the sides of the branches or terminating them. In examining leaves, therefore, we have to regard them in two conditions; as inclosed in the bud, and as freed from it in an expanded state.

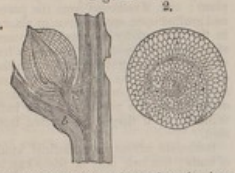
1. *Leaves in their unexpanded state.* The pyramidal bodies in which leaves are contained during winter, are termed buds or gems (*gemmæ*), and from their office, *hybernacles*, or winter habitations (*hybernacula*). Whatever may be the exterior form, or the position of the bud on the branch, the leaves within it are folded up, or applied to one another, in such a manner as to occupy the smallest possible space. The young shoot within its hybernacle is the progeny of the plant; and, if removed from the parent and grafted upon another tree, or planted in the soil, under favourable circumstances, it will grow and become a tree closely resembling the parent. In this case, however, the graft and the tree raised from the planted gem, are mere extensions of the parent, not new individuals, as if they were raised from seed.

Botanists notice four distinct kinds of buds; but two only of these can be regarded as Hybernacles; the *Bulb* (*bulbus*), which spontaneously separates from the parent plant; and the *Bud* or Gem (*gemma*), which remains attached to it. The other two, the *Propago* and the *Gongylus*, do not even inclose leaves. The former, the *Propago*, consists of cellular tissue, is of no regular shape, and is only sometimes covered with an epidermis. It separates spontaneously from the parent plant. Many of the less perfect plants, the Lichens and the Algæ, are propagated chiefly by the Propago. The latter, the *Gongylus*, consists also of cellular tissue, like the Propago; but it is firmer and of a solid consistence, and is always covered with an epidermis. It is attached to the parent under the bark, and separates spontaneously only when this decays.

The *Caulinar Bulb*, or *separating Hybernacle* (*Bulbus Caulinus*), is a cellular body, in some instances pyramidal, in others of a nearly globular shape, composed of scales, which are either concentric or overlap one another. The Bulb, although here termed caulinar, yet is also an appendage of roots. When it is produced on the stem, it usually appears in the axillæ of the leaves, and can sometimes be observed as a white speck there, long before the leaves expand. If we take a Bulb from the stem of the Orange Lily (*Lilium bulbiferum*), as an example of this species of Hybernacle, and cut it across, we find that it consists of cellular scales embracing one another, as represented in the section *fig.* 42, 2. and inclosing fasciculi of vessels, which appear as dark points in the transverse section. The cells are filled with mealy grains, mingled in a thick fluid, which diminishes in opacity as it approaches the centre of the bulb. Each scale is covered with a beautiful, easily detached epidermis.

In the longitudinal section of the bulb, in situ, (attached) (*fig.* 42, 1.) we perceive

Fig. 42.



that the fasciculus of vessels *a*, is given off from the fasciculus *b*, which supplies the leaf. This fasciculus *a* contains the *umbilical* or navel vessels, which in common with the conducting vessels of the scales, are simple spirals. When the bulb is capable of maintaining a separate existence, these umbilical vessels divide at the point of attachment, and the bulb falls to the ground in the same manner as ripe fruit, or the leaf in autumn. The young foliaceous plant is in the centre of the caulinar bulb; and when this vegetates, it produces a new bulb at its base, which is consequently a *radical* bulb. Each succeeding radical bulb contains a more perfect plant than the former, until the plant, which is to bear the flower and the seed, be perfected.

The *Bud*, *Gem*, or attached hybernacle (*Gemma*), consists of the young shoot and the inclosing scales, which, strictly speaking, form the hybernacle, being intended to protect the tender shoot in winter from the action of the atmosphere and of light. Some buds, even on the same tree, as has been already mentioned, inclose leaves only; others inclose flowers only; and some inclose both leaves and flowers: each kind is distinguishable by its external form, and according to its contents is named *foliifera*, *florifera*, and *mixta*, as it bears either leaves, or flowers, or both. In their organic structure, the scales of gems resemble those of bulbs, being composed of cellular tissue, with distinct fasciculi of vessels running through it; and this separation of the vascular fasciculi is the feature which distinguishes these scales from leaves. The inner scales perform the functions of leaves, until these are perfected and fully expanded, when they drop off; but in some trees, as the Apple and the Almond, they are converted into leaves; whilst in others, as the Rose, they are converted into the *petioles*, or foot-stalks of the real leaves, which spring out of them.

The origin of Gems has already been fully explained, and the truth of that theory is proved by the examination of the terminal gems of trees, those which carry on, as it were, the original line of stem. In the terminal gem of Horse-Chesnut, for instance, examined in the autumn, the pith is found to be completely terminated at the base of the bud, as seen at *a* (*fig.* 43.); and, in

Fig. 43.



the following spring, although the pith of the new shoot touches that of the old, yet it is evidently not a continuation of it, but a distinct production of the gem, and is continued downwards until it meet the old, as represented at the point *a* (*fig.* 44.), in the section of a

Fig. 44.



bud opened whilst the young shoot was advancing.

The buds of trees, being in a state of great sensibility, and feeling the first warmth of the sun, the vitality of the continued shoot is roused into action; it attracts the moisture contained in the neighbouring cells charged with nourishing matter; the rising sap, also, enters its vessels; it gradually swells, and bursting the inclosing scales, pushes into the light and air, unfolding its leaves successively as it advances,

until the whole tree becomes green. It should be remarked, however, that the terminal gems open sooner than the lateral, owing, most probably, to the current of the sap being more direct towards them, and its impulse consequently greater.

2. *Leaves in their expanded state.* Much of the beauty and interest of the vegetable kingdom depends on leaves, whether we regard them as the clothing of a single plant, or of groups. To the plants themselves, they are the most important of the conservative organs, performing nearly the same function in the vegetable economy, which the lungs perform in that of the animal.

Every leaf consists of two parts; the one thin and expanded, in ordinary language, the leaf (*folium*); the other as thick as it is broad, the footstalk or petiole (*petiolus*): these together constitute but one organ or proper leaf; and, with a few exceptions, when the leaf falls, it always separates from the twig at the base of the petiole. Leaves are more diversified in form and composition than any other of the vegetable organs: they are simple and compound; differ in situation and distribution on the branches; in direction and insertion; in respect of expansion, point or *apex*, base and margin; in surface, substance, composition, and appendages. In size they differ as widely: the leaves of *Hypnum trifariam* are almost microscopic objects, while those of the Talipot Palm (*Licuala spinosa*) have been known to exceed thirty feet in circumference. Leaves are either *caducous*, falling before summer is passed; or *deciduous*, falling in autumn; or *persistent*, not falling until pushed off by the new leaves, in the following spring; or *perennial*, of still longer duration.

Leaves are composed of three textures; a vascular, a cellular, and a cuticular tissue: and we expect to find these parts in the midrib and nerves, the parenchyma, and the surfaces of every leaf. When means, whether natural, as the atmosphere, and the moisture contained in it, or artificial, as steeping in water, and exposure to the air, are employed to destroy the cuticle and the parenchyma of leaves, the fasciculi of vessels which constitute the ribs and nerves, as they are improperly called, remain, and constitute what is termed a skeleton leaf. In skeleton leaves, we find the secondary ribs or nerves, running either in straight lines from the midrib to the margin, or branching off in an infinity of divisions, so as to produce the appearance of a reticulated web. On a more close examination, we find that these ribs (*costæ*), whether straight or reticulated, consist of fasciculi of conducting vessels, closely accompanied with proper or returning vessels. In those leaves, the ribs of which run in straight longitudinal lines, the fasciculi constituting these are united by transverse vessels, at certain distances, which are not given off from the fasciculi, as Grew and others have supposed, but are distinct vessels, united with the fasciculi by insertion. In thick and succulent leaves, as those of Aloe, thick cords of spiral vessels, accompanied by large bundles of proper vessels, separated only by a thin layer of cellular substance, are observed to traverse the leaf. This leaf is bordered by spines, into which cords of spiral vessels pass, given off from the fasciculus nearest to each of them. In leaves, in which the costæ, or ribs, are transverse, the same communication between the costæ, by inosculating, or uniting vessels, occurs, forming rhomboids; and this structure is common to all monocotyledonous leaves (or leaves of plants whose seed has one seed-lobe). At the point of attachment, between the branch and the petiole, if this be dilated, the vessels enter the petiole in distinct fasciculi, the number varying in different plants. The sap and the proper vessels are closely attached in the same fasciculus whilst in the leaf; but they separate at the point of attachment, the sap vessels passing from the medullary sheath of the twig into the leaf, and the returning vessels passing from the leaf into the bark of the twig.

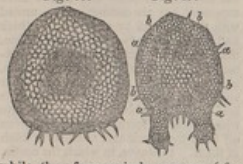
The arrangement of the vessels varies in different petioles:—thus in a transverse section of the footstalk of a leaf of Elder (*Sambucus nigra*), we find that there are five distinct compound fasciculi of vessels, *a a a a a* (*fig.* 45.), consisting

Fig. 45.



of both conducting and returning vessels, and five of reducent vessels only, *b b b b b*, immediately within the cuticle; one of the compound fasciculi passes into each leaflet, and, therefore, the number is determined by that of the leaflets. In the petiole of Kidney Bean *(Phaseolus nanus)*, however, which is composed of moveable articulations in order to enable the leaf to close at night, the fasciculi are collected into one fasciculus in each of the articulations, or joints, as represented at *a* (*fig.* 46.);

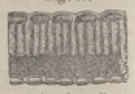
Fig. 46. *Fig.* 47.



while they form a circle, *a a a a* (*fig.* 47.), surrounding wedge shaped fasciculi, *b b b b*, immediately under the bark in the channelled part of the petiole. The advantage of this vascular arrangement is obvious; for had the fasciculi remained distinct, surrounding the pith in the articulations, those on the outside of the flexure, in the movement of the joint, must have described a circle of an extent to endanger the vessels by stretching them, and those on the inside would be equally injured by compression; but being collected in one fasciculus, in the centre of the moveable part of the petiole, every movement can be borne with impunity. In the distribution of the vessels, in the divisions and secondary divisions of the midrib, it appears that the whole are separations from the petiolar fasciculus or bundle of the leaf-stalk: but the single vessels connecting these are evidently not separations from the larger fasciculi. There are much fewer vessels in succulent than in membranous leaves, less fluid being conveyed from the roots of the plant; owing to the leaf perspiring less, and absorbing much to supply the deficiency from the root.

With regard to the cellular structure, all leaves are chiefly made up of cellular tissue. The cells present a variety of forms, as they happen to be more or less compressed; but the prevailing forms are the globe and the hexagon. In all leaves, the cells, immediately under the cuticle of the upper surface, differ from those next the lower. If the leaf of Christmas Rose *(Helleborus niger)* be selected to illustrate this difference of structure in the same leaf, we shall find a range of tubular cells, which terminate in the pulp of the leaf, immediately under the cutis of the upper surface; while those next to the lower disk are irregular hexagons (*fig.*

Fig. 48.



48.) The most singular cells are those of the Moss, called *Spagnum obtusifolium*, which exhibit spirals, as if open spiral vessels, *a a*, *fig.* 49. On the under side

Fig. 49.



of every leaf the cellular matter is less compacted, and many vacant spaces are found between the cells. The individual cells are transparent membranous vesicles, placed in contact with one another, or with the vessels, as represented in the greatly magnified morsel of the pulp of *Cactus flabelliformis* (*fig.* 50.); *a a*

Fig. 50.



a spiral vessel, *b b* beaded vessels, *c c c* a branch of beaded vessels, and *d d* the cells. Air repositories are present in the leaves, as well as the stems of aquatic plants; and the partitions or diaphragms separating these repositories are, in some instances, singularly constructed.

But the most interesting part of the leaf, is its cuticular system. Every leaf has a cuticular covering, which is composed of two distinct parts: 1. the *epidermis*, which forms the exterior covering of the leaf, in common with every other part of the surface of the plant, adhering firmly to the cutis below it, and entering into every pore; 2. the cutis, which consists of a vascular network, laid upon a layer of air-cells. The nature of the *epidermis* has been already explained, and it does not differ in the leaf; we shall, therefore, confine our attention to the *cutis*. The vascular network, which forms one part of this organ, is made up of lymphatic vessels, the meshes of which assume various forms in different plants; but maintain always the same form in the same plant. A powerful microscope is requisite for ascertaining the following particulars. In plants, the leaves of which have parallel costæ, these meshes are irregular parallelograms, as in Spiderwort (*Tradescantia*); sometimes the vessels are slightly undulated, as on the leaf of the White Lily *(Lilium candidum)*, (*fig.* 51); or zig-zag, as on that of Indian Corn *(Zea Mays)*, (*fig.* 52). The meshes sometimes form truncated lozenges, as in common Meadow Grass *(Poa trivialis)*; in some fleshy leaves they form nearly regular hexagons,

Fig. 51. *Fig.* 52. *Fig.* 53.



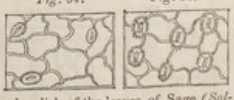
as on the upper disk of the leaf of *Hoya carnosa* (*fig.* 53), and on both surfaces of that of *Aloe verrucosa*; but in general they assume very irregular forms. Over the larger vascular fasciculi, or ribs of leaves, they invariably appear as irregular parallelograms, whatever may be their form on the other parts of the leaf. The size of these meshes differs in different plants; they are always larger than the diameter of the cells of the parenchymatous part of the leaf (see *figs.* 65 and 66), but, in some plants, they are so minute, that 55,296 are contained within a square inch of surface. This cuticular layer is perforated with organic pores or slits (*pori corticales*) which, as they perform a most important function in the vegetable economy, shall be examined a little in detail.

The organic pores of leaves were first noticed by Grew: they have since been more particularly investigated by Hedwig, Rudolphi, Link, Keiser, and De Candolle, who examined them in six hundred plants. We have ourselves attempted to arrange them, and to ascertain their external structure. They are found on the inferior surface or disk of the leaves of trees and shrubs; on both surfaces of those of almost all the herbaceous plants, the Grasses, the Coronariæ, or liliaceous plants, and the Palms. In aquatics, the leaves of which float on the water, the upper surface only is furnished with pores; but leaves which are wholly under water have no pores, although the leaves of the same plant which are in the air have them. Plants destitute of leaves, such as some of the Cactus tribe and the Rushes, are furnished with these pores on the stem; they are found also on the foliaceous parts of the flowers, as the Calyx, and on some seed vessels of a leaf-like structure, as for instance the pod of Bladder Senna (*Colutea Senna*). These organic apertures vary in form, size, and number.

As far as regards *form*, they may be arranged under six species.

1. A simple slit, more open in the middle than at either end, bisecting an oval shield. It may be named the *oval scutiform aperture (Osculum scutiforme ovale)*, *fig.* 54, as exemplified on the

Fig. 54. *Fig.* 55.



under disk of the leaves of Sage (*Salvia*), Holyhock *(Alcea)*, the Chesnut *(Fagus)*, Horse-Chesnut *(Æsculus)*, Laburnum *(Cytisus)*, Oak *(Quercus)*, Sumach *(Rhus)*, Rhododendron *Ponticum*, Aristolochia *Sipho*, Walnut

(Juglans), Pear *(Pyrus)*, Vine *(Vitis)*, Cobea *Scandens*, Philadelphus *Coronarius*, Vaccinium *Stamineum*, Poplar *(Populus)*, &c.; in the upper disk of the leaf of Palmated Rhubarb *(Rheum palmatum)*; and in both surfaces of the leaves of Plantago *Vulgaris*, the Broad-Bean (*Vicia faba*), Spinach *(Spinacia)*, Aster *Trifolium*, Menyanthes *Trifoliata*, and many other herbs. In Aeuba *Japonica*, the shield is divided into four portions. See *fig.* 55.

2. A simple slit bisecting an oval shield, enclosed within a ring:—the *annulated scutiform aperture (osculum scutiforme annulare)*, *fig.* 56. Examples of it are seen in the under disk of the leaves of Fœtid Hellebore (*Helleborus fœtidus*), the Coffee plant *(Coffea)*, Peony *(Peonia)*, Mulberry *(Morus)*, the Olive *(Olea)*, Gardenia *Latifolia*, the genus Theophrastus, and the outside of the tubular leaf of Sarracenia. It exists, also, on the upper disk of the leaf of Sorrel, Rumex *Acetosa*; and on both surfaces of that of the White Lily *(Lilium candidum)*, Amaryllis, Rudbeckia, Common Cabbage *(Brassica oleracea)*, Alisma

Fig. 56. *Fig.* 57. *Fig.* 58.



Plantago, Caltha *Palustris*, Iris, &c. In Gœrtneria, the shield lies, as in *fig.* 57, across the oval of the ring: in Jacquinia *Ruscifolia*, it is circular, and the slit bisecting it is extended beyond it (*fig.* 58).

3. An open slit, or oblong pore, within a simple oval ring:—the *oblong annulated pore (osculum annulare oblongum)*, *fig.* 59. It is exemplified on the under disk, in Hibbertia *Scandens*, Ivy *(Hedera)*, Wolfsbane (Aconitum *Neomontanum*), Spearmint (Mentha *Viridis*), Elder *(Sambucus)*, Cabbage Rose (Rosa *Centifolia*), Officinal Rhubarb (Rheum *Palmatum*), Mezereon (Daphne *Mezereum*), Lilac (Syringa *Vulgaris*), the Clove-pink *(Dianthus caryophyllus)*, Laurus *Canariensis*, the Privet *(Ligustrum)*, &c. On both surfaces in Wild Spinach (*Chenopodium*), Saxifrage, Dragon Arum (*Dracontium*), African Geranium (*Pelargonium*), Everlasting Pea *(Lathyrus latifolius)*, Mistletoe (*Viscum*), Fennel (*Anethum fœniculum*), although it has not an expand-

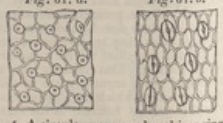
Fig. 59. *Fig.* 60.



ed leaf, and Glass Wort (*Salicornia*), although it is twice a day under water. The Scented Violet *(Viola odorata)*, has a double oval, with the outer one quartered, as in *fig.* 60.

4. A circular pore, in the centre of a circular shield:—the *circular scutiform aperture (osculum scutiforme circulare)*, *fig.* 61. *a*. It is observed on the under disk of Hydrangea *Quercifolia*, Great Flowering Saint Johnswort, (Hypericum *Grandiflorum*), Cambretum, &c.: on the upper disk of Holly-hock (*Alcea*), and Sorrel (*Rumex acetosa*), and on both surfaces in Cactus *Opuntia*: on Pettispora *Tubera*, (*fig.* 61. *b*.), the shield is divided.

Fig. 61. *a*. *Fig.* 61. *b*.

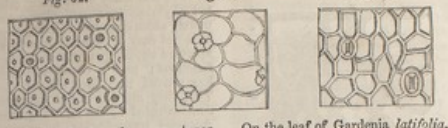


5. A circular pore, enclosed in a ring: the *annular pore (osculum annulare)*, (*fig.* 62.); as exemplified on the under disk, in Aloes, on both surfaces in the Air-flower (*Epidendron*), on Primrose (*Primula*), &c. In Cussonia *Thyrsifolia*, the circle is divided in quarters, as in *fig.* 63.

6. A *quadrilateral pore (osculum quadrilaterale)*, as on both disks in Agave *Americana* (*fig.* 64).

The modifications of these species of the cuticular aperture are very numerous; and, as the subject has been hitherto very little investigated, many new species may yet be discovered.

Fig. 62. *Fig.* 63. *Fig.* 64.



In respect of *size*, these apertures differ greatly in different plants. The largest yet seen are found in the under side of the leaves of Oleander (*Nerium Oleander*): it is a simple oval aperture guarded by hairs, which cross the opening in every direction. The smallest are found on the leaves of the Genus Myrtus. In the Coronariæ, their longitudinal diameter, according to Springel, is from $\frac{1}{12}$ to $\frac{1}{9}$ of a line; their diameter in a cross direction, from $\frac{1}{14}$ to $\frac{1}{12}$ of a line.

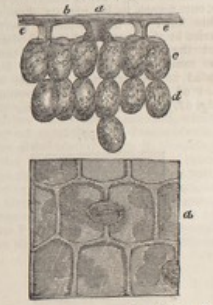
In number the difference is still more remarkable. The following tabular statement has been drawn up from actual observation.

Names of the plants on the leaves of which the pores have been counted	Number of pores on one inch square of surface. On upper disk.	On under disk.	On both
Andromeda *speciosa*	None	32,000	
Arum *dracontium*	8000	16,320	24,320
Alisma *Plantago*	12,000	6000	18,000
Amaryllis *Josephsiana*	31,500	31,500	63,000
Cobea *scandens*	None	20,000	
Dianthus *Caryophyllus*	38,500	38,500	77,000
Daphne *Mezereum*	None	4000	
Epidendrum	None	4800	
Hypericum *grandiflorum*	None	47,800	
Hydrangea *quercifolia*	None	160,000	
Gærneria	1000	142,750	143,750
Ilex	None	63,600	
Iris *Germanica*	11,572	11,572	23,144
Olea *Europea*	None	57,600	
Peonia	None	13,700	
Pettispora *tubera*	None	160,000	
Philadelphus *coronarius*	None	20,000	
Pyrus	None	24,000	
Sempervivum *tectorum*	10,710	6000	
Syringa *vulgaris*	None	160,000	
Rheum *palmatum*	1000	40,000	41,000
Rudbeckia	8000	41,000	49,000
Rumex *acetosa*	11,088	20,000	31,088
Theophrastus	None	172,032	
Tussilago *farfara*	1200	12,500	13,700
Tradescantia	2000	2000	4000
Vitis *vinifera*	None	13,600	
Viscum *album*	200	200	400

On the leaf of Gardenia *latifolia*, we find a pore in almost every mesh; on that of Aloe *Soccotrina* one pore for every twenty meshes, and on that of Nerium *Oleander* one for every sixty.

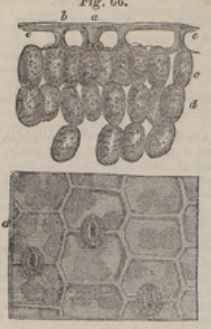
Such are the circumstances connected with the superficial state of these pores. The real nature of their structure can only be known by placing, under a powerful microscope, a thin slice of any leaf cut in the direction of its thickness, and bisecting one or more of its pores. The leaf of the Clove Pink (*Dianthus Caryophyllus*), is well adapted for this purpose. In the slice represented in *fig.* 65, the pore *a* is divided longitudinally

Fig. 65.



and in *fig.* 66 transversely: it is a short funnel-shaped tube, *a* (see the vertical section) penetrating the cutis *b*, and surrounded at the bottom with a hollow ring: it opens into the intercellular spaces formed by the parenchymatous vesicles *c d*, &c., not pressing closely upon one another. These vesicles are distended with a greenish fluid, interspersed with mealy grains. Surrounding the pore, the oblong cells *e e* are evidently cuticular air-

Fig. 66.



cells, and correspond to the meshes formed by the lymphatics on the surface of the leaves. This explanation also refers to *fig.* 66, in which the pore is cut across in its narrow diameter. This form of the cuticular aperture varies in the leaves of different plants; but the general character is nearly the same in all. This is well illustrated in the portion of the inner surface of the cutis of Iris *Germanica* (*fig.* 67.), in which not only the pore

Fig. 67.



is modified, but the intercellular spaces *a a*, under the pores, are considerably larger than those of Dianthus. The transparency of the cuticle permits the vesicles to be seen through it, as represented in *figures* 65 and 66: the vesicles are equally diaphanous, and are seen transmitting the form of the meshes in *fig.* 67.

M. Bonnet, Sprengel, De Candolle, Mirbel, and many other justly celebrated phytologists, regard these pores as merely absorbing and exhaling organs. It is not easy to conceive how the same aperture should perform such opposite functions; and a closer investigation has proved that they do not absorb. That they are the foliar exhalants is demonstrated by the following facts:—Aqueous transpiration is greatest in those leaves which have most pores*. Plates of glass, applied to the under sides of the leaves of trees, are soon covered with drops of water; but when applied to the upper surface, they are not bedewed. When the under surface of the leaves of trees is varnished, so as to obstruct the pores, no transpiration takes place. Facts and experiments, equally conclusive, prove that they are not absorbing organs. Thus, leaves which are fleshy and succulent, and which are scarcely, if at all, nourished by the roots, but chiefly by absorption, have very few cuticular pores. None are found on the under surface of floating leaves, but the upper is thickly covered with them; yet it is well known that these leaves absorb powerfully by the under surface, and exhale by the upper.

But is exhalation the sole function of these foliar apertures? It is out of place to enter fully into a physiological discussion, while we are engaged in explaining the vegetable structure; but we have no hesitation to state, briefly, the grounds of our belief, that beside being exhalants, these apertures are the respiratory organs or lungs of plants. In the *first* place, these apertures are found only on leaves which are exposed to the action of the air; and even leaves, which are not naturally under water, soon lose them if they are covered with water. In the *second* place, thin, membraneous leaves moveable in the air, are most liberally supplied with these apertures, owing to their probably requiring, like the more perfect animals, a constant supply of atmospheric air; while those which have thick, immoveable leaves, as they resemble the slow-moving and cold-blooded animals in their tenacity of life, so like them, also, require a smaller supply of air, and are, consequently, less liberally furnished

* *Hydrangea quercifolia*, which perspires so freely that the leaves wither and become crisp in a very short space of time, if the plant be not amply supplied with water, has 160,000 apertures on every inch square of surface, on the under disk of the leaf.

with breathing apertures. In the *third* place, these apertures are admirably adapted for admitting air into the substance of the leaf, to bring it into contact with the juice contained in the cellular vesicles, for the production of those changes which the sap is known to undergo in the leaves, and which cannot be supposed to depend wholly on exhalation. The minuteness of these apertures renders it difficult to ascertain whether they have the power of opening and shutting; but from their appearance on the leaf of Indian corn, *Zea mays* (*fig.* 68.), and on that of Iris *Germanica* (*fig.* 69.), which are highly magnified, it is not improbable that some degree of dilation and contraction of the orifice takes place, although the fact cannot be demonstrated.

Fig. 68.



Fig. 69.



From the examination of their structure, the importance of leaves in the vegetable economy may be readily conceived. The sap is carried into them by one set of vessels; is there spread out and exposed to the action of air and light, and exhales its superabundant water; and having undergone, by the influence of these agents, aided by an electro-chemical power, certain changes in chemical composition, it is received into another set of vessels, in order that it may be conducted downwards and distributed in the cortical cells, depositing there the various secretions requisite for the nourishment, health, and preservation of the stem and root. The cuticular system of the leaf is admirably adapted to aid these processes; by its transparency, its vesicular texture, and its respiratory pores. But the leaf itself is, also, a secreting organ, and retains in its cells many secretions, useful undoubtedly to the plant itself; but independently of it, of the first importance to Medicine and to the useful Arts, and in supplying food for the support of animal life.

CHAPTER VII.—*Of the Structure of the Appendages of the Conservative Organs—Scales — Suckers — Tubers — Radical Bulbs — Glands — Pubescence — Thorns — Prickles — Props — Foliaceous Appendages.*

THERE are certain organs attached both to roots and stems, which as they are not general, are not classed with the common members of the vegetable body: these are named *Appendages*. A brief description only of each is requisite.

1. SCALES (*squamæ*) are generally found on roots, as, for instance, on the root of Toothworth (*Lathræa squamaria*). They consist entirely of cellular tissue, enclosed in a cuticle.

2. The SUCKER (*Stolo*) is an underground bud, sprouting from the upper horizontal branches of the roots of trees; and rising above the soil, it is converted into a stem resembling the parent-tree. Its organization is exactly the same as that of the leaf-bud.

3. The KNOB (*Tuber*) is a solid, massive body, attached either closely, or by means of a vascular cord, or wire as it is usually termed, to the base of the stem of some plants: it is also sometimes produced on the stem. The tuber varies greatly in form and appearance; but it has, in every instance, nearly the same structure, and consists of a cellular parenchymatous mass, covered with an epidermis devoid of apertures, and furnished with vascular fasciculi, which either surround the central mass of cells, or are distributed through it, according as the plant which bears the tuber originates from seeds with one or with two cotyledons (or seed-lobes). Thus, in the Orchis tribe, which is monocotyledonous, the vessels are distributed as in the Palms, represented in the transverse slice of a tuber (*fig.* 70.); while in

Fig. 70.



the tuber of the Potatoe, which is dicotyledonous, the parenchyma is bordered with a complicated circle of vessels, which has a close affinity to the cortical part of the stem. The vessels, in both instances, are collected at one or more

points on the surface, wherever the embryon of a bud or gem is seated. The cells are filled with mealy grains; for tubers are merely reservoirs of nourishment for the young plants on their surface, which resemble the plantule in seeds, and are endowed with the same vitality, remaining latent until the tuber be placed under circumstances favourable for vegetation. The vascular cords which connect the tuber with the plant which forms them, resemble the umbilical cords (or navel strings) in animals, and decay as soon as the tuber is fitted to maintain a separate existence.

4. Radical Bulbs (*Bulbi radicales*) are like tubers, reservoirs of nourishment for aiding the developement, and the temporary support of the lateral progeny of a certain class of plants. They are *solid*, *scaly*, and *laminated* (or compounded of plates). In internal structure, the *solid* bulb resembles the monocotyledonous tuber. The organization of the *scaly* bulb attached to roots is nearly the same as that of the caulinar (or stalk) bulb: each scale is a distinct reservoir of nourishment, and appears, also, to possess a distinct vitality; for when detached from the bulb, and placed in a proper soil, a new bulb or bulbs form on its edge, although nothing of this kind occurs when the scales remain attached to the general bulb, in which the united vitality of all the scales seems requisite for the formation of one more perfect plant. The *laminated* bulb differs from the scaly in external character only. In both, the scale and the layer consists of a plate of cellular substance enclosed between two thin half-transparent cuticles, with equidistant fasciculi of spiral and entire vessels running vertically through them.

5. Glands (*Glandulæ*): the real existence of bodies which exactly merit this appellation in the vegetable system, is doubtful. There are, however, minute organs, differing in structure from the common texture of the part where they are situated, which separate some peculiar matter from the ordinary proper juice, and which may be regarded as glands. If this be admitted, these glands occupy the interior and exterior of stems and leaves, vary greatly in form and attachment, and perhaps in structure, although any attempt to demonstrate this can scarcely be depended upon.

Internal vegetable glands are generally seated in the substance of leaves, with a small excretory duct or channel opening upon the surface of the leaf. These furnish the little drops of essential oil found on many leaves, as, for instance, that of the Black Currant. In some leaves, when the cells are swelled with fluid, these ducts are pressed upon and closed, so that the leaf exhales no odour, although a powerful odour is exhaled as soon as the withering of the leaf opens the ducts. This is the case in sweet-scented Meadow Grass (*Anthoxanthum odoratum*), whence new hay derives its odour.

External vegetable glands are either (*sessile*) without a foot-stalk, or (*pedunculated*) having a foot-stalk. The first exhibits the form of Papillæ (*fig.* 71.), as found on each side of the midrib of *Passiflora lunata*; or of detachable scales, covering a papillary gland (*fig.* 72.), as in *Rhododendron punctatum*. The second exhibits various forms. Thus on the foot-stalk of the leaf of the Nectarine (*Amygdalus Persicus*), it resembles a shallow cup, supported on a thick, short *pedicel*, or stand, with the cavity which exudes the secretion devoid of epidermis (*fig.* 73.); in *Ricinus communis*, it resembles a small round-headed nail not driven home, as a carpenter would describe it (*fig.* 74.), and in this, also, the exuding surface is bare. On the upper disk of the leaf of Sundew (*Drosera rotundifolia*), it is a cup-shaped gland supported on a slender stalk (*fig.* 75.), and on the Moss Rose it is branched (*fig.* 76.) All of these glands

Fig. 71. *Fig.* 72. *Fig.* 73.



Fig. 74. *Fig.* 75. *Fig.* 76.

are cellular, with the cells more regular than those in the substance of the leaf, and arranged in circles: a cord of vessels can generally be traced into the substance of the gland.

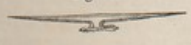
6. Pubescence comprehending *Downs* (*pubes*), *Hairs* (*pili*), *Bristles* (*setæ*). The structure of the first is more simple than any other part of the vegetable body, consisting of tubular cells so disposed as to form single, extended, or jointed hairs, with or without a globular point; or branched, or stellated, or uncinated or hooked hairs. The structure of *Bristles* is also cellular, but more condensed, and assuming a variety of forms, some of which, for instance the hooks in Clivers (*Galium aparine*), enable the plants to climb. Bristles are, also, sometimes the excretory ducts of glands, as exemplified in Borage (*Borago*), the Nettle (*Urtica*), Loasa, &c. In *fig.* 77, which represents the sting

Fig. 77.



of the Loasa, a plant from Chili, *a* is the cellular gland where the poison is secreted, *b* the receptacle of the secreted poison communicating below with the cellular gland, *c* the excretory tube or bristle. When the finger is wounded by the bristle, the force required to penetrate the skin presses down the dilated base of the tube upon the sponge, and forces a quantity of the fluid into the tube, whence it is ejected into the wound, and remaining there causes the pain and inflammation which succeed. The most curious of these bristles is that of Malpighia, which is a hollow, spindle-shaped body, supported horizontally on a short pedicel, (*fig.* 78.) In the stings

Fig. 78.



of the sharp ones may be traced a close resemblance to that of the bee; and serpents bite in like manner by a tooth with a channel or duct, through which the poison comes from a bag which the tooth squeezes in biting. If the bristle or sting of a stinging-nettle (*Urtica urens*) be examined with the microscope, its shape will be found closely to resemble the sting of the Loasa.

7. Thorns (*Spinæ*) are in general processes of the ligneous part of stems, and have nearly the same structure as branches. They are, indeed, sometimes abortive branches, as in the genus *Prunus*; sometimes the lobes of the leaf hardened, as in the Date; sometimes hardened stipules, as in Erythryna.

8. Prickles (*Aculei*) are productions of the bark and the cutis; as is well exemplified in the Rose, with the bark of which the prickles separate. They consist of a mass of oblong cells, which become condensed towards the point of the prickle; and over which the common cutis of the part is thrown back.

9. Props (*Fulcra*). Under this term is comprehended the *tendril*, the *claw*, the *hook*, and the *bladder*. The *Tendril* (*Cirrhus*), is a long, cylindrical, slender, spiral organ, issuing from various parts of the plant. It consists of a cortex, which resembles that of the foot-stalk of the leaf; and of fasciculi of vessels imbedded in a cellular parenchyma. It has apertures on its surface, the same as the leaf: so that the tendril partakes of the nature of the petiole of the leaf, and of the cuticular system of that organ. The *Claw* (*ungula*) is of two kinds, the *radicular* and the *cirrhal*. The *radicular Claw* is a small thread-like body, protruded from the stems of some flexible plants, which entering into the crevices of the bark of trees, and the cracks in rocks and walls, enables the plant to support itself perpendicularly upon such surfaces. The Ivy (*Hedera helix*) affords the best example of this organ. It consists of a cellular mass imbedding fasciculi of vessels, evidently proceeding from those of the albumnum; and enclosed in a cortex, the epidermis of which is covered with minute fibrils, which are the real adhering organs. The *cirrhal Claw* is a combination of the tendril and the claw. It is well exemplified in the Virginian Creeper (*Cissus hederacea*). As far as regards the tendril-like portion, its structure is the same as that of the tendril: the claw itself consists of cellular matter, which

being a continuation of the parenchyma of the other part of the organ, is here checked in its extension and expands sideways, leaving the under surface almost devoid of cutis, but studded with minute warts or short fibrils (*fig.* 79,

Fig. 79.



which represents the upper side of the claw, in the figure nearest to the centre of the page, and its base in that next the margin.) The warts and fibrils entering into the minute pores of stone, bricks, &c. swell there, and maintain the claw so firmly attached, as to support the branch, and enable the plant to climb on the face of a perpendicular surface.

10. The Bladder (*Ampulla*), is a small membraneous bag, attached to the roots and leaves of some aquatic plants, containing a watery fluid and a small bubble of air.

11. Foliaceous Appendages, as the name implies, have the form and structure of leaves, at least this is the case in the stipule (*stipula*), and in floral leaves (*bracteæ*). The most remarkable of these foliar appendages are the *Ascidia* or pitchers of the *Nepenthes* (*fig.* 80.), and of *Cephalotus follicularis* (*fig.* 81.), which are hollow foliaceous

Fig. 80 *Fig.* 81.



organs, with lids that are hygrometrical, opening and shutting according to the dryness or moistness of the air. Thus when the air is dry, the ring round the lip of the pitcher of Nepenthes contracts, and allows the lid to shut down, which is its natural tendency; but when it is moist, the ring swells with the moisture it has attracted, and forces up the lid. It is probable that the fluid contained in the pitcher is so essential to the plant, that this would be injured were the fluid to evaporate wholly, which would be the case in warm, dry weather, were the lid to remain open: but, as little evaporation goes on when the atmosphere is loaded with moisture, the lid may be then opened with impunity, to admit the air into the pitcher, which may also be necessary for the health of the plant. We must admit, however, that this opinion is hypothetical. We ascertained, some time since, that the fluid found in the pitcher of Nepenthes is a secretion of the plant, being found in the pitcher before the lid opens, and that it is of an acid nature. This observation has been lately confirmed by Dr. Turner, by an analysis of the fluid of an unopened pitcher of Nepenthes *distillatoria*, grown in a stove of the Botanic garden of Edinburgh. The quantity of fluid procured from the pitcher was sixty-six grains. It was limpid, of a subacid taste; emitted, when boiling, an odour resembling that of roasted apples, and, when slowly evaporated, yielded minute crystals of super-oxalate of potash.

The use of these singular appendages is still unknown. Nature has been careful to prevent the fluid which they contain from being lost, when the quantity is so great that it might overset the pitcher: for this purpose, she has supplied a small hook at the back of the pitcher, close to the hinge of the lid, in *Nepenthes*, by which, when it is hooked upon any neighbouring part of the plant, the upright position of the pitcher is maintained. Possibly the fluid may be both of use to the plant, and for the benefit of animals, like that of the hollow leaves of the Wild Pine (*Tillandsia*), which form reservoirs of clear water. That the fluid in these pitchers is a secretion of the plant itself, naturalists have now determined.

BOTANY.

Botany is that branch of natural history which relates to the structure, vital action, classification, and uses of those objects in the organic world which we call plants. In the language of some persons, indeed, it is confined to a mere explanation of the art of classifying plants, and to the power of using such classifications so as to ascertain the name of a given species with certainty; by others it is allowed to comprehend a knowledge of the various kinds of structure which we meet with in the vegetable kingdom, but scarcely to extend beyond those two departments. But, in reality, the former of these objects, however important, is only a collateral branch of the subject; and the latter is but a portion, although an essential one, of those investigations from which botany derives its claim to the rank of science.

The study of the works of nature, independently of its contributing in a powerful degree to elevate the mind of man, and to bring him into communion with his Creator, is of great consequence, as being the means by which he is enabled to compel all living things to minister to his comforts, his pleasures, or his necessities. It is to the latter objects, chiefly, that naturalists usually direct their attention; because it is justly supposed that all higher considerations of necessity grow out of the investigations in which we must engage, in order to apply any branch of natural history to practical purposes.

The properties of vegetable productions, with reference to their utility to mankind, are influenced by the species or varieties from which they are derived; by the mechanical structure or chemical composition of the part of the plant made use of; and by the phenomena and changes connected with the action of the vital principle of vegetation, which may be considered either independently of external circumstances, or when controlled either by natural causes or by artificial means. In order to apply the knowledge of such objects usefully, and to render it available to others, arrangement and method are indispensable; not only in regard to the ideas derived from a consideration of the nature of plants, but in regard to plants themselves.

Hence four grand divisions of the science of botany into—

I. Structural Botany; which comprehends whatever relates to the laws of vegetable structure, whether external or internal, independently of the presence of a vital principle.

II. Physiological Botany; to which belongs all that concerns the history of vegetable life, from the moment when the vital principle is imparted to the seed and the plant first breaks its shell, to the period of death: explaining the functions which the various organs are destined to perform; the changes they undergo in health or sickness, and under all the influences exercised by climate, seasons, accidents, or the art of man.

III. Descriptive Botany; from which we learn the art of describing plants with accuracy, so that their characters may be recognized with certainty by others, and of giving to plants names by which they can be mentioned without confusion when written or spoken of.

IV. Systematic Botany; which explains the principles upon which are determined the mutual relations that combine the seemingly discordant members of the vegetable kingdom into one harmonious whole; and which teaches the art of distinguishing any plant from all others, so as always to determine its name with precision.

These subjects we shall treat in the order in which they have been mentioned.

Part I.—Structural Botany.

Chapter I.

A general view of the external Structure of a Plant complete in all its Parts.

A plant is a living body, deprived of sensation or power of moving from place to place, and fed by means of external roots.

Animals, on the contrary, are endowed with sensation and the power of voluntary motion from place to place; and are fed by means of an internal bag consisting of one or more stomachs.

These differences are readily enough observed between animals and plants of the higher and more perfect grades; but there are many of the more minute, and apparently more simple, kinds which it may appear difficult to refer with certainty to either of the above classes. Aquatic animals of the polypiferous kind, for instance, have not only very much the appearance of a plant, being attached to rocks by a sort of root; but actually grow, as plants do, by the continual emission of new branches. Marine plants, like these animals, derive no food from their apparent root, and seem to have a sort of universal external stomach; while some of the minuter kinds of filamentous aquatic plants or sea-weeds, after being detached from the soil by accident or otherwise, continue to grow as they float in the water, and often appear to have a certain degree of motion, when it may be difficult to ascertain with certainty whether it be owing to internal volition or to external physical influences. In these cases the mode of nutrition is the only certain test by which the objects in question can be referred to one of the great kingdoms of animals and plants.

It is, however, obvious, that whatever difficulties may attend the distinguishing of plants from animals in particular cases, their differences are, generally, sufficiently apparent. Without occupying ourselves, then, with a question which belongs to the theory of creation more than to botany, let us cast a hasty glance over the structure of some plant in which is present every organ that is usually met with in what we consider a species complete in all its parts.

Such a plant is the violet (Viola odorata), or the heart's-ease (Viola tricolor). The latter consists of a number of green, or yellow, or purple parts, arranged symmetrically upon a green angular axis, which puts forth under ground many slender whitish threads, divided in an irregular manner. The green angular axis (*fig.* 1, *a*) is the *stem*, the slender threads (*b*) are *roots*.

Upon the stem are placed, at equal distances, certain flat, green, toothed bodies, which gradually taper into a thin stalk; it is almost superfluous to say that these are *leaves* (*c*). At the

Fig. 1.



base of each leaf are placed two other thin green parts (*d*), which are very like the leaves, only they are smaller, and are deeply gashed near the bottom instead of tapering into a stalk; to these is given the name of *stipules*.

The axis, consisting of stem and root, together with the leaves and stipules, forms the *organs of vegetation*; so named because they have no other destination than to enable a plant to live and grow, and perform those vital actions which are not connected with the office of spontaneous propagation.

From the angle (*e*), formed by the junction of the leaf with the stem, which is called the *axil*, springs a slender angular stalk, on the top of which the flower is seated. This stalk, called the *peduncle*, has, near its upper end, a couple of little scales (*f*) named *bracts*, which are of a nature intermediate between the organs of vegetation and those of *fructification*. The latter name is given to the parts of a flower, because their office is exclusively to enable a plant, by fructifying, to multiply its species spontaneously.

The *flower* consists, externally, of five small, narrow, green leaves (*g*), called *sepals*, and of the same number of larger yellow and purple leaves (*h*), called *petals*: the sepals taken collectively form a *calyx*, and the petals, in like manner, form a *corolla*. These two are often named *floral envelopes*.

Within the petals, and quite hidden from view by the bases of those organs, until they are pulled off, is a row of five thin, pale-yellow parts (*i*) sticking together a little by their edges, but separated from the body they surround; they are named *stamens*, and are the fertilizing apparatus of the flower. They surround a hollow body (*k*) tapering into a zigzag cone, and terminating in a globular head: this is the fructifying apparatus, and is called the *pistil*; within its hollow base may be found the young seeds, which we name *ovules*, from their resemblance to little eggs, or *ova*.

By certain curious operations, which need not now be explained, the pistil is fertilized; after which it swells, alters its form and texture, and at last becomes the *fruit* (*l*), which is hard and dry, splits into three pieces, and sheds the seeds which, by that time, are ripe and fully formed. The seed (*m*) consists of a shell, containing a quantity of fleshy matter (*o*), from its resemblance, in use, to the white of an egg, called *albumen*; in the midst of which lies an *embryo* plant (*n*), which is supposed to be nourished by the albumen until it breaks the shell and is strong enough to gain its food for itself.

Such is the heart's-ease; such are the organs which constitute the fabric of all the most perfectly constructed plants. Lowly a species as it is, it comprehends every part that is employed by nature in the formation of the loftiest tree of the forest; the difference in size between it and a tree being caused by nothing more than an endless multiplication of similar parts of vegetation, constructed always upon a similar plan, adjusted to each other in the most admirable manner, and all working in perfect harmony and order. The stem in the heart's-ease perishes every year; in an oak it lives from year to year and from age to age, constantly augmenting in size. This, however, is not owing to any material difference in the structure of the two species, but to a specific power of prolonged vitality in trees, which plants like the heart's-ease are destitute of. To make this more intelligible, suppose a heart's-ease to produce, in the course of the first year of its life, a stem with twenty leaves, and that its stem is hard and perennial, instead of soft and annual. In the second year, its stem, by virtue of a power hereafter to be explained, may form a new branch at the axil of each of its twenty leaves; and as the second branches may be as large, at least, as the first, it may, therefore, multiply its dimensions twenty times. In the third year the same operation may take place; and the consequence of this will be, an augmentation equal to four hundred times its original dimensions; and so on in a geometrical ratio. At this rate a heart's-ease would soon develop into an enormous tree; and although that species never does so change its nature, yet it is quite true that every tree, in the first year of its existence, is formed upon a plan analogous to that of the heart's-ease, and never more complicated; and that its subsequent growth into a giant of the forest takes place upon the plan that has just been adverted to in a suppositious case.

The adaptation of all these parts to the maintenance of a perfect system of life, in which each organ performs its allotted office with unvarying regularity and with the most admirable harmony, so that no one interferes with another, is among the most beautiful instances of contrivance in the creation. It is the especial business of physiological botany to explain this, which will therefore be the subject of detailed illustration hereafter. In the meanwhile, a brief exposition of the

leading functions of the several organs will render the account we shall have to give of their structure more interesting to the general reader than it otherwise would be.

The root is the part which attracts the liquid food of plants from the soil in which it is mingled, and impels it upwards into the woody part of the stem. Once introduced into the system of a plant, this food becomes altered from what it originally was, and is called *sap*.

Sap rises through the woody part of the stem, dissolving what soluble matter it meets in its passage, and at last is impelled into the leaves. Having arrived in those organs, it loses water by evaporation; peculiar chemical changes are produced in it by exposure to solar light; and at last, having been converted into the secretions peculiar to the species in which it is formed, it is returned from the leaves back into the stem, down which it descends, through the *cortical layer* or bark, passing off laterally into the centre of the woody matter in its downward course. In the bark and the centre of the stem a considerable proportion of the peculiar secretions from the sap is finally stored up, and eventually all those substances which it is necessary that the plant should get rid of are passed off into the earth again by the roots. Thus an ascending current of crude sap, a descending flow of elaborated sap, and a lateral deposit of the latter in the stem, are going on during all the time that a plant is in a growing state; and, in consequence of special routes being assigned to each of these currents, they act without in the slightest degree interfering with each other. By what particular vessels and by what microscopic apparatus this vegetable laboratory is kept in action, will be fully explained hereafter.

In the flowers the calyx and the petals may be supposed to act to a certain extent as leaves, to furnish food for the stamens and the pistil, which are enclosed within them. The stamens and pistil continue to increase with equal steps up to a certain period, which is the maturity of the former, and the commencement of a new growth in the latter. At this time the upper part of the stamen bursts and discharges a fine powder, the motes from which fall upon the tip of the pistil, which, at that particular time, becomes viscid, for the purpose of causing the motes to adhere to it. Here the motes, which in reality are hollow globes, filled with fertilizing matter, absorb the circumambient moisture, distend, and at last discharge upon the humid point of the pistil that matter whose mysterious influence is to cause the pistil to fructify. This accomplished, the stamens wither and die; but the pistil, to which a new life has been thus imparted, goes on growing and swelling; the ovules distend, and occupy all the cavity of the pistil; in their inside a little being is born, which feeds upon the liquid albumen, and at last assumes the form of a microscopic plant. When this takes place, the parts of the pistil lose their green colour, and assume the livery of death; the integuments of the ovule harden, seeds are formed, and in order to enable them to escape from the prison in which they are locked up within their parent fruit, the sides of the latter give way, either by rending, or splitting, or decaying, and allow the seed to fall upon the earth. There it lies till the hour for its further progress is at hand, when the moisture in the soil becomes warmed by the rays of the sun; a stimulus is thus communicated to the embryo plant, which swells, lengthens, pushes forth a tiny root through an opening in its shell, and at last disengaging itself altogether from its hard integuments, unfolds its little leaves, rears its stem into the air, pushes its roots down into the soil, and thus establishes itself as a new individual, with power to bear all the organs, to undergo all the vicissitudes, and to accomplish the same destiny as the parent from which it sprang.

This may be considered a correct view of the course of many a vegetable life; no doubt, there are many modifications of all these phenomena, and even some exceptions to them, but with these we are not to occupy ourselves in the present place.

Chapter II.

Of the degree in which perfect external Structure is departed from.

Although all the parts just named concur in the formation of a plant of the most perfect kind, there is not one of them that, in one species or another, is not either altogether wanting, or so altered in its nature as scarcely to be recognised. The root itself, by

which the food is conveyed into the body, is scarcely present in such marine plants as seaweeds, and even in the dodder (Cuscuta) which grows upon heaths, and the mistletoe, which fastens itself as a parasite upon other species, it is so rudimentary as to be scarcely capable of action.

The stem in numerous species is so short as to be almost invisible. Leaves are frequently mere scales which drop off almost as soon as they are formed, leaving the plant to shift for itself by the aid of other means, as is the case in cactuses, stapelias, and the like. Both leaf and stem are so blended into one body in the duckweed (Lemna) that it is difficult to say whether the part that really exists is the one or the other. Stipules are as often wanting as present. Bracts, in like manner, are frequently missing. Of the floral envelopes, sometimes the corolla is absent, as in the mezereon; and sometimes both calyx and corolla, as in the willow.

Even the stamens and pistils themselves disappear in a large number of plants. It is, however, to be remarked that this latter circumstance is always attended with a corresponding imperfection in the whole of the other organs, and is, therefore, before all other things, considered an indication of a greater degree of general imperfection. Ferns, for instance, in which this occurs, have neither calyx nor corolla, nor is their stem like that of other plants; in mosses, moreover, the leaves are mere scales; in lichens, the whole plant consists of but a flat plate composed of leaf and stem combined, with nothing for their seeds but excessively minute transparent bladders; and, finally, some confervæ and fungi are destitute at once of every one of the usual organs, consisting of nothing but a cell or two of exceedingly small size, in which the essence of root, stem, leaf, flower, and fruit, without the form, is supposed to be comprehended.

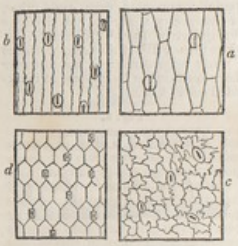
From these causes the diversity of appearance in the vegetable kingdom is very great. But an examination of all the organs in detail will show that every species is in that state which is best adapted to the purpose for which it is destined; and that plants, from the extremely simple plan upon which even those which are apparently most complicated are organized, offer peculiar facilities for the transfer of the functions of one organ to another.

Chapter III.

Of the Skin of a Plant, and the Parts connected therewith. Stomates, Hairs, Glands, Stings, Scurf, Prickles.

Over every part of a plant exposed to the air, except the stigma, is extended a skin, which serves at once to hold together and protect the parts beneath it. To the eye, even when assisted by powerful microscopes, it usually appears to be a thin transparent membrane, traversed by veins arranged with regularity in a netted manner. The meshes formed by the supposed veins are sometimes long hexagons (*fig.* 2, *a*); sometimes nearly regular

Fig. 2.



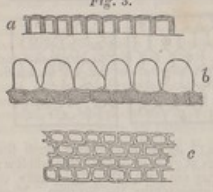
ones (2, *d*), resembling very much the panes of glass in some Gothic window; or they are some other figure more or less approaching the hexagon. More uncommonly they have an exceedingly wavy, curled outline, as in the common polypody (Polypodium vulgare) (2, *c*); and occasionally they are bounded by undulated parallel lines, as in the white lily (Lilium candidum) (2, *b*). In some instances the skin can be peeled off readily; in others, it adheres so firmly to the substance beneath it, that it cannot be separated.

But if it is examined with greater care and better glasses, it will be found to be by no means a simple membrane as it appeared at first sight. By making extremely thin slices of any part of a leaf for instance, perpendicular to its surface, and placing them in water under a powerful microscope, we find that this apparent membrane is in reality an excessively thin plate,

formed by the growing together of a vast multitude of little bladders or cells, squeezed flat, filled with air, and joined by their edges, which are what give the appearance of veins to the skin when it is peeled off.

The thickness, the form, and the number of layers of these little bladders are variable in different species; being apparently diversified according to the different circumstances under which species are exposed to the action of the atmosphere. Thus, in the white lily, the German iris, and the common bean, and perhaps the greater part of European plants, the bladders are in a single layer, and very thin-sided (3, *a*); in some succulent plants they are in three rows, one of which sometimes has the sides of the outer layer of cells partially separated from each other, as has been remarked by Adolphe Brongniart in Rochea falcata (3, *b*), when the surface of the plant acquires a warty appearance; in the *oleander* there are three or four layers of thick-sided cells (3, *c*).

Fig. 3.



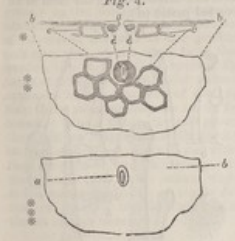
The object of these differences in the structure of the skin will be explained when the nature of the functions of that part comes to be considered. For the present it is sufficient to state that they are principally intended to adapt a plant to the nature of the medium in which the leaves are developed. It is a general rule that leaves growing in the air have a skin, and that those growing constantly in water have none; and it being necessary that evaporation should be regulated in the former case, while in the latter no evaporation can take place, it is inferred that this duty devolves upon the cuticle, which in fact is admirably adapted to the purpose. In plants growing in the shade, or in damp situations, the cuticle is thin and soft, and readily permeable to water in a gaseous state, but in leaves exposed to much heat and dryness it becomes proportionably thick and hard; in succulent plants in which evaporation is hindered, in order that their dropsical condition may be insured, more layers than one of cuticle are often present; and finally, in the oleander, which has to bear the parched atmosphere of a Barbary summer, there is a triple coating of hard thick cuticle.

It appears probable, from the observations of Henslow and Adolphe Brongniart, that over the true skin is drawn an excessively thin pellicle which exhibits no appearance of organization, and which is perfectly homogeneous and continuous, except over the openings of the stomates. It is supposed that this pellicle, the use of which is unknown, may be what repels the water from the surface of some leaves, and causes it to separate into drops. It is difficult to detect it in the fresh leaf, in consequence not only of its being firmly glued to the subjacent cuticle, but also because of its thinness and transparency. It may be, however, easily detected, by macerating a leaf for a day or two in water, slightly impregnated with nitric acid, when it may be easily peeled off; for, notwithstanding its thinness, it is often remarkably tough.

Among the meshes of the skin may be remarked a number of oval spaces, much smaller than the meshes themselves, and placed upon the lines that indicate the juncture of the little bladders. These oval spaces (*fig.* 2) are the *stomates* above referred to of plants, and have a highly-curious structure. They are openings through the skin into the inside of a plant, and serve to establish a communication between the atmosphere and a complicated pneumatic apparatus which lies beneath the skin. They are constructed of two little oblong bladders, placed parallel with each other, and having a power of contraction or expansion, as circumstances may require: when at rest they are perfectly parallel, and, by pressing their sides together, close up the opening; when in action they curve away from each other in the middle, and thus leave the passage open.

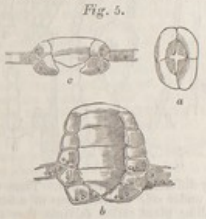
The stomates sometimes seem bounded by a transparent limb, which is the portion of the pellicle between the bladders of the stomate and the contiguous bladders of the skin. When open they also appear as if two other little bladders interposed between the principal bladders and the opening; this is, however, a mere optical deception, caused by the thickness of the edge of the opening through the pellicle. The structure of these curious organs will be best understood from the following highly magnified figures. *Fig.* 4ª represents a section of the skin of a plant perpendicular to the surface; *a* is the opening through the pellicle; *b* is the pellicle itself; *c*, *c*, are the bladders of the skin; *d*, *d*, are the two parallel bladders of the stomate. *Fig.* 4ᵃᵃ represents the same parts seen from under the skin. *Fig.* 4ᵃᵃᵃ shows the pellicle after the bladders of the skin and those of the stomate have been removed; the opening through the pellicle (*a*) being thus distinctly exposed to view.

Fig. 4.



It would be beside the object of this treatise to enter into an explanation of the many varieties of the stomate, especially as they are all formed upon a plan similar to that described; differing principally in the form of the constituent bladders; in their number, which is sometimes four, forming a square, or even five; and in their diameter, which, in the shortest direction, varies from the $\frac{1}{300}$ to the $\frac{1}{500}$ of an inch. But the structure of these parts in Marchantia has been ascertained by Mirbel to be so peculiar that it cannot be passed by in silence. In this imperfect plant there is no external pellicle, a slit in which forms the opening in the stomate; nor is the latter formed of a couple of bladders different in form and position from those of the skin. On the contrary, the stomate is a mere disunion and alteration in the adjustment of the bladders of the skin, with an addition to the under surface of four or five bladders which contract or expand, and thus enable the plant to respire. There is, however, very often an addition to the rim of the stomate of several tiers of bladders which rise perpendicularly from the surface. *Fig.* 5 represents some views of this kind of

Fig. 5.



structure: *a* is a stomate seen from above the skin, with the four bladders that form the contracting organ, which Mirbel calls "the obturating ring;" *b* shows a section of a stomate of several tiers, and *c* of a simple one, the contracting bladders being, in both cases, the lowest; in *b* they are shown closed up, in *c* separated and open.

The name *breathing pore*, which is often applied to the stomates, sufficiently explains that these are considered organs of respiration; and there is every reason to believe that they are really of that nature. It will be seen hereafter that the life of plants is chiefly maintained by the introduction of carbonic acid into the leaves, and the expulsion of oxygen, which results from the decomposition of the carbonic acid. From the situation, form, and other circumstances connected with stomata, it seems certain that this important function is principally performed through their agency.

From the surface of the skin often arise little processes, which, in fact, are mere expansions of it, to which we give the name of lymphatic hairs, or, more commonly, hairs only, from their resemblance in appearance to the down or hair of animals. These minute

parts, which are so very fine and transparent that their structure can be ascertained only by the aid of a microscope, are usually short needle-like bodies lying nearly parallel with the surface of a plant (*fig.* 6, *a*). But occasionally they assume some remark-

Fig. 6.



ably different appearances. Thus on the under side of the leaves of a little floating plant called salvinia they are jointed cylinders ending abruptly in a minute bristle (*b*); in spiderwort (Tradescantia) they have exactly the appearance of the antennæ of some coleopterous insects (*e*); in the marvel of Peru (Mirabilis) they are composed of short cylindrical joints, separated by irregular contractions (*d*). Salvinia, on the upper side of its leaves, has them consisting of a few oval joints, all of equal size, and arising from a little projection of the surface (*e*); in hawkweed (Hieracium cymosum) they are covered with short teeth (*f*); in other plants with a number of fine bristles; in Xanthium spinosum they have the appearance of a bamboo in miniature, with the joints contracted in the middle (*g*); some Borragineous plants have them armed with barbs like the head of an Indian arrow, so that they cannot be withdrawn from such bodies as they may pierce (*h*); in a kind of lavatera (L. mœans) they consist of a short stalk with a tuft of finer hairs springing from the top of it like the rays of a polype (*i*); and, finally, in malpighia and the Indigo plant, they are fixed by the middle, pointing in two opposite directions (*k*).

Glandular hairs, or *glands*, as they are more commonly designated, are formed upon the same plan as true hairs, and, like them, are generally too small to be examined with the naked eye; but they have a power of secreting various substances, such as resins, odoriferous essences, or other matter which the plants require to throw off; and to enable them to perform this office, they are provided with a little bag at their point, in which the secretion is collected before being discharged. Parts of this kind are found on plants, such as the sweetbriar rose, where they appear to the naked eye as rusty dots; in the chick pea (Cicer arietinum) they consist of a slender transparent stalk, terminated by a head full of little chambers (*fig.* 7, *a*); on the shell of the grey walnut (Juglans cinerea), they are terminated by cups, in which the secreting matter is collected before it is shed (*b*); in some erotons they spring up in clusters, and gradually thicken to the point; when very highly magnified, they appear like thick stiff bodies having the form of an inverted pestle (*d*).

Fig. 7.



Stings, the office of which would seem to be to keep off aggression by the pain they inflict when inserted into the skin of animals, are stiff, needle-like hairs, which arise from a thick swollen base full of chambers, in which the poison they secrete is collected and stored up. Some of the most characteristic forms are what occur in borage, where they consist of a bristle resembling the straight blade of a poniard (*fig.* 7, *e*); in the nettle, composed of one straight rigid hair bent at a very obtuse angle from the top of an obconical poison-chamber (*f*); and in the gourd, where the sting is jointed, less rigid, and gradually passes into a conical chambered base (*g*).

Scurf (or scales, technically *lepides*, whence the adjective *lepidote*, for a scurfy surface) is found on the leaves of the pine apple, the sea buckthorn (Hippophäe rhamnoides), and many other plants. It appears to the naked eye as a mealy substance of a whitish or brownish colour; but, in reality, it consists of minute scales adhering by their middle, and formed by the growing together of a number of hairs which happen to spring from one common point. *Fig.* 7, *c* and *h*, show the appearance of the scurf of the wild oleaster (Elæagnus angustifolia), when seen under a microscope.

Prickles (aculei) are nothing but hairs of a larger growth; they are hard, horny, sharp-pointed, conical, and often hooked excrescences, which rise from the surface of the stem, from which they may be easily broken off. When young, they are small, soft, and green; as the surface of a stem distends in consequence of the expansion of its inside, the base of the prickles enlarges, and, at the same time, they harden, till at last they become the large stiff bodies to which the name is applied; on the branches of the rose this their progress may be easily followed. When they are full grown, they can no longer adjust themselves to the distending surface on which they are planted, and are consequently thrown off: this is the reason why it is the young branches of plants only that are prickly, the old stems being almost always unarmed.

Chapter IV.

Of the Trunk or Caudex; difference between Root and Stem.

The central part, or axis, of a plant, to which the leaves and flowers are attached, is technically called the *caudex*, to which the English word *trunk* seems equivalent, notwithstanding its being generally applied to the thick bole of a tree.

It consists of two portions; the ascending trunk, or *stem*, and the descending trunk, or *root*. Between these there is no absolute separation, each being an extension of the other in an opposite direction; the ascending trunk, or stem, having from its earliest existence an invincible tendency to grow upwards into the air and light, the descending trunk, or root, an equally irresistible determination to the earth away from light. (See Physiology.)

The one being thus an extension of the other, there is no definite organic separation between them; but their structure melts, as it were, completely together. Nevertheless, the imaginary line formed by the divergence of these two parts has the name of *collar* or *neck*, and has been erroneously supposed to be the seat of vitality. It has been asserted, that if a tree be cut through its collar, it will never again grow. This opinion has arisen from the well-known fact, that if certain plants, such as the beech, or the pine, or the oak, are sawed through at the level of the ground, they will not shoot from the stump. This is, however, owing, not to their collar having been cut through, but to another cause: for by far the greater number of woody plants will, when cut down, throw up new shoots, whether their collar is cut through or not; as, for example, the plum, the poplar, and the rose. It arises from a specific power, which varies in different species, of forming adventitious buds, from which alone new shoots can proceed.

The great differences between root and stem consist in their organic characters, rather than in their physiological peculiarities; for many stems burrow under ground, and many roots are emitted, and can only live, in light and air, the one performing, apparently, the office of the other. The common distinction, therefore, of a root being the under ground, and a stem the above ground, part of a plant, is not sufficiently exact for science.

The real distinctions between them are the following:—A stem is divided into a number of projections called *nodes*, equidistant, or which are either at regularly diminishing or increasing distances. To each node there is usually either a leaf, or a scale, which is an imperfectly-formed leaf, and at least one bud capable of growing into a branch, which will be covered in like manner with other nodes and buds, themselves capable of again shooting into branches. Consequently, as the ramifications of a stem can proceed only from the nodes thus symmetrically arranged, the branches must, of necessity, grow symmetrically also; and hence the pleasing appearance of the

head of a tree, even when stripped of leaves. Roots, on the contrary, have neither leaves, nodes, nor buds, nor anything which can be considered analogous to them. They have no provision made for a regular ramification, which indeed could not exist in a perpetually and unequally resisting medium like the earth, but they divide and subdivide as occasion requires, without the least disposition to assume a symmetrical form.

As branches are produced by buds alone, and as roots have no buds, it is obvious that if a tree is cut down to the collar, so that nothing remains but root, it can never branch again; and hence the opinion that the collar is the seat of life. But though roots have no buds under ordinary circumstances, yet they, and all other woody parts, have occasionally the power of forming what are called adventitious buds, under special circumstances. These adventitious buds sprout irregularly from various parts of the surface; and thus in certain species of plants renew the growth which had been temporarily arrested by the destruction of the stem. No one can tell why particular species have this power, and others not; but the fact is certain. The roots of the silver fir (Abies Picea), for instance, will live on the mountains of Switzerland for half a century after the stem is destroyed (*Dutrochet*), but will never sprout again; while, on the other hand, the root of the willow will form adventitious buds, and grow nearly as readily as the stem itself.

In their internal structure roots and stems are nearly alike, except that the former are rarely hollow, although many stems are; and that in the plants called *Exogens*, which have a pith in the centre of their stem, the root has no pith.

Chapter V.

Of True Roots and their Modifications; of Stems improperly called Roots.

Perhaps the most simple manner of understanding the structure of a root, limited as has been just explained, is to consider every form of that part a modification of a simple fibre.

A simple fibre consists of a cylinder, soft externally, and woody internally, ending in a blunt and succulent point (*fig.* 8, *a*), through which the fluid matter of the soil is sucked into the circulation. The aërial roots of such plants as ivy, dodder, and epiphytal orchideæ, are simple fibres altered according to the particular circumstances under which they are produced, and the modified functions they have to perform. In the dodder, for instance, they have to act as suckers as well as roots; and, accordingly, they are dilated at the end to enable them to perform that additional office. Suppose such fibres to increase in diameter principally by addition to their woody centre, and at the same time to lengthen and divide into a number of branches, each of which is like the primitive simple fibre, we shall then have a fibrous root of the commonest kind, such as that of all trees and shrubs, and of most herbaceous plants (*fig.* 8, *b*). Let it

Fig. 8.



increase much more in diameter than in length, and consist of no other ramifications than a few fibres protruded from the sides of a common centre, and such roots as those of the carrot, the radish, and the turnip, will be the result (*fig.* 8, *c* and *d*), the special figures of which will depend upon the degree in which the preponderance of growth is longitudinal, or transverse. It sometimes happens that some of the roots retain their fibrous state, while others, then called tubercles or fangs, become extremely fleshy and enlarged, as in fig wort (Ranunculus ficaria), in which the tubercles are thicker and blunter at the lower than the upper end; the roots of the dahlia and the orchis (*fig.* 8, *e*) are of a similar kind; or one portion of the root will be fibrous and the other tuberecular, as in dropwort (Spiræa filipendula), (*fig.* 8, *f*). It is thought that such tubercles are intended by nature to contain a supply of food upon which the plant may exist when deprived of its usual nutriment from the earth or the atmosphere; there does not, however, appear to be sufficient evidence of the justice of this opinion. Sometimes a succulent root will ramify without increasing perceptibly in diameter, and consequently its ramifications will be all succulent and of equal thickness; such a root is that of the coral root (Corallorhiza), (*fig.* 8, *g*).

Whether or not the functions of all these sorts of roots are exactly the same is not known: their general office is, no doubt, firstly, to steady a plant in the soil in which it grows, so as to prevent its being blown about by wind; and, secondly, to suck from the earth the fluid matters which form vegetable food. The latter function may seem the more necessary of the two, but in reality the one is as important as the other; they always accompany each other, and when one is not provided for, the other appears unnecessary also. Thus, in sea-weeds, which are the only plants in which roots really seem to be unimportant, for they often grow while floating freely in the ocean, there can be no doubt that absorption of food takes place over all their surface; and it is always to be remembered that even plants like these are, at an early period of life, attached by a root, which may be supposed to perform at that time its ordinary double function. When roots are produced in the air, as in ivy, the vine in a hot damp stove, epiphytal orchideæ, and the like, it often happens that they have only the absorbing function to perform; but in such cases the business of fixing the plants steadily in their places is performed by other roots, which are emitted under or upon the surface of the ground.

In common language all kinds of underground stems are called roots; but it is necessary, both for the sake of exactness of language, and for practical purposes, to distinguish carefully between them; for while an underground stem is one of the means destined by nature for the multiplication of plants, a root will not act in that manner, except under certain special and very unusual circumstances. Neither do such stems ever appear to perform the office of roots; they seem to be chiefly intended to store up food for the use of animals. They are easily known from roots if the distinctions lately mentioned are attended to. The principal forms are the *rootstock*, the *cormus*, the *tuber*, and the *bulb*.

The *rootstock* (rhizoma in Latin) is a creeping or underground stem, which either has scales in the room of leaves, or is marked by the scars or remains of leaves that have either fallen off or withered. Of this nature are orris root and ginger; the former of which is the rootstock of a kind of iris (*fig.* 9, *b*), and the latter of the ginger plant. In the common polypody (*fig.* 9, *a*) it is a hairy body from which the leaves arise; and in the hare's foot fern (Trichomanes canariensis) it curves at its extremity like the paw of the animal after which it is named. What is commonly called a *creeping root* (soboles) (*fig.* 9, *c*) differs from the rootstock in nothing whatever except being more slender, and always subterranean, while the rootstock often lies prostrate on the surface of the ground. It has scales, which are the rudiments of leaves, at equal distances, and emits true roots from the nodes, where, also, are buds which are extremely active and ready to form new plants the instant they are placed in circumstances favourable to their development. Hence it is that couch grass, which has this sort of underground stem, if cut into pieces, forms a very vegetable hydra: for every joint is capable of growing into a new plant; and, consequently, by tearing an old plant to pieces a great number of new individuals is added to the soil, instead of one being destroyed. If it were a root, tearing it in pieces would probably destroy it. To this is also to be referred the *scaly root* of the old botanists (*fig.* 9, *d*), which is remarkable in Lathræa squamaria. It differs from the last in

nothing except that the scales with which it is covered are fleshy instead of being membranous, and that the buds at the nodes are much less active.

Fig. 9.



The *cormus*, for which we have no equivalent English word, is an extremely short subterranean stem, covered with several layers of dry withered scales, and usually having a roundish figure (*fig.* 9, *e*). It increases by the growth of the buds that exist at the axils of the scales, which, during their growth, feed upon the mother cormus, exhausting it of its soluble substance, and at last becoming cormi themselves when full grown. The root, as they say, of the crocus, the tulip, and the ixia, is a cormus.

The *tuber*, again, is a short, fleshy, underground stem, produced at the end of slender subterranean branches. Its surface is marked with scars, or covered with scales, from within which buds appear by which the species is to be multiplied. In the potato the underground branches are at first as slender as the roots among which they burrow; and are only to be known from them by their having scales upon their surface. But in time such a branch ceases to lengthen; its end then becomes swollen by the matter impelled into it, from the main stem not being able to proceed any further; it gradually increases in diameter, becomes more and more succulent, till, at last, a perfect tuber is formed, and the part of the branch not distended, decaying, separates from the parent plant as an independent individual. *Fig.* 10 shows the manner in which this takes place, and the appearance of the tubers at the different periods of their growth. When fully formed, a tuber is a fleshy body, on the surface of which are numerous depressions, each containing what a gardener calls an *eye*, which is in reality a bud, that, under favourable circumstances, will become a new plant. Hence such eyes or buds, along

Fig. 10.



with a portion of the tuber, forming together the *set*, are employed for the multiplication of a species, as in the potato. It generally happens that such eyes, like the buds on the branches of trees, do not develop the same year as they are formed, but pass the first season of their existence in gaining strength for their growth in the succeeding season. But if any circumstance should call them into action in the same season in which they are first created, a tuber will branch, and then assume an appearance very unlike its common state. This often happens to

the potato in long dry summers, when what are called clustered potatoes are generally produced. Such productions are excellent illustrations of the plan upon which tubers finally grow, and of the analogy that exists between them and branches, proving that what may appear to the superficial observer the obscure speculations of closet-philosophers, are in reality exact expositions of the plan of the creation.

The *bulb* (*fig.* 9, *f*) is a roundish body, consisting of scales packed closely one over the other, and emitting roots from its base, as in the onion. It is, in reality, an extremely short stem, covered with rudimentary leaves in the form of scales, and it differs in nothing from a bud, except that it either separates spontaneously from the part that bears it, as in the tiger lily, or it is a perfect plant in itself, as in the onion. Most commonly it lives underground; but in some lilies, alliums, and other plants, it is produced among the branches, leaves, or flowers. The tree onion is a plant in which bulbs are produced in the place of, and instead of, flowers; a singular circumstance which will be explained in another place. (*See* Chapter XXV.)

Chapter VI.

Of the Stem, and its external modifications: Spines; Tendrils.

Although the stem is, even more than the root, subject to modifications of form, yet its names are far less numerous. In its commonest state it rises erect from the earth, dividing into many branches: in herbs succulent and perishable; in shrubs and trees woody, and clothed with a thick and rugged bark. But from this state, which may be considered normal, it departs in a great variety of ways. In palms and similar trees of tropical countries it forms a cylinder, bearing a tuft of leaves at its point. In other plants it is little more than a delicate thread lying prostrate on the earth, as in the runner of the strawberry. In some species it takes a twining direction, following the sun in its course; and when of a woody structure, enfolding the largest trees with its gigantic coils. In the Museum at Paris there is a specimen of a palm-tree so surrounded by a monstrous twiner, the coils of which have grown to each other, as to be enclosed in a kind of vegetable sheath. Occasionally in the forests of tropical countries the stems of woody plants at first rise straight into the air; but not becoming sufficiently solid to support their growing weight, they gradually fall prostrate among the trees that surround them, and obstruct the traveller like cables drawn across his path. In most plants the stem is solid: in grasses and umbelliferous plants it is hollow; in a few species its bark is expanded longitudinally into green and leafy wings. These are the commonest forms we meet with in the stems of plants. Others there are which are yet more remarkable. In a kind of cabbage, called Kohlrabi, the stem shortens and distends till it acquires a globular form like that of a turnip. In the tortoise plant of the Cape of Good Hope, it is a roundish knob of considerable size, the bark of which is rent into deep fissures, separating spaces having the appearance of the scales on the back of a tortoise. Many tropical orchideous plants have a short conical stem named a pseudo-bulb, terminated by one or two leaves, and arising from a prostrate rootstock. In Stapelias (*fig.* 11, *a*), and some other South African plants, the stem becomes gouty, distorted, and succulent, bearing soft projections instead of leaves; and, finally, in the Cactus tribe it is sometimes flat and divided into a number of leafy limbs (*fig.* 11, *c*), or globular and deeply furrowed with sharp projecting ribs (*b*), or angular and erect, often rising into the air like a vegetable column.

Fig. 11.



Such are the most remarkable of the forms which occur among stems properly so called. Branches, in woody

plants, sometimes suddenly lose the power of lengthening, harden and sharpen at their points, and thus form spines, as in the sloe and hawthorn; or they lose their woody character, produce none but starved and scale-like leaves, becoming weak and curling up at their points, so as to form the tendrils by which some plants, such as the vine, contrive to climb among their neighbours. In the duck-weed, and all the Lichen tribe, the stem is a flat horizontal expansion, destitute of woodiness, and apparently amalgamated with the leaves.

Chapter VII.

Of the Stem, and its internal modifications: Exogens, Endogens, Acrogens.

In their internal structure stems are apparently constructed upon several different plans: in the bamboo they are hollow with transverse partitions; in the cane they are solid, and of an uniform density; in the oak they are hardest in the centre; in the cocoa-nut they are softest in the centre; in many climbers they have an uniform density, and appear pierced with multitudes of cylindrical channels parallel with the bark. In ferns the wood has a singularly twisted appearance; and, finally, in many herbaceous plants, it seems to consist of a mass of succulent substance, with a few fibres mixed among it. But it has been ascertained that all these variations are to be reduced to three primary forms, viz.: Exogens, or those which have their woody system separated from the cellular and arranged in concentric zones; Endogens, in which the woody and cellular systems are mixed together into a confused mass; and Acrogens, which consist of a cylinder growing at its point only, and never augmenting in thickness after it once is formed. We must examine each of these separately.

A stem which is formed upon the *Exogenous* plan, when cut through transversely, exhibits a central *pith*, surrounded by one or more circles of *wood*, on the outside of which is a ring of *bark*, which is connected with the pith by a number of lines passing through the wood called *medullary processes*. A branch of hazel, beech, or oak represents this structure very distinctly.

In plants whose stems exist only for a single year, there is but one circle of wood; and if such stems are very succulent, it may even be difficult to ascertain the presence of wood at all.

Fig. 12.



But it will always be found, upon close inspection, that some trace of woody matter exists arranged in a definite manner between the pith and the bark, separated perhaps by medullary rays, which are much thicker than the contiguous plates of wood, and which on that account tend to conceal the real structure. Such is the case in the stems and roots of many common herbaceous plants, and of cacti and similar succulent plants. Passing by, therefore, cases of this kind, the analogy of which with the exogenous structure a little consideration will serve to make apparent, let us examine in detail the exact structure of the various parts that make an exogenous stem.

The *pith* (*fig.* 13, *a*) is a spongy column which extends from the collar, where it usually ceases, to the extremities of the branches. When young it is succulent; when old it becomes dry. Usually it is solid; but in umbelliferous plants it is soon torn to pieces by the rapid distention of the woody cylinder that surrounds it, and its place is occupied by an empty tube, to the sides of which it adheres in fragments. In the walnut it is divided into a number of narrow chambers, placed over each other with great regularity. It is united with the *medullary* rays or plates, or *processes*, as they are more correctly called, by an infinite multitude of points arising from over all its surface. When young it is green and succulent, and at that time only is to be considered a living organ; its office, at that time, is to supply proper

food to the young buds which are in communication with it, until those parts, by their subsequent growth, become capable of obtaining it from other sources. After this business has been fulfilled, it dries up, and dies.

The *medullary processes* (*fig.* 13, *b*), which thus arise from the pith, of which in fact they are mere extensions, pass straight into the bark, cutting the intervening wood into a number of wedges, the broad end of which is next the outside of the stem. They are composed of the same spongy substance as the pith, squeezed in between the wedges of wood, and consequently very much compressed. In trees, the medullary plates are usually extremely thin; in succulent plants, or annual stems, they are more frequently of considerable thickness.

Fig. 13.



It must not be supposed, that because the medullary processes are spoken of as plates connecting the pith with the bark they are therefore of very considerable depth, or that they really divide the wood into distinct wedges. These terms are merely used to express the appearance of the parts in a transverse section of a piece of exogenous wood; in reality, the medullary plates are in general thin, and by no means deep processes, piercing the mass of wood as is seen at *fig.* 14, which represents a portion of a cylinder of wood stripped of bark, with the mouths of the medullary processes seen on the outside of the wood at *a*, *a*.

The office of these processes is very important. They are the great means of communication between the circumference and the centre of a stem, and are what enable the fluid matter, which passes down the bark, to reach the wood which is next the pith. To qualify them for performing this office the better, their component parts are placed with their longer diameter perpendicular to the bark; a position which is the most favourable which vegetable tissue could assume under such circumstances, to perform a function in which capillary attraction is the great moving power. When examined under a microscope, the component parts of the medullary processes resemble bricks placed across the fibres of the wood, and the processes themselves may be not unaptly compared to low walls stretching from the bark to the pith. This will be more particularly explained in the chapter on the elementary organs.

Fig. 14.



The *bark* (*fig.* 13, *d*) consists of two distinct parts; namely, of an external layer of a spongy substance which is usually green, and of an interior layer of fibrous matter which touches the wood, and at one time appears to be organically combined with the wedges of the latter. Of these layers, the external is called the cortical integument, and the interior the *liber*. Every year an addition of new *liber* is made, in the form of a concentric zone, within that of the preceding year; and consequently the bark would be marked with as many concentric circles of liber as it is years old; but as the wood that forms beneath the bark is perpetually straining the latter transversely, and so disturbing the relative position of its component parts, it happens that, in point of fact, the bark soon loses all trace of the concentric annual zones of liber, and becomes a confused mass of fibrous and spongy matter mixed together, its liming being the only part in which the liber remains undisturbed. The cortical integument, which has been justly called by Dutrochet an external pith, is sometimes soft and extremely thick, as in

the cork-tree, where it furnishes that material which proves so useful to the wine-merchant. In trees, however, it is more frequently hard and gritty, rent into deep fissures by the expansion of the wood, and mouldering under the corroding action of the atmosphere. When young it is always filled with fluid, and becomes dry only from old age. It usually has some fibrous matter mixed among its substance. The *liber* itself, although described as a cylinder of fibrous matter lining the cortical integument and overlaying the wood, is, like the wood itself, pierced in every direction by the medullary processes; so that in a section it seems to be cut into a number of wedges corresponding with the wedges of wood (*fig.* 13). Although it appears, when young, to be organically connected with the wood, yet it always separates freely when an attempt is made to tear it off, and, when full grown, the separation is made spontaneously. In some plants it is remarkable for its susceptibility of being stripped into a very considerable number of thin layers, which, in consequence of their fibrous structure, are tough enough to be employed for useful purposes. The liber of trees, before the invention of paper or parchment, was stripped into layers, flattened and cemented into leaves, upon which books were written, whence its name. In the present day, the liber of the lime tree is an important object with the Russians, who manufacture from it the coarse mats which bear their name; but the most curious instance is in the lace bark of Jamaica, in which the layers of liber are very numerous, quite white, extremely fine, and when stretched out, open into a kind of delicate net-work resembling lace. It must not, however, be supposed that nothing is liber except that young fibrous lining of the bark which we find in stripping the latter from a tree: on the contrary, it may happen that bark consists of liber on the outside as well as inside; because as bark is constantly wearing away externally, and the interior parts are perpetually pushed outwards, a time must come when the first-formed liber will reach the surface; and during the remainder of the life of such a plant the bark of its trunk must consist of liber at the very surface; such liber is, however, dead, like all the parts in contact with it. That the part of the bark which originally was internal does in time arrive at the outside of a stem is easily proved by inserting a wire into the bark of an exogen through the young and innermost liber; in a few years the wire will reach the outside, and be thrown off.

It is through the bark exclusively that the returning fluid of a plant descends to the root; and it is in this part that many secretions are chiefly stored up: for it is a remarkable fact, that in plants secreting substances of different physical properties, while one kind is freely conveyed to the central wood from the bark through the medullary processes, another part seems scarcely capable of following such a direction. Gum, for example, which so abounds in the bark of a cherry or a plum-tree, reaches the central wood in very small quantity, while a considerable supply of astringent matter passes off from the bark to the wood. To what cause this is owing has not been ascertained. It is not improbable that the gum may pass down through the woody vessels of the bark, which are not in direct communication with the medullary processes, and that the astringent matter may exclusively pass down by the parenchymatous portion of the bark, of which the medullary processes are a part.

The nature of the *wood* will be best understood by examining the structure of a single zone, and considering all the other zones subsequently formed to be merely repetitions of it. Next the pith is placed what is called the *medullary sheath* (*fig.* 13, *c*), which is a stratum of air-vessels forming a sort of casing to the pith, but interrupted perpetually by the medullary processes which pass through it. On the outside of the medullary sheath is a mixture of large vessels and fibrous matter, the former predominating; and on the outside of all, finishing the concentric zone, is a deep mass of fibrous matter, with a number of small vessels intermixed: in all the other zones exactly the same structure is repeated as long as the plant continues to grow; so that the trunk of the largest exogenous tree is a mere repetition of woody or cortical zones, the youngest of the latter being formed withinside the older, and the youngest of the former outside the older. Occasionally a small quantity of the cellular substance of the

medullary processes is interposed between the zones, as in Urtica gigas; but more frequently they touch each other without any such intervention. In some plants, scarcely any vessels are to be distinguished among the fibrous matter of the wood, or there is but little apparent distinction between the different zones; but, in the main, the structure just described is that of exogens in general.

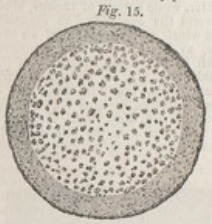
Perhaps it would be more correct to say that the woody matter is plunged into a mass of spongy or cellular substance, and arranges itself methodically in zones, than to use the language that has been hitherto employed; but this is merely a speculative point.

The anomalies which are met with in plants having this structure, however different from the normal state they may at first appear, are all easily to be reconciled with what we have described as the type of exogenous formation. Thus, in bauhinias the zones of wood are excessively irregular and unequal; in the water vine of India the medullary processes are very deep and thick, and filled with vessels; in arborescent birthworts, there is but one zone of wood, whatever the age of the stem. Finally, in calycanthus there are four centres of growth having each its own concentric zones lying in the bark at equal distances, and on the outside of the principal mass of wood. For these and other unusual kinds of structure, see *Lindley's Introduction to Botany*, &c.

Like the roots, wood has two distinct offices to perform. In the first place, it gives plants that solidity and toughness which enables them to stand erect in the air, without being destroyed by winds, or crushed by their own weight; a position which it is indispensable that the greater part of the vegetable kingdom should occupy, whether for the due performance of their own vital actions, or for rendering the earth habitable by man. In the second place, it is through the wood exclusively that the crude sap rises from the roots towards the leaves, for the better performing of which it has a simple and yet highly elaborate apparatus of tubes and vessels. The latter, which, when young, serve as conduits for fluid, become, when old, receptacles of the peculiar secretions of trees. In their young state they are nearly colourless, and form a pale mass, which we call *alburnum* or sap-wood; when old and filled with secreted matter, they become dark brown, or green, or even nearly black, in different species, and then are *heart-wood* or *duramen*. Being in this state clogged up by the matter that is lodged in them by the medullary processes, they are unfit for the conveyance of fluid, which accordingly takes place principally in the new tubes and vessels which remain open.

Endogenous stems apparently differ very much from these, for they have neither pith, nor medullary processes,

Fig. 15.



nor bark, nor wood properly so called; but they consist of a confused mass of bundles of woody substance lying in the midst of a spongy matter. In a palm we find an external cortical integument without liber; the bundles of woody matter so arranged as to be much more numerous and compact at the circumference than towards the centre. In the cane, which is another kind of palm, the woody bundles are distributed equally throughout the whole substance. In the asparagus, the aloe, and other soft-stemmed species, the woody bundles are not only equally distributed, but are so soft as to be scarcely recognised for the same thing as the hard fibres of a palm stem. Now, if we compare a stem of this sort with that of an exogen, we are, at first sight, unable to discover any analogy between them; but upon a more careful inspection, it will be discovered that the principal organic difference consists in the woody matter of exogens being arranged in wedge-shaped parcels, plunged into the spongy substance of the stem, and disposed in annual zones; while in endogens the woody matter is neither collected into

wedge-shaped parcels, nor arranged in annual concentric zones, but is broken up into fibrous bundles plunged without order into the spongy mass. The correctness of this view of their analogy will be better shown, if the anatomical structure of a woody bundle of an endogen be contrasted with that of the woody wedge of an exogen. The woody bundle of an endogenous plant, if examined under a microscope, is found to be concavo-convex, with its convexity turned towards the outside of the stem. The convex part uniformly consists of compact woody matter, while vessels of various kinds traverse the concavity; an organization which is precisely that of an exogen, as has been already described. Such is the usual structure of the woody bundles of an exogenous stem. Occasionally, however, in stems of small diameter, such as the cane, the woody bundles are cylindrical (*fig.* 16), with the vessels in the interior, and a casing of hard woody matter all round

Fig. 16.



them. Another and a more remarkable deviation from the general structure of endogens is met with in grasses, the stems of which are generally hollow between the nodes where the sides are connected by transverse partitions; but the arrangement of matter in the solid shell being entirely that of palms, grasses cannot be considered to offer an exception to the law of endogenous structure. It is unnecessary to add that where stems are of very small size, corresponding modifications in the arrangement of the parts are to be expected; such, for instance, as the reduction of the woody matter to one single woody bundle, surrounded by a thin coating of cellular substance.

Arborescent Endogens being exclusively natives of hot countries, where Europeans have seldom an opportunity of examining minutely into matters which require the long and patient investigation of resident observers, nothing certain is known of the channels through which the ascending and descending currents pass in their stems. From analogy, it is presumed that the sap rises by the woody bundles, and descends through the soft spongy matter, but this is entirely conjectural.

Acrogens are totally different in their organization from both the last. In ferns, which are most remarkable both for their size and singularity of structure, the stem (*fig.* 17) is a cylinder, usually hollow; if solid, having the

Fig. 17.



centre filled with a spongy substance, destitute of bark, with neither woody bundles nor woody wedges interspersed among the general substance of the stem. The shell of this cylinder, which answers to the woody part of other plants, is composed of excessively hard plates, folded upon themselves in such a manner that a section of them represents a number of sinuous lines doubling about among spongy matter. These never increase in thickness, number, or quantity, after being once formed; but they seem as if they were, as in all probability they are, mere prolongations of the woody matter lying inside the footstalks of the leaves; whereas exogens increase by addition to the outside of their wood, and endogens, by addition, to the inside of their stem, whence their respective names have been formed. Acrogens seem to have little or no power of increase in diameter, but simply to lengthen by continual extension of their points; their name has been contrived from this circumstance.

To these principal variations of the mode of growth in the stems of plants should, perhaps, be added a fourth form, of which little notice has hitherto been taken by botanists. This, which might be called the *centrifugal*, occurs in fungi, lichens, and the lower orders of plants; and consists of a fleshy or spongy mass, or of filamentous processes radiating from a common centre.

In many respects this is the same as the Acrogenous, of which, indeed, it may be considered a mere variety; for its ramifications do not increase much in thickness after they once are formed; it nevertheless deserves to be specially explained. In an obscure plant called Marchantia, Mirbel found that a little thin green plate was first formed by the action of the reproductive grains or seedlets; and that it was from the edges of this plate, when once fully formed, that all the succeeding expansions took place, as from a common centre, but always upon the same plane; so that in such plants the central part is the oldest, and the circumference the youngest. This is very apparent in lichens, which, when very large, are always dead in the centre, while they continue to go on growing from every part of their margin. Fairy rings are an exemplification of the same thing in fungi; these appearances are external indications of the centrifugal growth of the subterranean stems of certain agarics, which originally spring from a common point, continually spreading outwards upon the same plane, the central or first-formed parts perishing as the circumferential or latest-formed parts develope.

Chapter VIII.

Of Leaf-buds.

From little conical projections from the stem, which are at first of an uniform substance, but which are eventually covered by minute scales very regularly and closely arranged one over the other, the branches of a plant are produced; and without them, no other increase in bulk can take place besides an expansion in all directions such as characterizes the centrifugal mode of growth, and such as we find in fungi. In other words, they may be said to be growing points, covered with rudimentary leaves, for their protection, and to consist of a highly-excitable mass of parenchymatous matter originating in the pith, and possessing a special power of extension in length.

Such conical projections are called *leaf-buds*. They are normally (that is, under common circumstances) formed exclusively at the nodes and from the axil of a leaf. Even in the very infancy of a plant, while it is yet in embryo, they appear at the axil of the seed-leaves or cotyledons, when they are called the *plumule;* and at every successive stage of growth they are ultimately produced as the leaves expand.

Although they appear to be mere projections of the surface, yet in reality they are not so; but are intimately connected, for most important reasons, with the very centre of the stem. In exogens they universally originate either from the termination of the pith, or at the outer end or mouth of one of the medullary processes, of which they are, in fact, an external prolongation, and by which they are, consequently, in direct communication with the pith. In endogens, their origin has not been traced with the same exactness; but there seems no reason to doubt their originating in the pulpy substance which in these plants corresponds with the medullary system of exogens.

Being axillary to leaves, they are consequently confined to the nodes, of which they are, therefore, an indication, as they must also indirectly be of the leaves when those organs have fallen off. Usually they grow singly; but in some plants, as in the peach-tree, they appear in greater numbers.

They most commonly lengthen out into branches; but sometimes if anything tends to interrupt or stunt their growth, they exchange their power of lengthening for that of hardening and sharpening at the point, and thus become *spines* or *thorns*, which are consequently very different from prickles. This may be distinctly ascertained by examining the wild orange, or which will do as well, the common hawthorn, in which the branches will be found in all their different stages of alteration into spines.

The analogy of a spine of this kind with other parts is not generally explained in elementary works. Yet, if the nature of a bud is correctly understood, such a structure is by no means difficult of explanation. It has already been stated that the leaf-bud

is a growing point capable of longitudinal extension. Usually it produces leaves as it lengthens, and if those organs are green and at regular appreciable distances, it forms a branch, but if they are coloured, placed close together, and differently shaped from leaves, it forms a flower; it is only when the lengthened point is absolutely naked, hard, and sharp, as in the wild orange, that it is a spine. There are several unsuspected analogies with this: one of which is the spadix of an arum, the succulent, blunt, subcylindrical, naked end of which is an undoubted form of the growing point; another is the succulent receptacle of a strawberry; a third the curious chambered disc of Nelumbium.

When leaf-buds appear from any other part of the stem than the node, they are considered altogether irregular in their position, and are called *adventitious*. Such, for instance, are those which often arise from the roots. Botanists are unacquainted with the cause of parts which do not habitually produce those organs occasionally giving rise to them; but it is certain that any of the pulpy or parenchymatous parts may, under particular circumstances, produce leaf-buds. Thus they are of constant occurrence at the margin of the leaves in the plant called bryophyllum; they are generated in abundance by the roots of the Cydonia japonica, and many others; and they have even been seen by Mr. Turpin sprouting from the surface of the leaves of a kind of Star of Bethlehem—not to mention other instances.

These facts explain many circumstances that would be otherwise unintelligible in the growth of plants, such as the power that roots possess of propagating an individual, and the appearance of branches from places where they would not otherwise be expected, of which we shall treat fully under Physiology. They also throw great light upon the origin of seeds.

It is sufficient to mention in this place, that the office of leaf-buds is to propagate individuals, seeds having no power to do more than increase a species; so that if a variety of any species is to be multiplied, that can only be done by aid of the leaf-buds, as is exemplified in the common gardening operations of *budding* and *grafting*, and *striking* from eyes. They, and the leaves together, are also the origin of the woody part of all plants, which first appears when the *seed-leaves* or *cotyledons*, and the *seed-bud* or *plumule*, begin to act, and which is afterwards augmented in proportion to the development of leaves and leaf-buds.

After the leaf-buds have begun to grow, and have been covered with scales for their protection, they form, beneath the scales, a number of rudimentary leaves, which are ready to unfold and augment in size with rapidity as soon as the branch is called into action. Nothing can be more curious than the manner in which these little rudiments of leaves are packed up within the bud, so as to occupy the smallest possible quantity of room; or more remarkable than the exactness with which the particular mode of folding which may be peculiar to a given species, is observed in every bud of every individual. There is no uncertainty in the disposition of these minute parts, no confusion in the arrangement, nor anything left to chance; but every plait is so evidently ordered by some great and unvarying superintendent Power, that the manner in which the young leaves are folded up has been adopted for purposes of systematic arrangement under the name of *vernation*, or *gemmation*, or *prefoliation*.

Fig. 18.



A chapter might be written upon the many different ways in which vernation takes place; but we must here confine ourselves to an indication of the most remarkable, trusting to the figures which represent the plan of transverse sections of different leaf-buds, for an explanation of the terms. The principal forms of vernation are, 1st, the *appressed* (*fig.* 18, *a*), as in misletoe; 2nd, *conduplicate* (*b*), as in the rose; 3d, *imbricate* (*c*), as in the lilac; 4th, *equitant* (*d*), as in the iris; 5th, *obvolute* (*e*), as in the sage; 6th, *plaited* (*f*), as in the vine; 7th, *involute* (*g*), as in the violet; 8th, *revolute* (*h*), as in the willow; 9th, *convolute*, or *supervolute* (*i*), as in the apricot; and 10th, *circinate* (*k*), as in sundew (drosera).

Chapter IX.

Of Leaves, their position and external structure.

The stem is clothed with what are collectively called its appendages, or appendages of the axis, consisting of leaves and their modifications, and of flowers with their parts. The former, taken with the stem itself, are called *organs of vegetation* or *nutrition*; the latter of *fructification* or *reproduction*.

Leaves are usually those expansions of the bark into which slender processes of the wood and fibre insinuate themselves, and within which, after shooting beyond the surface of the stem, they expand and branch in every direction, filling the whole of the pulpy substance with a network of tough and stiff fibres, which serve to sustain the mass of the leaf. The leaf is therefore in intimate connexion with both parts of the bark on the one hand, and with the wood on the other, consisting of portions of the systems of these two important parts intimately intermingled, but each capable of acting singly as well as in concert. The pulpy substance which expands from the surface of the bark and forms the principal part of the leaf, is technically named the *parenchyma*, and the fibres that sustain it *veins*. The latter are also frequently called *nerves* or *nervures* in botanical language, although improperly, for they are merely channels through which fluids are impelled, and they have no connexion, as far as we know, with any action resembling the nervous system of animals.

Leaves are exceedingly diversified in form, in the figure of their outline, in their position with respect to each other, in their texture, and especially in their degree of development; some leaves being nothing more than minute scales, into which the fibrous system can hardly penetrate, and others being of a size which, to those accustomed only to contemplate the foliage of European plants, must appear almost fabulous. The leaves of the bujoor palm of India (corypha elata) often measure thirty feet in circumference, and have a stalk to support them twelve feet long; so that if placed on the ground, one of these enormous leaves would be four times as high as a tall man. There is no machine of human invention, however extensive and complicated, which can for a moment be compared with such a natural apparatus as this for wonderfully elaborate mechanism. Its digesting cells are infinitely more numerous than all the houses of London and its environs; and all the streets, alleys, and passages of that huge metropolis shrink into insignificance when contrasted with the myriads of ramifications of the veins of such a leaf.

Where the bark first projects into a leaf, which is called *the point of insertion*, the leaf is usually narrow, and either round or half cylindrical, and it forms a stalk to the thin and flat part; the former is called the *petiole*, and the latter the *lamina* or *blade*. If a leaf has no stalk, it is said to be *sessile* upon the stem. The stalk of a leaf is therefore merely the channel of communication between the leaf and the stem, and may be supposed to be produced by the woody matter when it first quits the stem to form a leaf, before it begins to ramify; and it in fact consists of one or more bundles of woody matter surrounded with cortical integument. In many plants, such as grasses and sedges, it is thin, and organized exactly like the blade itself; in some plants it appears to exist without any blade, and consequently to be of itself capable of performing all the functions of a leaf, as in some strelitzias, in what are called leafless acacias, and possibly in the majority of endogens. Although, therefore, apparently a distinct organ in many cases, sometimes being even jointed with the blade, the stalk is in fact nothing but the lower portion of the leaf; and hence in all reasoning concerning identity of structure, or of

origin of parts, the stalk and blade are to be considered one and the same organ, and need not be specially distinguished. The importance of this axiom will appear hereafter.

If the branch of any plant be taken for examination, it will always be found that the leaves are arranged in some particular order; and that all other branches of the same individual, or of the same species, have the leaves arranged in the same order, so that the largest tree is merely a mass of branches, all of which are essentially the same. In all cases they arise from a node, and form one or more leaf-buds in their axil. In position, with relation to one another, they are either placed *alternately* one above the other (*fig.* 19, *a*), seemingly on opposite sides of the stem, or they arise from opposite sides of the stem at the same level,

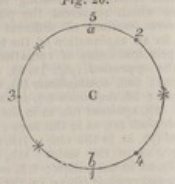
Fig. 19.



when they are called *opposite* (*b*), if growing in pairs, or *whorled* or *verticillate* (*c*), if there are several in opposition.

It is, however, especially to be remarked, that in alternate leaves, one leaf is not exactly opposite the other at a higher level on the stem, although it seems to be so, but it is placed a little to the right or left of what would be exactly a central point, and the leaf which succeeds is in like manner a little out of opposition, and so on; thus several leaves may be produced before another shall be exactly opposite to that from which the observer started. This will be clearer if we project the places of the leaves upon a circle. Let *a b*, in the circle C, be two opposite points: *b* we will suppose is the origin of a leaf, number 1; the second may appear at 2; the third at 3; the fourth at 4; and it would not be till the fifth leaf was produced that *a*, the point opposite to *b*, would be exactly touched. Now, as the wood of a branch is formed by the action of

Fig. 20.

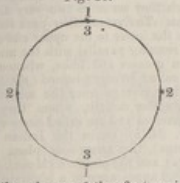


leaves, as will be hereafter shown, this is a beautiful provision of nature to insure the exact symmetry of the branches: for, although if the branch represented by the circle C consisted of but five leaves, as placed upon the diagram, more wood would be formed from 2 to 5, and from 1 to 4, than from 1 to 3, or from 3 to 5, or from 2 to 4, yet if only three more leaves were developed, those three would, upon the same principle of arrangement, be stationed in the wider spaces at *, and thus would fill up the very parts where they would be required to form wood to complete the circularity of the branch. This law is adhered to in a most remarkable manner in all leaf-bearing plants; and appears to be in reality owing to leaves being constantly disposed in a spiral manner from the base to the apex of a branch. This order is not, indeed, obvious in branches, when the leaves are very far asunder, although even in such cases it may be detected by drawing a line from the base of the lowest leaf to that of the one above it, and so proceeding until the bases of all the leaves on the branch are connected. But when leaves are small and arranged very compactly, as on the branch of an araucaria pine, or on the cone of any fir or pine, the spiral disposition is at once manifest; and in the trees called pandanus by botanists, the spiral arrangement is so very remarkable over all the branches, that they are hence called by the English screw pines.

It is not in alternate-leaved plants alone that this order of leafing is observed; even in those with opposite and verticillate leaves it takes place, only in a somewhat different manner. In opposite-leaved plants the pairs

generally *decussate*, that is, cross each other at right angles; so that the corresponding leaves of each alternate pair are placed exactly one over the other, as at *fig.* 21, where 1, 1, repre-

Fig. 21.

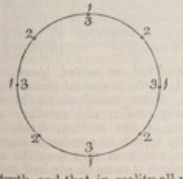


sent the places of the first pair of leaves: 2, 2, those of the second pair, and 3, 3, those of the third pair, which corresponds with 1, 1. The consequence of this is, that the young branches of opposite-leaved plants are usually more or less four-cornered, instead of circular.

Whorled-leaved plants have their leaves placed in precisely the same manner as the last; that is, each whorl crosses that which preceded it, as in *fig.* 22, where the first whorl is represented by 1; the second by 2; and the third by 3.

That leaves such as those last described should also be reconcileable with the notion of a spiral arrangement seems at first sight improbable. But if they are studied with care, certain facts will be discovered which not only tend to render such an opinion probable, but almost to demonstrate

Fig. 22.



its truth, and that in reality all modes of arrangement in leaves are reducible to the theory of a spiral. In all considerations of this nature we must study intermediate forms and structure, and not confine ourselves to extreme cases; and in seeking to discover the analogy between the opposite and alternate forms of leafing, we must not confine ourselves to branches where leaves are invariably one or the other, but take those in which there exists a tendency to vary. Thus, in the rhododendron ponticum some leaves are opposite, some alternate. In this case we find that the leaves become opposite where the internode, or space between two leaves, is not developed; and that when it is developed, the leaves are alternate. Again, in many heaths, whose leaves are habitually whorled, or in honeysuckles, in which they are opposite, it is found, that if anything disturbs this arrangement, such as preternaturally rapid growth, the whorls or pairs separate, and the leaves become alternate, acquiring a spiral order. Again, if branches, the leaves of which, under common circumstances, are alternate, become unnaturally contracted, as in the majority of what are called stemless plants, the strawberry, for instance, the leaves, which would, under different circumstances, have been alternate, become opposite or whorled. Hence it is inferred, that when branches grow in an uninterrupted manner, their leaves are always alternate; that when they are alternately stopped in their growth, as if subject to a sort of oscillation of development, they become opposite; and that when this stoppage takes place, till three or more leaves are produced before the growth of the branch is continued, they become whorled. No cause can be assigned for such a growth and stoppage of growth in branches; but it appears to be one of those specific vital phenomena, with a knowledge of the existence of which the human mind must remain satisfied.

Chapter X.

Of Leaves continued; their usual modifications of Form.

In its usual or regular state, a leaf is a thin expansion with one surface turned towards the heavens and the other towards the earth. In this state it is liable to very numerous varieties of form, by which botanists distinguish species from each other, but into all the details of which this is not the place to enter. The greater part of these are designated by terms

which are either used in their ordinary acceptation, or, being applied to other parts as well as leaves, enter into the list of names which will hereafter be explained in descriptive botany. We shall confine ourselves to those forms which are peculiarly characteristic of leaves.

It is the opinion of botanists that the most remarkable of the forms we meet with in leaves are owing to the peculiar manner in which the veins ramify in the parenchyma; that one class of forms is produced when the veins pass straight from the top of the petiole to the margin; another class when they curve inwards, and grow to one another without touching the margin; a third, if they pass in parallel lines from the base to the apex of the leaf, and so on. And hence the arrangement of veins has been made the fundamental principle of a classification of their modifications. Although this may be carried too far, and is certainly not free from objections, it is, nevertheless, the most convenient mode which has yet been devised. Upon this principle the three following primary groups have been proposed; of each of which we shall give some examples.

1. *Forked-veined*.
2. *Parallel-veined*; of which *straight-veined* and *curve-veined* are forms.
3. *Reticulated*; to which are referred the *ribbed*, the *radiated*, and the *feather-veined* leaves.

Forked-veined leaves are those in which the veins, whenever they divide, separate into a fork, the arms of which fork again, without forming a net-work by growing into some other veins. Instances of this are most usual in ferns (*fig.* 23), which are known by this among other characters.

Fig. 23.



Parallel-veined leaves have their veins proceeding from their origin to their termination without branching, only connecting themselves by equally simple veinlets which pass off from them at right angles. Leaves of this sort are characteristic of endogens, in which they occur in two very distinct forms. The veins either pass straight from the lower to the upper end of the leaf running parallel with the mid-rib, as in grasses and lilies, whence they are called *straight-veined* (*fig.* 24, *a*), or they diverge from the mid-rib towards the margin, where they lose themselves and are called *curve-veined* (*fig.* 24, *b*), as in the Indian shot (Canna), the arrow-root plant (Maranta), and the plantain (Musa). The ragged appearance of a plantain tree, when exposed to wind, is owing to this cause: its leaves are long, heavy, and broad; and, consequently, offer much resistance to the wind; but they are also very thin, and easily torn; therefore, when this happens, the laceration will necessarily take place in the line of least resistance, which is from the edge to the mid-rib, parallel with the veins, and not across them. Palms, on the contrary, which are straight-veined plants, never exhibit the appearance of the plantain; but, if torn, rend from one end towards the other into long shreds.

Fig. 24.



Reticulated, or *netted*, leaves, are formed by the perpetual branching of veins, whose ramifications become gradually smaller and smaller; and growing to one another, divide the leaf into an infinite number of angular spaces, and form that beautiful net-work which is so much admired in the dissected leaves of the shops. In their most usual state the veins of these leaves proceed from the mid-rib at an angle more or less acute, towards the margin, sending off veinlets in their passage which meet and anastomoze

with the veinlets of other veins. The veins themselves curve inwards as they approach the margin, and finally grow to the back of the vein immediately before them, sending off throughout their whole length their delicate net-work of ramifications up to the very margin itself. The rose offers a familiar instance of this.

Fig. 25.



De Candolle has shown that the forms of leaves of this sort are very much dependent upon the relative proportions of the veins: thus, if all the lateral veins are short and of equal length, a leaf will be linear (*fig.* 25, *a*); if those of the middle are sensibly longer than the veins of the base and apex, the form will be elliptical (*b*), oblong, or even orbicular; but if the veins near the base are the longest and generally diminish towards the point, the leaf will be ovate (*c*); or if the longest veins are beyond the middle, obovate (*d*).

Sometimes the netted form is varied by the presence of several ribs which run side by side from the base to the apex, as in the melastoma and the dog-wood; this is called *ribbed* (*e*), and may be mistaken for a parallel-veined leaf if attention be not paid to the netting of the veins between the ribs. In another state several ribs proceed like the rays of a circle from the point where the blade and the stalk of the leaf unite (*f*), as in the poplar, and form a radiated leaf. And, finally, in the oak and many other plants in which the veins proceed straight from the mid-rib to the margin, without bending inwards, the feather-veined form is produced (*g*).

It is not by the arrangement of their veins alone that the characters of leaves are affected; they are essentially determined by the manner in which the margin is directed: for this, although in some measure dependant upon the disposition of the veins, is itself, to a great extent, an independant phenomenon.

On this subject, as upon almost all others connected with the theory of vegetable structure, the older botanists held erroneous opinions. They considered a leaf to be a body originally undivided, which, owing to some unintelligible action, became cut into segments in different ways, so as to acquire eventually a lobed structure. There can, however, be no reasonable doubt that the explanation given of its nature by De Candolle is the true one. This distinguished botanist has entered much more at large upon this subject in his '*Organographie*' than is consistent with our plan; instead, therefore, of taking his words, we shall give an explanation of our own of the theory of the structure of leaves founded upon them.

We have already shewn that the stalk of a leaf is a bundle of vessels and fibre surrounded by cortical integument or parenchyma. At a certain distance from the stem the stalk begins to branch, and each branch carries with it

Fig. 26.



its own coating of parenchyma; every separate ramification, however minute, has also its parenchymatous envelope.

Suppose the ramifications to remain perpetually distinct, and merely to develope upon a plane without touching; and we have such a leaf as the capillary many-parted one of a water ranunculus, or of a hymenophyllum (*fig.* 26, *a*).

Let, however, the ramifications of such a leaf grow together at their edges in a slight degree, and a leaf like that of jatropha will be the result (*b*). Suppose the mutual adhesion of the contiguous edges take place still further, and the leaf of meadow geranium will be the result. If all the secondary ramifications of that leaf grow together, we shall have the digitate form of the common passion-flower (*c*). The principal divisions of this last united halfway up will produce a five-lobed leaf like that of sterculia platanifolia (*d*); still more consolidated, the crenelled leaf of dichondra will be the result (*f*). And, finally, if a coalition of all the exterior ramifications be completed, we shall have the entire orbicular leaf of the common asarabacca (Asarum) (*g*).

This explanation has thus been applied to a particular class of structure, —namely, the radiated; but it must be obvious that it is equally applicable to all other forms. For the terms that are employed to describe all these and other modifications we refer to the chapter upon Descriptive Botany.

There is, however, a kind of division somewhat different from this, although the same in principle, of which particular mention must be made. Suppose the primary ramifications of a skeleton feather-veined leaf to remain quite distinct, while the ramifications of all their divisions are consolidated into separate leaves, or rather leaflets, and a sort of compound leaf, such as we find in the liquorice, the pea, &c., will be produced; this is called *pinnated* (*fig.* 27, *a*). Now, imagine the skeleton of the same leaf to become consolidated in its tertiary ramifications, while the first and second veins remain distinct, and we have the bipinnated leaf of the gum acacia (*b*). It is possible to conceive the fourth order of ramifications of the venous system to be grown together, while the first, second, and third are distinct, and the unusual structure of *tripinnation*, such as is found in thalictrum, will be produced (*c*). Such divisions may be carried still farther, but the only name which is then applied is *supradecompound*.

Leaves thus deeply divided are commonly called *compound*, while leaves which are less than pinnated are said to be *simple*; but these terms are now

Fig. 27.



restricted otherwise. When a petiole is jointed with the blade, or with the leaflets, the leaf is considered compound, whether the blade be undivided or not; and, on the other hand, the most deeply or frequently divided leaves are considered simple, if no articulation exists between the blade and the petiole. Thus the leaf of an orange is compound, of a palm simple.

Chapter XI.

Of Leaves continued; their unusual modifications of Form.

Besides the variations in the external structure of leaves treated of in the last chapter, there are others which, being exceptions to general rules, deserve to be noticed separately.

These exceptions are chiefly owing to five causes, or to a combination of more than one of them, namely, 1, a turgid state of all the parts, owing to the parenchyma being excessively succulent; 2, a general or partial diminution in size; 3, an excessive expansion of particular portions; 4, an unusual contraction and hardening of parts which are generally broad and leafy; and 5, the growing together of parts which are usually distinct.

It is to the extreme succulence and

consequent distention of the parenchyma in a particular direction that the singular leaves of the mesembryanthema are indebted for their curious forms. In one species they are *scimetar-shaped* (acinaciform) (*fig.* 28, *a*), because the parenchyma increases in thickness from the front to the back, while the width is not augmented in a corresponding degree; in others they are *axe-shaped* (dolabriform) (*b*), or deltoid (*c*), from the action of the same cause in a different direction; or they may be cylindrical conoids (*d*), as in mesembryanthemum barbatum, or the

Fig. 28.



common onion, in which latter they are also hollow, because the circumference of such a leaf grows faster than the centre, which is in consequence torn and left without parenchyma to fill it up.

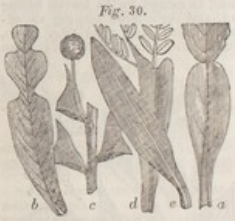
A general or partial diminution in the size of parts produces some great deviations from the usual structure. If all the parts are reduced to their smallest size, such leaves as those of the moss, which are mere minute and thin scales, or of lathræa and similar parasites, which are larger and more fleshy, but still mere scales, may be the result. But if the diminution in size take place only partially, it will simply be attended by a loss of symmetry, which will hence cause remarkable changes in appearance. In Begonia, for instance, one side of the leaf is considerably smaller than the other, and it becomes what botanists call *oblique*, or one-sided (*fig.* 29, *a*); in a pinnated leaf, the leaflets of one side may disappear, as in anthyllis and others (*b*). These circumstances are always caused, according to De Candolle, by the situation of such leaves upon the stem being more favourable to the development of one side than of the other; but this statement is scarcely borne out by facts, which seem rather to stand isolated and incapable of explanation from any secondary cause.

Fig. 29.



The excessive expansion of particular portions is much more frequently productive of singularity of form than any of the preceding. The expansion of the petiole in the orange (*fig.* 30, *a*), and the dionæa gives that part very much the appearance of a leaf; a similar structure in the compound leaf of a begonia from Madagascar, combined with the non-formation of leaflets, converts the petiole into what has been called a lomentaceous leaf (*b*); and a similar loss of leaflets connected with an excessive expansion of the petiole forms the *phyllodia* of the so-called leafless acacias of New Holland (*c*, *d*, *e*).

Fig. 30.



When certain parts of the leaf contract and harden, *spines* are formed, as in the edges of the common holly leaf, where the hardening is confined to the lobes; and in the berberry, which has the principal veins of its leaves separated and hardened (*fig.* 31, *a*, *b*). In a species of prosopis, the one half of the leaflets contracts into a spine, while the other half remains leafy. But the most singular instance of this kind of deviation from usual structure occurs in a palm called desmoncus (*c*), in

which the upper leaflets of its pinnated leaves contract and curve into scythe-shaped hooks by which the desmoncus climbs, while the lower leaflets retain the usual appearance of leaves.

Fig. 31.



But none of all these causes produces so strong an effect upon the general appearance of a leaf, or tends so much to render it unlike itself, as the adhesion of one part to another, especially if accompanied by some of the alterations already spoken of. Thus in the iris the leaves resemble the blade of a straight sword with one edge turned towards the sky, and the other towards the earth. This, which is called *equitant*, is caused by the leaves folding up, and their faces forming an adhesion with each other (*fig.* 32, *e*). In the nasturtium (*fig.* 32, *a*), the two

Fig. 32.



lobes of the base of the leaf grow together, so that the stalk looks as if it proceeded from the middle of the leaf, the latter becoming what is called *peltate*. In the honeysuckle the stem seems to grow through the leaves, in consequence of the base of two opposite leaves adhering; a similar appearance is produced in bupleurum, by the bases of each alternate leaf curving round the stem, and then growing together into a *perfoliate leaf* (*b*). But it is when a leaf, or some part of it curves inwards till the opposite margins touch, and then grow together, that the most singular appearances are produced. What are commonly called pitchers originate thus. In some species of dischidia the blade of the leaf acts thus, and at the same time becomes enlarged and succulent; the consequence is a sort of leathery bag (*c*), in which the plant carries to the tops of trees the water it requires for its support. In the side-saddle flower (Sarracennia) it is the whole petiole which is thus affected, the blade of the leaf remaining unchanged, and acting as a sort of lid to the pitcher; while in nepenthes, or the true pitcher plant of India (*d*), the petiole is partly round, and, in its common state, partly expanded into the form of a leaf, and partly rolled up into a pitcher, leaving the blade of the leaf at its extremity as a cover to the pitcher.

Thus it appears that all the varied forms of leaves are to be reduced to one primitive type, from which they are deviations, and which are to be explained upon perfectly simple and intelligible principles. It will hereafter be seen that the leaf is the type of forms still more remarkable than any now mentioned, and having a totally different class of functions to perform.

Chapter XII.

Of Leaves continued; their internal Structure.

The universal presence of leaves upon all plants, their highly complicated structure, the intimate connexion which it has been shown that they maintain between the systems of the wood and bark, their extremely high development in many cases, and their multiplied variety of form, all lead to the opinion that they are organs of the most essential importance. This is confirmed by their internal structure, independently of experiment.

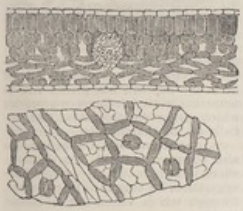
Most leaves are no thicker than a piece of paper or parchment, and appear to the naked eye as nothing more than a thin green plate, so that an

ordinary observer would never suspect that their internal structure, which no eye, unassisted by glasses, can investigate, was one of the most complicated and highly-organized character; and yet there is no part among those with which plants are furnished which is more complex. It is necessary, indeed, that it should be so, in order to be enabled to perform the important functions of digestion, respiration, and perspiration, for which it is destined.

This subject has been very carefully investigated by Messrs. Mohl, Adolphe Brongniart, Meyen, and Mirbel, to whom we are chiefly indebted for our knowledge concerning it. Perhaps the most simple mode of explaining the result of their observations will be to take some common kind of leaf as a type, of which all others may be considered modifications. For this purpose we will select the apple.

The leaf of an apple-tree (*fig.* 33)

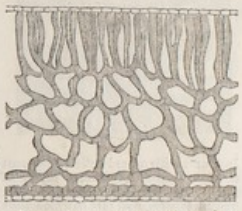
Fig. 33.



consists of a mass of parenchyma, through which pass bundles of vessels and wood tubes in the form of veins; the whole of which is enclosed between two extremely thin plates of cuticle which are united at the edge of the leaf. This cuticle consists of a single layer of minute bladders containing air, and pierced with stomates which are generally much more numerous on the under than on the upper side. Beneath the skin of the upper side are about three layers of cylindrical bladders filled with green pulp, which are packed closely together *perpendicular* to the skin, but with minute cavities between the bladders, and more open spaces caused by the total separation of the bladders beneath each breathing pore. Beneath the skin of the under side are four or five layers of similar cylindrical bladders lying *parallel* with it, touching each other only at their ends, and forming the sides of a number of chambers which communicate freely with each other. This lower layer joins the upper layer, thus dividing the whole of the inside of the leaf into two portions, the constituent parts of which are perpendicular to the upper surface and parallel with the lower; the upper, where the skin has comparatively few stomates, being very compact, the lower, where the stomates are numerous, being very lax and cavernous; a beautiful adjustment of parts most admirably adapted to the functions of the leaf, as will be hereafter shown.

This is the common structure; that side of the leaf being the most cavernous where there is the greatest number of stomates, and the reverse. Thus, in the water lily (Nuphar) (*fig.* 34), in which the lower side of the leaf has no stomata, the compact structure of bladders is on that side, and the cavernous parenchyma is on the upper, where the stomata are extremely numerous.

Fig. 34.



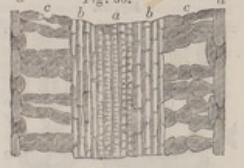
In succulent plants, whose leaves have neither upper nor under surface, the parenchyma is of equal density throughout; in leaves which are constantly under water, as in many floating plants, the skin is entirely absent, and the cavities of air are distributed equally through the whole mass of the parenchyma (*fig.* 35); and in thin leaves, such as the Iris, the two sides of which are exposed alike to the action of light, in consequence of their edges being vertical instead of horizontal; the parenchyma next the skin is cavernous on both sides with perpendicular bladders,

while the centre is often filled with compact parallel bladders. The following section of the leaf of a pine-tree (*fig.* 36), copied from Adolphe Brongniart, in which *a* is a bundle of vessels; *b b*, parallel compact bladders of the centre; *c c*, the perpendicular bladders of parenchyma filled with air cavities; and *d d*, the skin of the two surfaces, illustrates this.

Fig. 35.



Fig. 36.



In plants with a hard cuticle, that part is often formed of several layers of empty bladders, as in the oleander; and in mosses, and plants which have very imperfect leaves, two or three layers of thin-sided bladders often constitute the whole mass, without distinction of skin from parenchyma.

In marchantia, the structure is, if possible, still more remarkable than in the instances already cited. This plant, which, in the hands of Mirbel, has been the subject of the most profound and complete examination that has yet been instituted in vegetable physiology, has been found by that skilful observer to consist, on its under side (*fig.* 37, *a*), of a thick layer of nearly empty bladders, firmly arranged without air cavities, and not covered by skin; but on its upper surface (*b*), where alone stomates occur, it is covered by a skin, beneath which the parenchyma is filled with green pulp, and

Fig. 37.



divided into a multitude of lozenge-shaped chambers completely cut off from one another, but giving rise to numerous jointed deep green processes which spring from their sides, and partially fill the chambers (*c*).[1]

As in common leaves, these chambers also communicate with the stomates, which in marchantia may, without exaggeration, be compared to chimneys, through which ventilation is carried on (*d*).

What has hitherto been stated refers only to the parenchymatous structure of leaves. The venous system which pierces them in every direction consists of vessels surrounded by woody tubes, which stiffen and protect the former (*fig.* 33 and 36, *a*): these are largest near the base of the leaf, and gradually diminish in thickness towards the extremity of their ramifications, till they altogether lose themselves in the parenchyma. To the eye, aided by the most powerful microscopes, the veins seem to be altogether single; but it is well known that when a leaf has been macerated till the parenchyma is quite decayed, the veins will separate into an upper and a lower stratum, so neatly and regularly, that it is impossible to doubt their having

originally consisted of two distinct systems, the one placed above the other. As the sap is propelled from the wood into the leaf in a crude state, and returned into the bark in an elaborated state, and as the veins of leaves are evidently connected with both the wood and the bark, it is supposed that the upper of the two layers is for the onward flow of the crude sap, and the lower layer for the backward flow of the elaborated sap; but there is no distinct evidence of this opinion being well founded.

The anatomical structure of the leaf appears distinctly connected with its functions of respiration and evaporation. That side of the leaf which is next the sun being most exposed to heat, the cylindrical bladders that form it are placed with their narrow ends next the cuticle, by which means they not only each present the smallest evaporating surface, but are so circumstanced with respect to each other, as to be able, with the least difficulty, to absorb fluid from each other as they empty. The bladders next the lower surface not being exposed to the same kind of external influence, do not require the same kind of internal adjustment of their parts, but are arranged with wide intervals between them, which communicate with the chambers below the numerous breathing pores of the lower surface. Here, then, the functions of respiration are best performed, each bladder, on the one hand, exposes the greatest possible extent of surface to the action of the oxygen or carbonic acid that may be received by the breathing pores, and has, on the other, the greatest possible power of parting, firstly, with the oxygen, which results from the decomposition of the carbonic acid in these vegetable stomachs, and secondly, with the superfluous water, which is not evaporated by the upper surface through the cuticle. It will be observed, that in the water-lily (*fig.* 34), in which the most cavernous part of the parenchyma is next the upper surface, the leaf floats with its lower face upon the water, respiration consequently cannot take place at the under surface, and the function is of necessity transferred to the upper, where the stomata all are.

From these statements it is to be inferred that leaves are a sort of pneumatic apparatus, of a highly-curious and elaborate structure; and that the variations which occur in their internal organization are beautiful adaptations of the parenchyma to the particular circumstances under which the leaves themselves are placed.

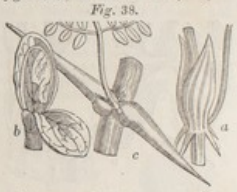
Chapter XIII.

Of Stipules, Tendrils, and Hooks.

The *stipules* are, in many respects, analogous to leaves; like those organs they are often green, lobed, or otherwise characterized; they frequently have buds in their axils, as in the peach and the willow; and they sometimes are not distinguishable from leaves by anything in their form, colour, or consistence. Nevertheless they are, in most cases, sufficiently different from leaves, and are always to be recognised by their position at the base of a leaf, one on each side.

In their most complete state they are little leafy bodies, as in the vetch (*fig.* 38, *a*) and the pea; they are large, lobed, green organs in the heart's-ease (*fig.* 1, *d*); in the tulip tree they are flat, oblong, undivided membranes (*fig.* 38, *b*); in the bird cherry they are

Fig. 38.



nothing more than fine green bristles; and in other plants, as buckthorn for instance, they are frequently reduced to the state of a minute withered scale. By hardening and becoming conical, they resemble spines in some mimosas (*c*); and by losing their parenchyma, and lengthening their mid-rib, they are transformed into long, soft, thread-like processes, which will twine round neighbouring bodies, and thus support the weak and slender stem in the air, as in gourd-like plants. They are then real tendrils.

By adhesions either with each other, or with the leaf, they sometimes alter their appearance in a remarkable de-

gree. In magnolia, they grow together by their upper end, and rolling round the young buds, form a long horn-like sheath, which effectually protects them till they are ready to unfold. The pondweed (potamogeton) has a structure analogous to the last (*fig.* 39, *d*). In cinchonaceous plants they adhere sometimes by one edge, sometimes by another; but most commonly the two contiguous stipules of a pair of opposite leaves unite by their edges, and grow into a scale placed between their two footstalks, which is called an interpetiolar stipule (*fig.* 39, *c*). In polygonum they are thin, rolled round the stem, and united to each other by both edges, so as to form the sheath to which the name of *ochrea* is technically given (*b*). In the rose they grow to the edge of the footstalk, of which they become a thin, leafy margin. And finally, in alternate-leaved plants they are sometimes large enough to surround the stem and unite where they meet on the side opposite to the leaf, which is then called *synochreate* or *hypoglottideous*, as in many species of astragalus (*a*).

Fig. 39.



Many other modifications might be pointed out; those now explained will serve to show that the stipules are such variable organs, that neither form, texture, size, nor colour will define them; but that they are simply characterized by being placed *at the base of the leafstalk*.

The use of stipules in their most complete state is supposed to be to protect the young leaves; such at least seems to be the case in species whose stipules are very highly developed: in the fig and magnolia, for example, they roll round the leaves till the latter are large enough to burst through them, and are able to bear exposure to the air without injury; and in the tulip-tree (Liriodendron tulipifera) they act like two dishes which fit together by their edges, and enclose the young leaves in their concavity (*fig.* 38, *b*). But it is difficult to believe that protection is the only office these organs have to exercise, for in by far the greater number of cases they are so small as to be unable to perform any such purpose. If instances of their being rudimentary bodies were rare, instead of so very common, it would be easier to believe that the business of stipules is really that which is assigned to them.

Tendril is a name given to any part of a plant which is thread-like and capable of twisting round neighbouring plants; it cannot, therefore, be referred to any particular class of organs. In the vine it is a transformation of flowering branches; in the gourd it is an altered stipule; in the pea it is the extremity of the petiole; in gloriosa it is the point of the leaf (*fig.* 40, *a*), which is nearly the same thing; in nepenthes it is the cylindrical part of the petiole; and in the singular genus strophanthus it is actually the points of the petals which have become tendrils, and twine round other plants.

Hooks, which, like tendrils, are contrivances by which weak plants cling to those that are stronger, are also mere adaptations of other organs to that purpose. The hooks of uncaria (*fig.* 40, *c*) are abortive branches, leafless, spiny, and very much curved; those of combretaceæ are produced by the hardening of the petiole after the leaf has withered; and in the singular genus ancistrocladus they appear to be also petioles, but of leaves which never develope in any other form (*d*).

Fig. 40.



Chapter XIV.

Of Bracts.

All the parts hitherto treated of belong to what are called *the organs of nutrition or of vegetation*. Their office is so strictly conservative, that nothing has been assigned to them beyond the power of absorbing crude food from the earth by the roots, altering it a little in the stem, digesting and separating it in the leaves, and storing up in the bark and wood the matter thus altered and inspissated. Every thing which is developed subsequently to the leaves belongs to the *organs of reproduction* or *of fructification*; the sole office of which is to secure the perpetuation of species by seed,—an action they are enabled to perform by the nutrient properties of the stem and leaves.

A little below the flower, interposed between it and the leaf, from the axil of which it arises, are, in the Heart's-ease, one or two little scales, which are evidently organs in an exceedingly rudimentary state. Botanists call them *bracts* (*fig.* 41, *a*), and suppose them, when sufficiently large, to be destined for the protection of flowers before they unfold; but they are frequently in an extremely imperfect state, and quite unfitted for such a purpose.

Although bracts are so exceedingly minute in the Heart's-ease, and, in such plants as we are most in the habit of examining, are seldom so large as ordinary sized leaves, or of any other colour than green, yet they are sometimes of remarkable dimensions, and coloured white, or purple, or crimson, or some other gay tint, and then receive the especial name of *spathe* (*fig.* 41, *d*). An instance of this we find in the Cuckoo-flower of our own hedges (Arum maculatum); in some foreign Arums the spathe is very much larger than in our indigenous species; but it is in Palms that this part acquires its most extraordinary dimensions. The spathe of Alfonsia amygdalina, a South American species, is computed to contain upwards of 200,000 flowers; and that of Corypha Taliera, an East Indian palm, is often as much as twenty feet long.

When bracts are collected into a whorl, as in umbelliferous plants, they are said to form an *involucre* (*fig.* 41, *e*), which, if very small, receives the diminutive name of *involucel*. This kind of organ is very remarkable in compound-flowered plants, appearing as if it constituted a calyx common to many flowers (*fig.* 41, *c*); and hence it used to be called a common calyx. It however does not differ from the involucre in any thing more than its bracts being more numerous, more closely packed, and parallel with each other, instead of diverging. *Periphoranthium* and *periclinium* are names given by foreign botanists to this kind of involucre.

Sometimes bracts not only collect in a whorl, and grow parallel with each other, as in the true involucre, but they actually grow together into a solid cup-shaped body, their points only remaining distinct: such is the cup, or *cupule*, of the acorn (*fig.* 41, *b*). The real nature of this part is not very obvious in our wild oaks, but it may be distinctly observed in the cupules of the mossy-cupped, or Turkey oak (Quercus cerris), which is common in plantations. If the young acorns of that species are examined, the cup will be found to consist of numerous whorls of bracts loosely cohering, and evidently not distinguishable from common bracts; as it gets older they grow together by their lower ends, till at last the acorn cup is fully formed. In Grasses and Sedges the flowers seem to be composed of nothing but bracts, in different states, packed closely one over the other; in these instances we must suppose they perform the office of calyx, whatever that office may be.

Fig. 41.



Bracts being thus variable in their appearance, their limitation becomes proportionably difficult. The best perhaps is that which defines them to be all leafy bodies which intervene be-

tween the calyx and the leaves. To this, however, the impossibility of determining, in some cases, where the calyx begins, is an objection. (See Chap. XVI.) Difficulties of this kind arise, out of the very nature of things, and are consequently not to be overcome, as will be hereafter explained. (See Chap. XXV.)

As all leaves have the power of forming leaf-buds in their axils, so have all bracts the power of forming flower-buds in their axils; and it rarely happens that flowers occur which do not thus originate. Hence it is a general rule, that where bracts are found, flowers may also be expected.

Chapter XV.

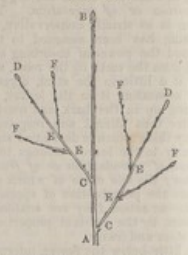
Of the Inflorescence.

The manner in which flowers are arranged upon a stem, or, more correctly, upon that part which bears the flowers without lengthening into a leaf-bearing branch, is called the Inflorescence. A variety of different forms is mentioned by botanists, and it is found necessary to distinguish them with care for systematic purposes; but they are, in reality, all modifications of two primitive types, which, if well understood, will readily explain the origin of the others.

In order to make this intelligible, we must consider upon what principle branches ramify. When an embryo plant shoots up its first stem, it is terminated by a growing point, which keeps leaving leaf-buds behind it on the surface of the stem as it lengthens. This growing point finally occupies in the winter the centre of that leaf-bud by which a stem is terminated, and again lengthens in the spring when vegetation is renewed. Let us call the stem of the first year, with the leaf-bud at its extremity, the *primary axis* (*fig.* 42, A B); this part is covered with other leaf-buds, which, when they lengthen, do so upon exactly the same plan as the first, each having its own growing point, and forming a *secondary axis* (C D), which itself, in like manner, generates *tertiary axes* (E F), and so on.

Now, the inflorescence of a plant obeys the same laws of branching; only for leaf-buds we have flowers. And the two primitive types to which all modifications of inflorescence are reducible, depend upon whether the growing point of the primary axis has the power of lengthening indefinitely or not. If it have the power of growing indefinitely, inflorescence is said to

Fig. 42.



be *indeterminate;* if its powers of lengthening are uniformly arrested at an early period, inflorescence becomes *determinate;* these being the original causes of the various forms of branching we meet with among flowers.

§ 1.—*Indeterminate Inflorescence.*

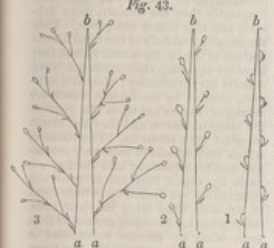
The characteristic of this is, that the primary axis is not arrested in its growth at a very early age, but its secondary, tertiary, or other axes are; and it comprehends some of the most common modifications. Let the lines *a a*, *b* (*fig.* 43), represent such an axis, the lateral buds or secondary axes of which are flowers. As those buds which are nearest *a a* were the first formed, they must of course be the oldest; they will therefore be the first to open; and consequently the flowers, when they expand, will do so first at *a a*, and last at *b*, or in an ascending order. This order of flowering is called *centripetal*, because *a a* is considered to represent the circumference of a cone of which *b* is the apex or centre. Now, suppose that while the primary axis *a a*, *b*, is indeterminate, all the secondary ones *o*, *o*, *o*, are determinate, and have no power whatever of lengthening (*fig.* 43, 1), an inflorescence will be produced analogous to that of the Rib-grass (Plantago): this is called a *spike;* or if it only bears barren flowers, and drops off after shedding the pollen, as in the Hazel, an *amentum* or catkin; or if it is covered very densely by flowers, and is enclosed within a spathe,

as in Arum, it receives the name of *spadix*.

But if the secondary axes *o*, *o*, *o*, have the power of lengthening equally, without however producing tertiary axes, a *raceme* (*fig.* 43, 2) is the result, as in the Currant.

And if the secondary axes develop tertiary axes (*fig.* 43, 3), a *panicle* will be formed, as in Poa annua, which will be more or less compound according to the number of degrees of its ramification. When the upper and lower branches are shorter than those in the middle of a panicle, as in the Lilac, we have a *thyrse*.

Fig. 43.



§ 2.—*Determinate Inflorescence.*

Forms referable to this type are distinguished by the primary axis being arrested in its growth, before the purposes of flowering are at an end; the consequence of which is, that determinate inflorescences, if consisting of more than one flower, are broad instead of being long. A solitary flower, such as that of the stemless Gentian, is taken as a type of this. It consists of a primary axis terminating in a single flower. An idea of it may be obtained from *fig.* 44, 1, in which the lines *a a b* represent the primary axis, bearing bracts from which secondary axes do not arise.

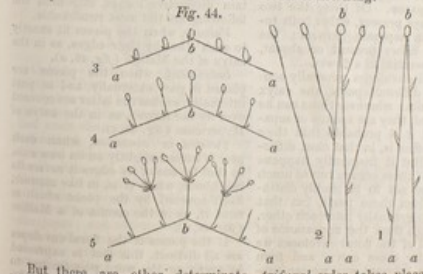
Now, let secondary axes arise from this, of which the lowest are longer than the uppermost, and each long enough to be elevated as high as the central flower, and we have a *corymb* (*fig.* 44, 2).

Suppose the primary axis to be exceedingly short, and the buds of secondary axes to be closely crowded upon it; if, in such a case, the secondary axes do not lengthen, but merely unfold their flower, as in *fig.* 44, 3, a head or capitulum, like that of the Dandelion, is the consequence, in which the axis is distended laterally, in order to make room for the flowers.

But if, while the primary axis is very short, the secondary axes lengthen partially so as to form stalks to the flowers, as at *fig.* 44, 4, an *umbel* will be formed, which umbel will become *compound*, if the secondary axes develop upon the same plan as the primary (*fig.* 44, 5).

Hence it is evident that the head is a spike with a short primary axis, the umbel a raceme, and a compound umbel a panicle in the same condition. All these forms follow the centripetal order of flowering.

Fig. 44.



But there are other determinate forms of inflorescence in which a *centrifugal* order takes place; that is to say, in which the uppermost, or most

central, flower opens first, and the lowermost, or most external, last. In these cases the theory is, that it is not till after the central flower is formed that the lateral ones begin to develop, and that consequently the central flower, in such instances, is really the oldest. A bit of the Laurustinus (Viburnum tinus, *fig.* 45) shows this very well.

Fig. 45.



If this sort of centrifugal development resembles a panicle, or rather an irregular umbel, as in the Laurustinus, it is called a *cyme*.

When what would otherwise be a capitulum expands its flowers centrifugally, it is called a *glomerule*.

And if a cymose arrangement of the parts is much contracted and but little branched, as in a Sweetwilliam, we have the *fascicle*.

Chapter XVI.

Of the Floral Envelopes.

A perfect flower consists of three principal parts; namely, the *floral envelopes*, the *fructifying system*, and the *fertilizing system*. Of these the two last are always present, either both together or in separate flowers; the first may be either present or absent, not being essential to a flower.

The floral envelopes generally consist of two different parts, the calyx and the corolla: wherever these can be distinguished, they are spoken of separately; and it is probable that their respective office is, in that case, different also. But it frequently happens not only that these organs run so much into bracts as not to be readily distinguishable from those parts, but that they pass so gradually into each other, that although from the appearance of the external of the floral envelopes we may consider these calyx, and from that of the internal ones we can suppose those to be corolla, yet we are quite at a loss to know where the outer ends, and the inner begins. This happens in the Carolina allspice (Calycanthus), the white Water-lily (Nymphæa), and various other plants. To designate such cases, the word *perianth*, or *perigone*, has been contrived; and in descriptive botany is employed to express floral envelopes consisting of several whorls of parts passing gradually into each other. This seems to show that whatever the calyx and corolla may be, they are extremely similar, or, indeed, identical in nature.

In some cases the parts of which they are composed are green like leaves, particularly in the calyx; but most frequently they are thinner, more delicate, and of a colour not green. They are usually destitute of the hard fibrous texture of leaves, for which indeed they have no occasion, their existence being usually very transitory; they are, however, pierced by air-vessels, which are arranged somewhat upon the plan of the veins in leaves, and they are amply supplied with stomates. The tissue of which they consist is uniformly colourless and transparent; and the gay colours by which they are so generally remarkable, are caused by minute drops of coloured fluid lying in their cells. Such drops are therefore separated from each other by minute air-cavities or plates, and this is probably the cause of the beautiful satiny lustre we find upon almost all petals.

The manner in which the pieces of the floral envelopes are respectively arranged in the flower-buds is called their *æstivation*, and has received certain distinctive names, of which the following are the most remarkable.

Valvate, when the pieces fit exactly to each other by their edges, as in the calyx of the Mallow (*fig.* 46, *a*).

Imbricated, when the pieces are placed in part externally, and in part internally, so that the latter are covered over by the former, as in the calyx of Hypericum (*fig.* 46, *c*).

Twisted or *contorted*, when each part is turned slightly on its own axis, so that by one of its edges it covers its neighbour, while it is, in like manner, itself covered by the piece which is next it, as in the corolla of a Mallow (*fig.* 46, *b*).

If the pieces of the floral envelopes are all distinct, this fact is expressed by prefixing the word *poly* (many) to the part which is spoken of, as *polysepalous*, if the calyx consists of several pieces or *sepals*; and *polypetalous*, if the corolla consists of several *petals*.

Fig. 46.



But if the pieces grow together by their edges and form a tube or cup, we then say *monosepalous* or *monopetalous*, that is, *one-sepaled* or *one-petaled*; by which is to be understood that they are all grown into one, and not that such a tube or cup is only one piece notched at its edge. The Greek privative *a* is also employed to designate their absence, as *asepalous*, or *apetalous*.

Sometimes the upper part of the floral envelopes grows into a solid lid, and separates from the lower, falling off like a cap; this happens to the calyx of Eucalyptus (*fig.* 47, *a*), and to the corolla of Eudesmia (*fig.* 47, *b*).

Fig. 47.



Calyx.—When the calyx is distinguishable from the corolla, it is commonly known by being smaller, greener, and more leaf-like, or more permanent. But such characters will not always indicate it, for we find it more richly coloured and larger than the corolla in the Fuchsia, and more deciduous in the Poppy. In fact, there seem no means of defining the calyx better, than as the most exterior whorl of the floral envelopes; and consequently the name is so applied, whatever the colour, size, or other characters of the exterior whorl may be; and hence if there is only one whorl, that one is calyx. Care, however, must be taken, when the sepals and petals grow together into a tube, that such a circumstance does not prevent our perceiving the presence of two whorls, as in the Crocus, in which a careful examination will show that there are really two whorls, each consisting of three pieces, one on the outside of the other, and consequently that both calyx and corolla are present.

The calyx frequently drops off when the flowering is over, but sometimes it continues to grow for a long time afterwards. Thus in the Gaultheria and the Strawberry-blite, it becomes red and succulent; in Christ's thorn (Paliurus australis), it expands into a broad thin woody rim; and in the black varnish tree of Burma (Melanorhæa usitatissima), it grows from little green scales into as many large, leafy, veiny, red parts, looking like a corolla surrounding the fruit.

Not only do the sepals grow together and form a tube or cup, but they sometimes grow to the outside of the ovary, so as to become quite incorporated with it, as in the Apple. When this happens, the calyx is called *superior* (*fig.* 48, *a b*), for it looks as if it actually grew upon the ovary; while, on the other hand, it is called *inferior* (*fig.* 48, *c d e*) in its ordinary position, as in the Cherry. The French, with more reason, say it is *free* in the latter case, and *adherent* in the former; but the first-mentioned terms, although not to be defended, are in most common use.

Fig. 48.



Corolla.—This part, which, it will be seen from what has lately been said, is only to be known with certainty from the calyx by its being placed between that part and the stamens, is often, nevertheless, the most conspicuous part of the plant, because the gay colours and the fragrant odours of flowers are generally resident in it.

The pieces, or *petals*, of which the

corolla consists, are sometimes so much narrowed towards the base as to be separable into two parts, just as a leaf may be separated into stalk and blade; in that case the stalk part of the petal is called the *unguis* or *claw*, and the blade has the name of *limb*. It is probably by petals of this sort that monopetalous corollas with long tubes are formed, the border consisting of the limbs, the petals and the tube of their claws in a state of adhesion. The orifice of such a tube is called the *throat*, or *faux*. The petals alternate regularly with the sepals, and are usually either equal to them in number, or twice as numerous; but in consequence of the irregular way in which the petals and sepals respectively cohere, this cannot always be very well made out. For instance, in the garden Sage, the calyx has apparently two lips or parts, while the corolla has four; but if the former be attentively examined, its upper lip will be found to consist of three, and its lower of two sepals; while in the corolla the upper lip consists of two petals, and the lower of three, adhering unequally and irregularly. Hence the calyx and the corolla of that plant really consist each of five pieces.

The pieces of a corolla are not unfrequently extremely unequal in size, and irregular in form and direction. It is, however, only in a *papilionaceous* corolla that special names are given to the parts. A corolla of this description is found in the Pea, and consists of, 1st, a broad roundish petal, which stands erect from the others (the *vexillum* or *standard*) (*fig.* 49, *a*); 2nd, of

Fig. 49.



two oblong, parallel, slightly convex petals (the *alæ* or *wings*) (*b*), which conceal, 3rd, the *keel* or *carina* (*c*), which consists of two petals sticking together by their front edges.

Sometimes petals have membranous scales growing from their upper surface, as in the Catchfly (Silene); they are in that case said to be *crowned* or *coronate*, and their appendage is named the *corona*. Parts of this nature are not to be confounded with abortions of the stamens, which are extremely common, and very like them, but of an essentially different nature. Abortive stamens are processes of a distinctly fleshy nature, and usually traversed by at least one minute parcel of vessels; mere processes of the corolla, on the contrary, are nothing but membranous expansions of cuticle, without any distinct trace of vessels.

The office of the floral envelopes is in part to act as a protection to the fertilizing and fructifying organs when they are young, and to guard them from sudden variations in temperature, by the thin layers of air which they cause to be interposed between those parts and the atmosphere; but it is also probable, that when green, they act like leaves as elaborators of food upon which the organs of reproduction may be nourished, and that when coloured the corresponding change in their chemical operation still further contributes in a special manner to the same end by the conversion of crude fœcula secreted at their bases into sugar, the superfluous parts of which flow off in the form of the honey, which many flowers are so well known to yield in considerable abundance. For the detailed evidence upon which this is supposed to be proved, the reader is referred to Physiology.

Chapter XVII.

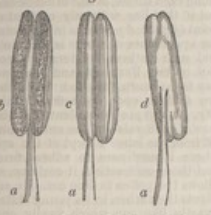
Of the Stamens, or Fertilizing System.

The fertilizing system, called by many modern writers the *andrœceum*, consists of the organs which are arranged between the floral envelopes and the pistil, or fructifying system. Such organs are technically named *stamens*, and usually consist of two parts, viz., a slender white stalk or *filament*, and a yellow or brown head or *anther*. Of these the essential part is the anther, the filament being of no more importance to the latter than the foot-stalk to the leaf.

An accurate idea of the normal state

of the filament and anther may be taken from the Lily. In that plant the filament is a long, fleshy, awl-shaped, greenish-white body (*fig.* 50, *a*), the

Fig. 50.



surface of which is furnished with stomates, and the centre with a bundle of vessels. On its point is placed the anther (*b c d*), which is a narrow, reddish-brown body, having a deep furrow passing down its longer diameter, and being thus separated into two parallel lobes. The part that unites the lobes is a continuation of the filament, and is called the *connective*. Each lobe, before it opens, is marked in front by a shallow furrow which passes from end to end of the lobe, dividing it into two somewhat equal parts (*c*). In course of time the sides of the lobe contract and separate at the last-mentioned furrow, which consequently opens (*b*), and allows a brownish-orange powder, named *pollen*, to fall out; the two sides of the lobe when they thus separate are called *valves*, and the furrow itself the *suture* or *line of dehiscence*. The anther of a Lily, therefore, consists of two parallel lobes, united by a connective, each formed of two valves opening by a longitudinal suture and discharging pollen. This may be considered typical of all filaments and of all anthers. Both these parts are, however, subject to numerous important modifications.

The filament owes the chief differences in its appearance to *flattening*, *distension*, or *contraction*. When exceedingly flattened it becomes so like a petal that it can only be distinguished from that part by its bearing an anther (*fig.* 51, *a c b*); this happens in the Indian shot (Canna), and in a less degree in the white Water-lily (Nymphæa). Distension acts in the most remarkable manner at the base, where it causes the filament to assume the appearance of a fleshy scale (*b*), as in Zygophyllum and Campanula. In a state of contraction it becomes a mere thread, as in Grasses; and even disappears altogether as in a great variety of plants. It is generally smooth, but in the common Spiderwort (Tradescantia) it is covered all over in the middle with long, necklace-shaped hairs, arranged in a dense tuft; in this state it is called *stupose* (*fig.* 51, *d e*).

Fig. 51.



The anther is much more variable in its appearance than the filament, and from causes of a different nature. In cases where the lobes unite so as to be undistinguishable, the anther may become absolutely one-celled (*fig.* 52, *a*), as in Epacris, or it may be two-celled, without any external indication of that fact, as in Arum and all its allies; or finally, the sutures may grow by their edges to the inside back of the cells, and so convert a two-celled anther into one with four cells, as in the Ash. But if one of the lobes of the anther is undeveloped, or abortive, it may become one-celled from that cause alone, as in the Indian shot (*fig.* 51, *a*).

On the other hand, a distension of the connective will produce very singular anomalies. Suppose that part to spread right and left without lengthening, as in the Monarda, the lobes will be at right angles with each other, instead of being parallel; and if they should grow together at their points (*fig.* 52, *n*), the anther itself will become one-celled from this cause, in addition to those before mentioned, as actually happens in the Mallow. Let

the connective grow much beyond the lobes without widening, and the horns of the anther of some Orchideous plants, the membranous crest of the Violet, or the fleshy crest of the Ginger tribe (*fig.* 51, *h*) (Scitamineæ), will be the result. A third modification of the appearance of this organ may arise from the connective growing much more on one side than the other, having no anther on the side of excessive growth, and also taking on that side a direction different from what is habitual to it in other plants. This is particularly remarkable in the Sage genus, the anthers of which are one-celled, and look as if they rode upon a two-legged body (the connective), which is itself astride of a slender fleshy process (the filament). See *fig.* 52, *f*.

Fig. 52.



Occasionally the lobes of the anther, instead of being parallel with one another, and at the same time straight, retain their parallelism, but fold and double up upon themselves; and this produces the sinuous appearance in the anthers of a Gourd (*fig.* 52, *r*). Or, finally, they may give birth to processes of different shapes, which give them a horned or spurred, or crested appearance, as in many plants of the Heath tribe (*e d*).

The manner in which the anther bursts, so as to allow the pollen to escape, is usually by an opening all along each suture, or line of dehiscence; but if that line will only open at one point (*fig.* 52, *d p m l*), as in the Potato, the appearance of a pore is the result; and such anthers are termed porous. But in the Barberry, and the Sweet bay tree (Laurus nobilis), the anthers are said to open by reflexed valves (*fig.* 52, *o q*); in those plants the whole face of each valve of the anther comes off from the lobes except at the apex, where it continues to adhere firmly, and there contracting, it curls up, and allows the pollen to drop out. In such plants the anther, in its young state, is exactly like one which finally opens longitudinally; but it would seem that eventually it is unable to expel the pollen by the usual suture, which will not give way to the force exerted by the pollen grains from within. It is, however, indispensable that something should give way, and, consequently, the face of the anther separates all round, and having separated, curls up in consequence of the contraction of all its parts.

In Mistletoe, the mode in which the anther opens is altogether anomalous: bursting when ripe by a number of holes which are scattered over its whole surface (*fig.* 52, *s*).

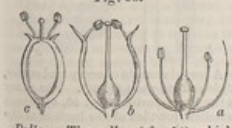
In their number the stamens follow no constant rule; for although it is certain, as will be hereafter proved, that their most normal number is, in all cases, the same as that of the segments of the calyx or of the corolla, yet, what with multiplication, abortion, and transformation, they are very often extremely different from the quantity of the floral envelopes. The only rule that can be said to be fixed concerning them is, that if they are fewer than the segments of the calyx or corolla taken separately, the difference is owing to a part of them being abortive or transformed; and if there is more than the segments, they are always in that case some multiple of the number of the latter, unless in consequence again of transformation or multiplication. For illustration of this position the reader is referred to Chapter XXV.

The stamens sometimes grow to one another, or to neighbouring parts, by both which circumstances their true

character is more or less masked. In the Mallow, the filaments of a great many stamens grow together into a tube, and are called *monadelphous*; in the Pea, they grow into two unequal parcels, and are *diadelphous*; in the Tutsan (Hypericum), they grow into several parcels, and are called *polyadelphous*. In common Groundsel (Senecio vulgaris), Lobelia, and many others, the anthers unite to each other by their edges, and are called *syngeneous*. And in Birthwort (Aristolochia), and the Orchis tribe, anthers, filaments, styles, and stigmas become all consolidated and confounded in one central body, named the *column*; plants with this remarkable structure are said to be *gynandrous*.

In addition to adhesions of this sort, there is another class, of which great use is made in systematic botany. In the normal state of a flower, the stamens arise from the angle formed between the base of the calyx or corolla, and the ovary (*fig.* 53, *a*), and are then said to be *hypogynous*; but in the Plum, the stamens grow by their lower end to the side of the tube of the calyx, only separating from it at the line where the petals arise; they are then called *perigynous* (*b*); and in the Myrtle they not only grow thus to the side of the tube of the calyx, but also to the face of the ovary, and join those two parts into one body: from this cause they look as if they grew upon the top of the ovary, and are said to be *epigynous* (*c*).

Fig. 53.



Pollen.—The pollen (*fig.* 54), which to the naked eye looks like very fine dust, is the most curious and most varied part of vegetation. It consists of a prodigious multitude of little grains, whose figure is generally uniform in the same species, but which have some hundred modifications of form in different species, and which vary in size from the $\frac{1}{3000}$th to the $\frac{1}{1000}$th of a line in diameter. Most of their forms are reducible to the spheroidal and the triangular, but some are oval, as in the majority of Umbelliferous plants (*fig.* 54, *l*), and others polyhedral, as in some Compound flowers. The grains of pollen are most commonly single, but in many Acacias they are clustered in little round balls (*m*), and in Orchideous plants in threes or fours; their surface is for the most part smooth, but many are hairy or bristly, or covered with little tubercles symmetrically arranged. Occasionally there are circular spaces upon the surface which open like little lids when the contents of the pollen-grain are discharged, as in the Passion-flower (*h*).

Fig. 54.



In some species, such as many of the Orchis tribe, and all Asclepiadeous plants, the pollen falls in mass from out of the anther, the grains adhering to one another in different ways. In the Orchis, they are collected into wedges, which stick to a central elastic thread; in Neottia they are joined imperfectly in threes and fours, and united by an elastic web; and in Malaxis they form a solid, homogeneous substance, of a waxy texture. In Asclepiadeous plants they are collected within a bag which appears to be the lining of the anther separated from the valves.

The shell of the pollen-grain seems from the best modern authorities to consist of two layers, the external thick, fleshy, and cellular, the internal very thin, membranous, and extensible. Of these the external has often apertures at its angles through which the inner membrane projects in a slight degree, from which cause the angles appear semi-transparent when the pollen is magnified and viewed in water by transmitted light. In these cases in which only one membrane is present, it is said that it is the interior, and that in such instances no trace of aperture is visible.

The structure of the pollen, in consequence of the excessive minuteness of the parts, is not to be seen without much difficulty; but Dr. Fritzsche, a young Prussian botanist, has lately

shown that it may be observed with greater facility than was before supposed by examining the grains in a liquid composed of two parts of concentrated sulphuric acid and three parts of water. By this means, the external coating of the pollen is rendered transparent, the matter within it is coagulated, and partially forced out through the apertures, in the form of long intestine-like sacs, which are called *pollen-tubes*. This phenomenon occurs spontaneously when the grains of pollen have fallen for a few hours upon the stigma, and it is through such intestine-like sacs that the fertilizing matter is ejected from the pollen-grain into the conducting portion of the tissue of the stigma.

The matter which is ejected appears, under a microscope of low power, to be merely a turbid fluid, denser than the water into which it is discharged; upon magnifying glasses of sufficient power being applied, the turbid fluid is found to consist of oblong particles about the $\frac{1}{2500}$th of an inch in diameter, and spheroidal molecules varying in size from the $\frac{1}{7500}$th to the $\frac{1}{15000}$th of an inch in diameter, according to the computation of Mr. Dollond. These, when floating in water, are in active motion, each revolving upon its own axis, and the larger kind having often a sort of spasmodic contraction of the side. It is a general belief that these larger particles are the rudiments of embryos, and that the effect of fertilization is to convey one of them into the ovule; but there is not, and probably from the nature of things never can be, any proof of the correctness of this opinion. Fritzsche, however, asserts that the particles are nothing but grains of amylaceous matter, or globules of oil, and denies their having anything to do with fertilization. It may, however, be observed, that supposing them to be grains of amylaceous matter, yet as they are of definite and regular form, and have a specific motion, it is by no means improbable that nature may have destined them to perform the important action that is ascribed to them. Amylaceous matter, in a dead state, ought not to be confounded with the same substance imbued with the living principle, which takes it beyond the ordinary laws of chemical action, and gives it powers of a special nature. Nor is it to be admitted that the particles of the pollen-fluid cannot be destined to act as a fertilizing power, because grains apparently of the like nature taken from parts having no fertilizing action, will move, as it were, spontaneously when suspended in water; as, for instance, the particles of which the ovary of wheat consists. For in bodies so infinitely small as those in question, nothing is revealed by the microscope beyond their external form, and no one can say that bodies which seem under the microscope to be identical, would not, in fact, be found to be entirely different if it were possible to perceive their structure more distinctly.

Chapter XVIII.

Of the Pistil, or Fructifying System.

The fructifying system, or *gynæceum*, occupies the centre of a flower, and is the part round which all the other parts are arranged; it is generally called the pistil.

The pistil consists of certain component parts called *carpels*, which are either distinct from each other, as in the Strawberry (*fig.* 55, *a*), or all grown together into one body, as in the Rhododendron (*fig.* 55, *b*); or if the pistil consists of but one carpel as in the Cherry, then the terms pistil and carpel have the same meaning.

Fig. 55.



A carpel consists of *ovary* and *ovules*, *style* and *stigma* (*fig.* 56). The ovary is the lower portion (*fig.* 56, *b*), which is hollow, rounded at the back next the calyx, and sharp at the opposite edge, within which is a double line corresponding with an external suture, and called the *placenta*. The ovary tapers upwards into a slender horn or thread, called the *style*, and on the point of that organ there is a humid space, destitute of cuticle, and usually a little, sometimes very much, distended, which is the *stigma* (*a*). Of these parts the ovary and stigma are present in all carpels, but the style is not more essential than the footstalk to the leaf.

Fig. 56.



The part from which the ovules originate, consisting of an excrescence, more or less considerable, of the united edges of the carpel, is what has been called the *placenta*. Sometimes it bears but a single ovule, more frequently two, and generally a greater number; in many cases it is scarcely visible except in consequence of the ovules growing out of it, but most commonly it has distinctly a fungous appearance, and very often is of considerable size, as in the Primrose and the Lychnis dioica. We shall see, as we proceed, that it is an organ of great importance.

All the principal modifications of pistil with which we are acquainted are produced by the various modes in which the carpels are joined or arranged, or by the state of the growing point round which they are placed.

When one carpel only is present, as in the cherry, the pistil is *simple*; but if more than one carpel is found in the same flower, it is *compound*. Supposing its constituent carpels to be separate from one another either entirely, or to a considerable degree, the pistil is called *apocarpous* (*fig.* 55, *a*), as in the Crowfoot (Ranunculus), the Rose, the Aconite, &c.; but if the carpels grow completely together, the pistil is *syncarpous*, as in the Arbutus, the Lilac, the Chickweed, &c. (*fig.* 55, *b*).

In the disjoined state of the carpels, there are few states of the pistil that deserve to be pointed out, except such as result from an enlargement or hardening of the growing point round which the carpels are placed.

The nature of the growing point in a leaf-bud has been already explained; see page 19. In a flower-bud it has usually no power of extension; for the act of forming the floral organs seems in general to paralyze the central tissue, and to render it incapable of further development; and consequently the carpels are usually the absolute termination of the axis of growth. But in some cases, after the carpels are formed, a partial tendency to develop is manifest, and the central substance rises up between the carpels, disjoining them, and sometimes extending far beyond them (*fig.* 57, *c*). Thus in the Strawberry this power of extension produces a succulent receptacle, which bears the carpels scattered over its surface; in the Geranium it projects beyond the carpels, growing to their styles in the shape of a hardened beak; in the Rue it forms a central column, which is not very visible till the fruit is ripe; and finally in the Nelumbium (*fig.* 57, *d*) it rises up about the carpels, and forms a sort of hemispherical disk in which they are immersed. When it is succulent and belongs to a greater number of carpels than five, it is called *torus*, or receptacle; but when it has five carpels, or a smaller number, placed regularly round it, and finally separating from it, and from each other, when ripe, it is called a *gynobase* (*fig.* 57, *a b*).

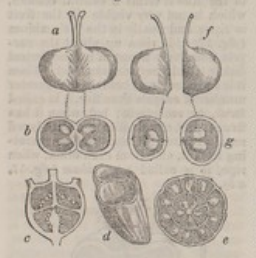
Fig. 57.



An idea of the manner in which the appearance of the pistil is modified by the number of carpels that form it by their union, will be best obtained by

first considering the effect of two being completely combined. Let *fig.* 58, *f*, represent two carpels placed opposite each other, but distinct, each having its own style and stigma; then the *fig. g* will represent the appearance of a transverse section of them, with the two placentas pointing towards each other. Also let *fig.* 58, *a*, represent a pistil formed of two carpels combined, and *b* the transverse section of the same. It will then be obvious that the style and stigma of *a*, although apparently simple, are, in fact, composed of two styles and two stigmata grown to each other throughout their whole length, and that the ovary of *a* is in like manner made up of two ovaries complete

Fig. 58.



in all their parts. It will further be apparent that the partition which divides the cavity of the ovary *b* into two equal parts, consists in part of the face of the right hand, and in part of that of the left hand carpel at *a* and *f*, and is consequently organically double, however simple it may appear to the eye to be. The placenta also at *b*, although seemingly simple, must in like manner be composed of the placentas of two carpels.

Now if we exchange a pistil formed of two carpels for one into the composition of which five enter upon a similar principle, we shall have an ovary with five cells, five dissepiments, and five placentas united into one in the centre.

If we consider the relation which these parts bear to each other, it will be apparent that as the dissepiments are formed by the sides of carpels, and as the stigmata are the termination of the backs of the latter, the stigmas must of necessity be placed in all cases of normal structure between the dissepiments, or alternate with them. Hence it is an axiom in structural botany that no partition in an ovary is a genuine dissepiment, unless it bears this relation to the stigmata, and that all others are spurious; and moreover, that all true dissepiments must radiate from a common centre in a direction parallel to the stalk of the ovary. So that such vertical partitions as are met with in the ovary of Amelanchier and Astragalus, proceeding from the back or front of the cell, opposite the stigma, or as occur horizontally in the fruit of Cathartocarpus fistula, are not called dissepiments, but have the technical name of *phragmata*.

The only exceptions that can possibly occur to this law of the relation borne by the dissepiments to the axis and to the stigmas, is in cases where more rows than one of carpels grow together. When this happens *upon the same plane*, the outer row grows by the placentiferous face of each carpel to the back of the carpels of the inner row, as at *fig.* 58, *e*, and then new dissepiments are produced *at right angles* with the common radiating ones. But if two rows, which arise from two different planes, adhere to each other, the position of the parts will become, as at *fig.* 58, *c*, so oblique, that genuine horizontal dissepiments will be the result. This has been shown by Dr. Lindley to be the explanation of the curious structure of the Pomegranate.

Although, from what precedes, it would seem to follow that all pistils consisting of more carpels than one grown together should contain cells separated by true dissepiments, yet this rule is sometimes deviated from in consequence of certain special modifications of the usual manner of growth. Suppose the constituent carpels of a syncarpous pistil not to be closed up at the edge which bears the placentæ, but to be partially opened, and yet to grow together where they touch; they would, in such a case, form what is called a one-celled pistil, with *parietal* placentæ (*fig.* 59, *a*), in which the sides of the carpels only project from the inside of the pistil into its cavity, without meeting in the centre: this happens in the Poppy, and many other plants. Or it may occur that a pistil, originally of the most normal structure, may assume an anomalous appearance after a certain period, in consequence of an inequality in the rate at which its different parts may grow. Thus, in what are called Caryophylleous plants, such as the Lychnis dioica, the Mouse-ear chickweed (Cerastium), &c., the pistil, when very young, has several cells, separated by complete dissepiments, and joining in the middle by their respective placentas. But after a time the dissepiments lose all power of growing, while the placentas expand, and the shell of the ovary increases steadily in dimension; in consequence of this the dissepiments are ruptured by the opposing strain of the placentas on the one hand, which will not separate, and of the shell of the ovary on the other, or, in other words, of the back of the carpels, which are compelled to spread away from the centre by the addition that is constantly making to their dimensions in every direction; the circumference of such a pistil is perpetually pulling against the centre, and as the dissepiments will neither grow nor stretch, they must necessarily be rent in twain (*fig.* 59, *b*). From this results—1. if the placentæ grew along the whole length of the inner edge of the carpels, a *free central placenta*, as in Lychnis (*fig.* 59, *b*); or 2. if they appeared only at the base of the inner edge of the carpels, a *free basal placenta*, as in the Tamarisk (*fig.* 59, *c*).

Fig. 59.



Instances of this kind serve to show the student of botany, that the most singular anomalies of structure are susceptible of easy explanation if attention is steadily fixed upon first principles; and that it is highly unphilosophical to suppose that the simplicity of design which is so generally manifested in the works of nature, is departed from in certain special cases, merely because we may be unable rightly to understand them without reflection.

There are few modifications of the *style* which are worth noticing, except such as are caused by its distension in one direction, when it becomes petal-like, or in all directions when it is club-shaped and massive. In the Iris is one of the most remarkable instances of its assuming the appearance of a petal; and Indian shot (Canna) affords another. In Asclepias, Stapelia, Tupistra, and others, it becomes succulent, and acquires a fungus-like appearance.

The *stigma* is subject to similar alterations, but in a much less degree, and it is probable that many anomalous forms referred by botanists to the stigma really belong to the style. Some of its most singular states are the following:—in Rhubarb (Rheum) it forms three flat orbicular disks, in Dock (Rumex) as many fringed round tassels, and in Grasses a tufted hairy body like the brushes with which holy water is scattered about in Catholic churches. In the Poppy the stigmas collect into a star-like body, crowning the top of the ovary; in the Heart's-ease it is a hollow globe with a small aperture on one side; in the Monkey flower (Mimulus) it consists of two membranous lips which have the power of contraction when irritated, and in Clarkia it consists of four broad white petal-like lobes. In Orchideous plants it is an oval humid space hollowed out of the face of the central column of those plants, and in general it has a surface which is covered with a clammy or gluey secretion; this is no doubt a provision for enabling it to retain the pollen grains when they fall upon it; when it has not such a contrivance, it is covered over with long finger-like processes, in which the pollen is entangled, as in Grasses, &c. There are, however, some plants in which the surface of the stigma is undistinguishable from that of the style, as in Birthwort (Aristolochia), Asclepiadeous plants, and Tupistra.

Generally the stigma is undivided, and consequently the number of stigmas indicates the number of carpels of which a syncarpous pistil consists. But this mark is not always to be trusted; for in most Euphorbiaceous plants the stigma of each carpel is divided into two deep lobes, and in Grasses, the pistil of which is perfectly simple, there are uniformly two stigmas some distance apart at the base. It is important that this should be well considered by those who are engaged in the study of vegetable structure; for it will sometimes offer an easy solution

of what may at first appear a most difficult problem. For instance, Cruciferous plants have their stigmas apparently opposite the placentas; Dr. Lindley has attempted to explain this away by assuming that the structure of the pistil of such plants is in reality much more complicated than it seems to be; but Dr. Brown, on the contrary, finds a simpler and apparently a more probable explanation in the original two-lobed structure of the stigma of Cruciferæ.

Chapter XIX.

Of the Ovule.

To the naked eye the ovule is an oval grain with a mother-of-pearl colour, and seems, when crushed, to be simply a bag of gelatinous matter; but in reality it is an organ whose structure is by no means so simple. It consists of a central part called the *nucleus*, over which are placed one, two, three, or four membranes, called from their position the *primine*, *secundine*, *tercine*, and *quartine*, the primine being the most external. All these are pierced, at the part which corresponds with the point of the nucleus, with a hole called the *foramen* (*fig.* 60, *a*), so that the point of the nucleus is freely exposed to external influence. It is believed that the

Fig. 60.



fertilizing influence of the pollen, of whatever nature it may be, is here introduced; for it is uniformly found that the rudiment of an embryo first appears at the point of the nucleus; and, in fact, the foramen of the ovule may be taken with perfect confidence as the situation of the future radicle of the embryo; a point of no inconsiderable importance in systematic botany. Although the ovule is in some cases furnished with the four integuments just mentioned, to which a fifth, the *quintine*, or immediate coat of the nucleus, has to be added, yet in the majority of cases the primine, secundine, and tercine are all that can be detected, and even one of these is absent in the Alder and its allies, whose ovules have only a primine and a coat to the nucleus. These facts have been elucidated chiefly by the careful investigations of Brown and Mirbel.

The situation of the foramen is always at a very early period of the growth of the ovule at the apex; and in many ovules it subsequently remains there; but in the majority of plants the ovule bends down upon itself, and gradually brings its apex down to its base, when the foramen becomes con-

Fig. 61.



tiguous to the point of insertion of the ovule. This is particularly well seen in the gourd tribe, whose changes from a very early state, when the ovule is a mere pulpy tubercle, to its perfect condition, are easily followed, and have been admirably illustrated by Mirbel. *Fig.* 61 represents this: *a a* are two very young ovules in their original state; *b b* are the same grown older, with the foramen just appearing; *c* is one of them with its three coats fully formed and half bent down upon itself; *d* shows the further change when the ovule has actually become inverted in consequence of the bending down being accomplished; and *e* represents the ovule in its perfect state, when ready to be fertilized.

It appears probable that the different stations of the foramen upon the surface of the ovule are closely connected with the peculiar manner in which, from the structure of other parts, the phenomenon of fertilization takes place in different species of plants.

The position of the ovule, with regard to the ovary, is *erect* when it rises from the very base of the cavity; *ascending* when it originates a little above the base; *pendulous* when it hangs from the very apex; *suspended* when it is hung up as it were from a little below the apex; and finally, *horizontal* or *peltate* when it is attached by its middle to the middle of the placenta.

Further, ovules are said to be *definite* when their number is uniform and easily counted; and *indefinite*, if their number is uncertain and too great to be correctly counted.

Chapter XX.

Of the Disk.

This name is given to a body which arises from the base of the ovary in the form of a ring, or of scales, or glands, or of a sort of cup. It is almost always fleshy, and seems in most cases to secrete honey.

In the Orange, it is a yellowish fleshy ring (*fig.* 62, *a*); in the alpine Scullcap (Scutellaria) (*fig.* 62, *b*), it is a thick scale placed on one side of the ovary; in the Mignionette (Reseda), it is a broad hairy plate, out of which the ovary arises; in Grasses it is two minute hypogynous scales; in the tree Pæony it is a purple cup, which covers the pistil all over except the stigmas (*fig.* 62, *c*); and in the Cherry it forms a thick shining lining to the tube of the calyx. Besides which, it is found under other forms.

Fig. 62.



It is probable that this organ is, in all cases, a rudimentary state of some undeveloped stamens; and that it is altogether of a different nature from the torus (see p. 43) with which it is generally confounded. That such is its real nature, seems to be proved by these circumstances: that in some Meliaceous plants, such as Turræa pinnata, it is exactly like an external cup, which bears the stamens, and is manifestly produced by the juncture of their filaments; that in Scitamineous plants its parts occupy the place of certain stamens which are not to be found in the place where they ought to be stationed in a case of regular structure; and that in the tree Pæony it has actually been seen with an anther growing upon it.

Chapter XXI.

Of the Fruit.

The fruit of a plant is the fertilized ovary arrived at maturity, and consequently both organs must have the same structure in all their more essential points; for the plan upon which the ovary is to be constructed is finally determined at the period when fertilization takes place, and all that happens to it afterwards is an enlargement and hardening or softening of its parts, together with, in some instances, a suppression of one portion by the excessive growth of the adjacent portions; or in other instances by the addition of something which only existed in a rudimentary state at the period of fertilization. A few instances will serve to show how this happens. In the Oak the ovary has three cells, in each of which there are two ovules; in the acorn, which is the fruit of the oak, there is only one seed and one cell: here two cells and five ovules are destroyed by the exclusive growth of one ovule. In the ovary of the Sweet chestnut (Castanea) there are seven cells with two ovules in each; the ripe fruit consists of but one cell and one seed, so that in this instance no fewer than six cells and thirteen ovules are suppressed, in order to enable a single ovule to grow and be matured. Another common instance in which a variation exists between the ovary and the mature fruit, but from a different cause, occurs in the genus Astragalus, of which the ovary is absolutely one-celled, but the fruit two-celled; an extension of the back of the cell, subsequent to fertilization, projecting forward into the cavity, and touching the placenta, is the cause of this. But one of the most remarkable deviations from original structure has been described in the *Botanical Register*, t. 934, in the fruit of a genus called Martynia. The author says that its fruit had been always described as four-celled, but that upon a careful examination of the ovary, it will be found that the fruit, in that stage (*fig.* 63, *a*), is neither four-celled, nor even two-celled, but consists of only one cell, traversed by two projecting parietal placentæ, each of which is two-lobed, the lobes dividing at right angles from their point of separation, and

bearing on their edges a few horizontal ovules, of which part project into the open centre of the ovary, and the others

Fig. 63.



into the cavity between the placenta, and the lining of the ovary. Now, the fruit (*fig.* 63, *b*) differs from the ovary in no essential point of structure; but the following changes take place: the shell of the ovary and the placentas become hard and woody; the inner faces of the latter become pressed together, so as to destroy the ovules which were placed between them, and to exhibit the appearance of a dissepiment of two plates; and the remaining ovules become pendulous and reduced in number, mature in the form of large wingless seeds between the inner edge of the lateral lobes of the placenta and the shell of the fruit. To this we may add that in a genus called Pretrea, nearly related to Martynia, the lateral lobes of the ovary actually grow to the shell where they touch it (*fig.* 63, *c*), and to each other in the middle, so that an ovary of one cell becomes changed by adhesions into a fruit of six cells. These, and there are multitudes of similar instances, ought to teach the young botanist never to hope to understand the true structure of the fruit of a plant, without having recourse to the anatomy of its ovary; for plants are perpetually in a state of masquerade, which, to the eyes of those who do not know the value of a rigid observance of first principles, must be impenetrable.

Having premised thus much concerning the general nature of the transitions from ovary to fruit, we proceed next to some observations upon the normal condition of the latter organ.

Its shell is what botanists call the *pericarp;* this part is usually homogeneous, but in some plants is not so. In the Peach, for example, the outside is a thin membrane, which may be easily peeled off: it is called the *epicarp;* then comes a quantity of sweet pulpy matter which we eat: that is the *sarcocarp;* and finally there is a hard bony wrinkled part called the *stone* by the vulgar, and the *endocarp* or *putamen* by the botanist. These distinctions are important in describing plants, because descriptions often require that not only all parts, but all modifications of parts, should be indicated by special names.

Some fruits are always closed up to the latest hour of their existence, as the cocoa-nut; others have the property of bursting into separate pieces or *valves* when ripe, as the lilac. This act of bursting is called *dehiscence*, and its varieties are often of material importance in distinguishing plants from each other. We must therefore state what are the typical forms of dehiscence. But for this purpose we must revert to the original structure of the pistil.

A simple pistil is composed of a single carpel, which has a *ventral suture*, to which the placenta adheres, and a *dorsal suture*, which has no placenta. All fruits are composed either of one or of many carpels. If of many carpels, the dissepiments are formed by their union; if of one carpel, there are necessarily no true dissepiments. Suppose that when a ripe fruit dehisces, its carpels all separate from each other, as in the Rhododendron (*fig.* 64, *a*), then the dehiscence is called *septicidal*, and the fruit is resolved into its original elements; but if the carpels refuse to separate and give way only by their dorsal suture (*fig.* 64, *b*), then the dehiscence becomes *loculicidal*, as in the Lilac. These two cases are the most common, and the only ones which are worth naming, as instances of a regular manner of dehiscing; and almost all others are reducible to such types. When, for example, a fruit is said to burst by valves at its point (*fig.* 64, *c*), as in the Mouse-ear chickweed (Cerastium), a partial separation of the carpels takes place both at their dorsal sutures and between

each other, just at the end of the fruit; and in the Palma Christi (Ricinus), and many other plants, a sort of compound bursting occurs; first of all, the carpels separate from each other, and septi-

Fig. 64.



cidal dehiscence is the result; then each carpel splits by its two sutures: this is loculicidal opening; and finally, the shell divides into two layers (the sarcocarp and endocarp), which contract and separate from each other with some force.

There are, however, some irregular forms, which are too curious to be passed by in silence, as they are not reducible to either or any of the two foregoing types. The Poppy (*fig.* 65, *d*)

Fig. 65.



discharges its seeds by a number of little openings which lie below the rim produced by its broad peltate stigmas; the Snapdragon (Antirrhinum) (*fig.* 65, *a*) has similar openings near the apex of its fruit; and the Blue bells (Campanula) burst by ragged holes at the bottom of their capsule (*fig.* 65, *c*, &c.). The Spirting cucumber (Momordica elaterium) discharges its slimy pulp and seeds by ejecting them violently through the place where the fruit and the peduncle are joined, forcing out the peduncle like a plug from a barrel of fermenting liquor. The Primrose, and many others, bear fruit which opens by a transverse separation of the shell into two parts (*fig.* 65, *b*), the upper looking like a cap to the under; and the Bird's-foot trefoil (Ornithopus) has pods which break across into a number of joints. Finally, in most Cruciferous plants the valves of the fruit drop off a *frame* (*replum*), to which the seeds adhere, and which seems formed by a junction of the sutures.

In order to avoid circumlocution, the numerous varieties which occur among fruits have been classified by botanists, and names given to the most important of their modifications. By some writers this has been carried to a great extent; but by others the number of essentially distinct forms has been much circumscribed. Although for many purposes, especially for arranging a carpological collection, the more exact definitions of the former deserve to be adhered to, and consequently their nomenclature adopted; yet it must be admitted, that for the common purposes of descriptive botany, a very small number of terms is sufficient. No others will therefore be admitted into this sketch than such as are of every-day occurrence in the writings of botanists.

The *follicle* (*fig.* 66, *d*) may be considered as a carpel in its ripe state, opening by its ventral suture only, and consequently to be typical of all modifications of fruit, as the carpel itself is of all modifications of pistil. Instances of a solitary follicle are found in the Larkspur (Delphinium), and of several in the same flower in the Pæony, the Star anise (Illicium) (*fig.* 66, *c g*), and many others.

From the latter, botanists distinguish the *legume* (*fig.* 66, *f*), which is, however, hardly susceptible of a definition, so various are the forms under which it occurs. Its most genuine state is as we find it in the Pea, where it is a

follicle opening by both dorsal and ventral sutures into two valves. But it is often incapable of opening, and then is only to be known by the distinct double suture which runs round it. In this state it is sometimes divided into a great number of cells, each containing one seed, and formed by hori-

Fig. 66.



zontal partitions arising from the lining of the shell (*fig.* 66, *l*), as in Tetragonolobus and the Carob tree (Ceratonia); or it may be precisely like a common legume, except that it does not open; or it may be reduced to a single seed, as in Clover, Psoralea, &c. (*fig.* 66, *k*). But its most singular appearances take place when the shell contracts round the seeds, so as to look as if it consisted of a number of distinct joints; in the Sawpod (Biserrula) (*fig.* 66, *i*) it is compressed from the back to the front, and is deeply and regularly scalloped at each edge; in Horseshoe-wort (Hippocrepis comosa) (*fig.* 66, *h*) it is compressed laterally, and one side only is scalloped; in the French honeysuckle (Hedysarum coronarium) (*fig.* 66, *a*) it is simply contracted, and eventually falls into pieces, each of which contains a seed; in the Caterpillar plant (Scorpiurus) it is rolled up upon itself, and covered with tubercles (*fig.* 66, *b*); and finally, in the Snail-plants (various species of Medicago), the convolutions are extremely like those of some univalve shells (*fig.* 66, *e*). Such legumes as separate transversely into distinct pieces are sometimes called *lomenta*, or *lomentaceous*.

The *achenium*, or grain (*fig.* 67, *b*), is a carpel which is one-seeded, does not open when ripe, and has no suture at all. It is what the old botanists called a naked seed, because it resembles a seed in size and texture. Instances of it occur in the Strawberry, the Crowfoot, and the Fig, in which what are popularly called the seeds are the *achenia*. Sometimes this kind of fruit is terminated by a kind of plume (*fig.* 67, *a*), as in Virgin's bower (Clematis), which is the hardened style covered over with long feathery hairs; or it is crowned by a number of scales or hairs called *pappus*, placed in a ring at its summit, as in Compound flowers (*fig.* 67, *c d*). Two achenia combined form the fruit of an Umbelliferous (*fig.* 67, *g*) plant, and two or four, united at their bases only (*fig.* 67, *e*), that of a Boragineous one.

A *cariopsis* is an achenium with a thin shell, which grows so close to the skin of the seed as to be inseparable and undistinguishable; such is the

fruit of Wheat, Maize, and other kinds of corn.

A *utricle* is a cariopsis with a thin loose shell; it would be an achenium if the shell were hard; it occurs in Goosefoot (Chenopodium), and often divides transversely (*fig.* 67, *i*).

A *nut* is an achenium in every thing, except that it results from a compound pistil, and is really composed of several carpels, although all of them may be abortive except one. The Hazel-nut, the Chestnut, the Acorn, are familiar instances of this.

The *key* (Samara) is either an achenium, or a nut with the summit expanded into a wing, as in the Ash and the Sycamore (*fig.* 67, *a*).

The *drupe* is an achenium with the shell separable into two layers, of which the inner is hard and bony, forming a *stone* or *endocarp*, and the other soft and juicy, forming a flesh. The fruits of the Peach, the Plum, the Cherry, are drupes (*fig.* 67, *f*).

Fig. 67.



The walnut is a drupe, the endocarp of which separates into two valves, each of which has an imperfect spurious dissepiment projecting from the back, and cutting the seed into deep lobes (*fig.* 67, *k*).

The *berry* (bacca) is composed of several carpels, which, when ripe, are a mere mass of pulp, in which the seeds lie buried, as the Grape and the Gooseberry.

The *gourd* (pepo) is a berry with a hard rind, like a Melon.

The *pome* is a sort of fleshy berry, in which the inside of the cells is dry, so that the seeds do not lie in pulp; it is composed of a few carpels surrounded by a fleshy calyx, to which they grow, and may either have a thin and papery, or a thick and bony lining to its cells. The former, which occurs in the Apple, may be considered as a combination of fleshy follicles with a fleshy calyx; the latter, which we find in the Medlar, as a union of drupes to a fleshy calyx.

The *siliqua* (*fig.* 68, *c*) is a dry fruit, with two valves that separate from a frame to which the seeds are attached: in the Cabbage it is long and narrow; in the Shepherd's purse (Capsella), it is short and broad (*fig.* 68, *a*); the latter is called a *silicle*; in Sea-kale, the valves do not separate from the frame.

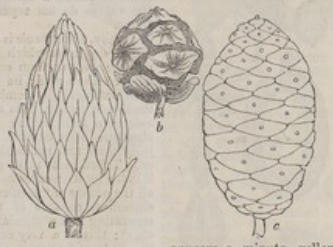
Finally, the *capsule* is a general term for all dry fruits which are composed of more carpels than one, and which dehisce when ripe; its application is even extended by combining it with modifying words; thus a *berried capsule* is a fruit having the ordinary structure of a capsule, with a soft, juicy shell, and not dehiscing; and so on. Taken in its most general sense, it is the most variable in appearance of all the organs of fructification. In Colchicum it consists of three follicles separating in a septicidal manner (*fig.* 68, *e*); this is a very common form of it. In Snapdragon, it consists of two cells opening at the summit by three pores (*fig.* 65). In the Sun-tree (Heliocarpus), it has two cells, opening in a loculicidal manner, and surrounded by long feathery processes which give it the appearance of a Catholic glory. In Hypecoum it is long, taper, curved, and separates into one-seeded joints like a lomentaceous legume (*fig.* 68, *d*), from which it is known by its seeds being attached to *both* sutures. In the Screw-fruits (Helicteres) it consists of five slender, narrow follicles, which are twisted together in a most remarkable manner (*fig.* 68, *b*).

Fig. 68.



Besides the foregoing, there are several fruits which are not produced by single flowers, but which are formed by the adhesion of a considerable number of flowers into a single mass. Such is the fir-cone, each of whose scales represents a single flower (*fig.* 69, *c*); the pine-apple, which consists of as many flowers as there are rhomboidal spaces upon its surface; and the mulberry, each of whose tubercles represents a single flower. These may either be all considered as varieties of the *strobilus* or cone; or with some others may be looked upon as forming a section in a methodical arrangement of fruits, in which latter case they would have several different names. It is more conformable to the plan of this treatise to take the first view of them; for an explanation of the other, the reader is referred to *Lindley's Introduction to Botany*, in which this subject is treated in detail. True cones (*fig.* 69, *b c*) must not be confounded with such aggregations of carpels as we find in the Magnolia (*fig.* 69, *a*), which are like cones in appearance, but which, in reality, are the result of the growth of one single pistil.

Fig. 69.



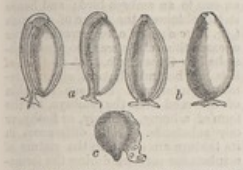
Chapter XXII.

Of the Seed.

While changes are coming over the pistil subsequent to the discharge upon the stigma of the fertilizing principle of the pollen, the ovules are also undergoing a metamorphosis still more interesting and important. No sooner has the mysterious influence of the pollen been introduced into the ovule, than its foramen closes up, its integuments extend and harden, the pulpy substance within them consolidates, and in the midst of the latter, within the kernel, close to the foramen, there appears a minute, yellowish, opaque speck, which gradually enlarges and projects forwards into the centre of the kernel, absorbing the fluid that surrounds it, and, by degrees, assuming the appearance of an organized body which it ultimately becomes, in the form of an *embryo* plant.

The interior integument, within which, under the name of kernel, all this goes on, absorbs its food from the placenta either *directly* in those cases in which, the foramen being at the summit of the ovule, the base of the kernel is next the placenta (*fig.* 70, *b*), or indirectly by means of a cord of vessels which expand at their termination in those cases in which the foramen is at the base of the ovule (*fig.* 70, *a*); in the latter case, the

Fig. 70.



cord of vessels is called the *raphe*, and their expansion, which corresponds with the base of the kernel, the *chalaza*. It will, therefore, be obvious, that where a raphe and chalaza are present, the kernel is inverted, and where they are absent, it is erect; a fact of considerable practical value. This may, indeed, be made out by two other means, either by discovering the foramen, which, in the ripe seed, is sometimes called the *micropyle*, or by dissection; but both these modes are more difficult of application than ascertaining the presence or absence of a raphe and chalaza. Now it has been previously stated (p. 46), that the radicle of the embryo is uniformly found next the foramen; and from this and the other facts just recited, two axioms of the greatest practical value in examining seeds are derived. 1. *When there is neither raphe nor chalaza, the kernel of the seed is erect, and the embryo inverted.* 2. *When a raphe and chalaza are present, the kernel is inverted, and the embryo erect.*

When fully formed, the seed separates from the placenta, retaining a scar, called the *hilum* or *eye*, at the spot where the separation takes place. In some seeds this hilum is very minute, in others it extends more than half round the seed in the form of a broad belt, as in the genus Dolichos.

The integuments of the seed, called collectively the *testa*, or skin, are uncertain in number, like those of the ovule, of which they are merely the ripe state. While, however, they may be fewer in consequence of one or more of them disappearing in the course of the transition from ovule to seed, they never can be more numerous. Two integuments are very obvious in the walnut, the outer of which is brown and tough, the inner white and filmy; and a similar structure is apparent in the almond; in the gourd there is a thin exterior skin, a hard intermediate crust, and a fine inner membrane lying immediately upon the embryo; in the two first cases, the primine and secundine only are discernible in the ripe seed; in the third, the tercine also may be separated.

Nothing can well be more beautiful than the marking of the surface of seeds, especially the minuter kinds, nor anything more varied. In the common Almond, the whole surface is regularly veined by ramifications of the raphe (*fig.* 71, *a*): in the Primrose, it is marked with little projecting points; in a Brazilian plant named Physostemon, it is coiled up like a snail (*fig.* 71, *c*); in Snapdragon, it is marked all over with deep impressions (*fig.* 71, *e*); and in the Prickly poppy it is ribbed and barred across like a closely-grated prison window (*fig.* 71, *g*). Of the

Fig. 71.

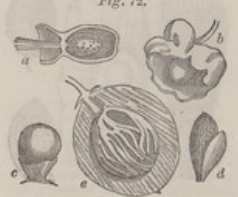


greater number of seeds the surface is perfectly bald, but there are some remarkable for their excessive hairiness: the Cotton-seed, for example, is enveloped in long hairs which grow from every point of its surface, and form the substance so extensively used in manufactures (*fig.* 71, *b*); in the Oleander and similar plants (*fig.* 71, *f*), the hairs are chiefly confined to one

end of the seed, and appear destined to carry it aloft in the air so as to be conveyed to a distance from its spot of birth. Nor are hairs the only means of transport through the air which seeds possess; some have broad, membranous expansions, called *wings*, the office of which they really seem to serve, as in Bignonia, and plants allied to it (*fig.* 71, *d*).

It frequently happens that seeds are attached to the placenta by a sort of stalk, called the *umbilical cord;* which is an extension of the placenta itself, and consists of a bundle of nourishing vessels surrounded by spongy matter. In its ordinary state, the umbilical cord rarely attracts much attention; but it sometimes assumes a very remarkable appearance. In the common Spindle-tree (Euonymus), the seed is enveloped in a red fleshy bag, which is open at the mouth, and which is an expansion of the top of the umbilical cord just below the hilum (*fig.* 72, *b*). An organ of this sort is called an *aril;* the most remarkable instance of it occurs in the Nutmeg, in which it forms the mace of the shops, being a tough, lacerated, fleshy body, overlapping the whole of the seed (*fig.* 72, *e*): in an almost equal state of development it occurs in the Akee plant (Blighia sapida), in which it forms a fleshy, eatable fungosity, in which the seed is half buried. In the Passion-flower it is a pulpy hood, quite enclosing the seed (*fig.* 72, *a*);

Fig. 72.

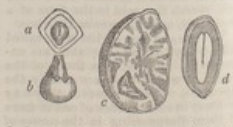


in Heart-seed (Cardiospermum), it is a little plate (*fig.* 72, *c*); and in Turnera it is only a scale standing by the side of the seed (*fig.* 72, *d*). The uses of this organ are unknown; it is however to be remarked that it is never formed until after the fertilization of the ovule has been accomplished.

It has been already stated that the embryo is originally formed in the midst of the pulpy substance of the kernel, and that it is nourished by it during its growth. This pulpy matter bears, apparently, much the same relation to the embryo plant as the white of an egg to an embryo bird; and hence it has obtained the name of *albumen* (*fig.* 73, *c d*). In a very great number of cases this substance is so wholly absorbed by the embryo, that no trace of it is left behind; but in others it remains interposed between the skin of the seed and the embryo, in the form of a horny, or mealy, or fleshy, or oily substance. These differences in its texture are owing to the nature of a substance secreted during the formation of the seed within the cellular tissue of the kernel, and replacing the fluid matter consumed by the embryo; a substance which, in Corn, consists of farinaceous matter adapted for the food of man; in Coffee, of a stimulating secretion, the infusion of which forms a grateful beverage; and in the Poppy, of greasy matter, from which a valuable oil is extracted; but which, in all cases, seems more particularly destined for the nutrition of the embryo in its infant state. If a part only of the cellular substance of the kernel is filled with a solid deposit, and another part remains empty after having been drained by the embryo, the albumen will, in that case, represent a heterogeneous mass, full of irregular cavities, among which solid matter is interspersed, as in the Nutmeg and some other plants. Albumen of this kind is called *ruminated* (*fig.* 73, *c*).

These are generally the only parts of a seed of any importance except the embryo, of which we shall treat in the succeeding chapter. There is, however, in some cases, an additional part called the *vitellus*. In the yellow Water-lily (Nuphar luteum), there is a

Fig. 73.



fleshy bag which intervenes between the albumen and embryo, enclosing the

latter (*fig.* 73, *a*); a similar structure occurs in a few other instances, especially in all species of the Ginger tribe, where it forms a sort of cup, beyond which the embryo protrudes (*fig.* 73, *b*). This part, which is, in reality, the innermost integument of the ovule, in an indurated state, is the *vitellus;* and before the anatomy of the ovule had been made out by Brown and Mirbel, was a very puzzling organ for botanists to account for. Its use is unknown.

From what has gone before, it is clear that the ovule is the origin of the seed; and as nearly all ovules are originally enclosed within a carpel, there can be no such thing as naked seeds except in a very few instances. What the old botanists called naked seeds were usually achenia; and true naked seeds are hardly known beyond Coniferous and Cycadeous plants; concerning which see the Systematic part of this Treatise.

Chapter XXIII.

Of the Embryo.

This part is so extremely varied in its structure, that it is absolutely necessary to take some one form as typical of the remainder, if the endless modifications it exhibits are to be correctly understood. For this purpose let *a b*, *fig.* 74, represent the central portion or

Fig. 74.



axis of any embryo, and *c c* two *seed-leaves* called cotyledons, growing from it. The part from *a* to *b* will then represent a stem, of which *a*, called the *plumule*, is the growing point; *b*, the *radicle*, is the root; and the intermediate space between the radicle *b* and the base of the cotyledons *c*, an internode: upon which supposition the plumule will be axillary to both cotyledons at once. From this form of embryo all our ideas of that organ may be derived: it represents more particularly what is called a *dicotyledonous* embryo, in which not only there are two cotyledons, but they are opposite to each other; let the number of cotyledons be increased, all other things remaining as before, and it is *polycotyledonous*, as in Fir trees (*fig.* 75, *d*).

In the Lime tree (Tilia) the cotyledons are broad, thin, and leafy (*fig.* 75, *c*); in the genus Ardisia, they are very short, while the radicle is undulated and very long in proportion (*fig.* 75, *b*); in Cactus they are almost rudimentary (*fig.* 75, *e*); in the Horse-chestnut they grow together by their faces into a solid body, enclosing the plumule.

Usually they are undivided, but in the loop-holed Menispermum they are pierced with holes (*fig.* 75, *a*); and in some Cruciferous plants are deeply gashed.

Fig. 75.



Ordinarily they lie flat face to face, but there are many exceptions to this; in the common Maple (Acer campestre) they are folded and plaited something like a bat's wings (*fig.* 75, *g*); in the Pomegranate they are rolled round each other in a spiral manner (*fig.* 75 *f*); in Cordia myxa they are plaited in such a way, that when cut through horizontally, they resemble the quilling round a lady's gown; in the Chocolate plant (Theobroma cacao) they have a broken and most irregular arrangement, forming when within the seed an oblong wrinkled body (*fig.* 75, *h*).

Commonly the embryo is straight or but slightly curved; but in certain

plants it is rolled up in a singular way; in the Chalcedonian Lychnis, and many species of the same natural order, it is *annular*, that is, curved into the form of a ring, the summit of the cotyledons touching the point of the radicle (*fig. 75, l*); in the Caterpillar plant (Scorpiurus) it is folded so as to resemble the letter S; and in Dodder (Cuscuta) it is spiral (*fig. 75, k*).

All the foregoing modifications are easily intelligible upon reference to the typical form of the embryo; but there are others called *monocotyledonous*, because they have only one cotyledon, in which the analogy between them and the supposed type is at first sight not apparent. Take, for instance, the embryo of a Cocoa-nut (*fig. 76, d*); it is a taper fleshy body, somewhat club-shaped at one end, and abruptly blunted at the other; no trace of cotyledon, plumule, or radicle, is externally discoverable. If however it is divided with a thin and sharp knife from top to bottom into two equal parts, it will be found that near the blunt end there is an internal conical tumour directed upwards; this is ascertained by the germination of a cocoa-nut to be the young *plumule*; and this being known, it follows that the abruptly blunted end of this embryo is the radicle, and the other the cotyledon; hence it derives its name of *monocotyledon*.

But although thus much is to be determined without great difficulty, there still remains a want of proof that the so-called single cotyledon is not in fact composed, like that of the Horse-chestnut, of two grown together. The demonstration of this is by a curious series of proofs. 1. The embryo of an Arum is like that of a Palm, only there is a slit on one side of it through which the plumule easily escapes (*fig. 76, c*). 2. In Rice (Oryza) this slit is very much lengthened and widened (*b*). 3. In Barley the plumule projects beyond the slit, leaving a flat cotyledon on one side (*a*); and 4. In Wheat the embryo has the structure of Barley, with this most important exception, that at the base of the plumule in front there is a rudimentary cotyledon alternate with the large flat one, on the opposite side of the plumule (*f*). Hence we are to infer that the monocotyledonous embryo of a Palm *is analogous to that of a dicotyledon, of which one of the cotyledons is abstracted, and the other rolled round the plumula and consolidated at its edges*. And this is the view that must be taken of the monocotyledonous embryo in general, all the modifications of which seem reducible to this standard.

Fig. 76.



Thus in Sea-wrack (*fig. 76, g*) (Zostera marina) of which the embryo is an oblong almond-shaped body with a cleft on one side, in the cavity of which a long flexuose process is placed, the latter is the plumule, and the former at one end the cotyledon, and the radicle at the other; in Ruppia maritima, whose embryo is an oblong body, cut suddenly off at one end (*fig. 76, h*) on which a sort of curved horn crouches, the latter is the plumule, and the former chiefly cotyledon; and so in Frog-bit (Hydrocharis morsus ranæ), the embryo of which is an oblong fleshy kernel with a hole on one side, in which there lies a short cylinder; the latter is the plumule, and the former the cotyledon. It is amusing to compare these simple explanations with the overstrained and far-fetched notions of the late Professor Richard of Paris, as set forth in his *Analyse du Fruit*, translated by Lindley some fifteen years ago. At that time no one had a notion of the true theory of the structure of fruits and seeds, the luminous views of Göthe, although for above twenty years before the public, not being known to a single individual in this country, and all that concerns the seed being still an unexplained mystery.

The embryo called acotyledonous, not being the result of specific fertilization, is not, properly speaking, an embryo at all, and will be adverted to in another place.

Chapter XXIV.

Of Abortions, Degenerations, Adhesions, &c.—Of Flowerless Plants.

What has been stated in the preceding pages is to be understood to relate to organs in their usual state; and to be explanatory either of what may be considered normal structure, or, at all events, of deviations which are easily reconcilable with it. This Treatise would, however, be incomplete without some account of the principles upon which it is conceived that all great exceptions to normal structure may be accounted for, and by which they may be reduced to such types as those already spoken of. But as the limits of such a sketch as this forbid the question to be examined in much detail, a few examples only will be given in connexion with very general views.

It must be obvious, from all that has as yet been advanced, that the different parts of which plants consist are extremely simple in their nature; and it is a matter of surprise that such a prodigious diversity, not only of general appearance, but of arrangement and structure, as the vegetable kingdom presents, should result from their combinations. Some French author has indeed said that vegetation is the masquerade dress of nature; it is, however, a masquerade which forms a disguise only to the eyes of those who look at Nature without studying her.

The three principal modes in which the true or typical structure of plants is obscured, are *abortion*, or the non-development of organs; *degeneration*, or their imperfect development; and *adhesion*, or the growth of one to the other.

The term abortion would seem to express, that a part shortly after its original creation became deformed and ceased to have the power of further development; such, however, is not the sense in which botanists use it. By abortion they mean the non-appearance of some organ at the place where one would expect that it would appear, and where in fact it would be found if the structure were regular. There are no parts of plants that may not become abortive, either accidentally or normally; for instance, even in branches, it is their abortion in Pine trees which causes the fascicled appearance of the leaves of such plants; if the greater part of their branches were not abortive, the leaves would not be fascicled, but alternate as in common firs. In leaves, very curious instances of abortion take place; it is by that of the leaflets of Acacias that phyllodia are caused to develope (p. 27); and it is the same cause which produces in Stapelia, Euphorbia, Cactus, &c., those remarkable stems (p. 13) which seem to us as leaves. It is this, also, to which we are to ascribe the peculiar appearance of such plants as Chara, Duckweed, and submersed Algæ.

Thus the abortion of the calyx and corolla produces the kind of flowers we find in the Willow, and to that of either the pistil or the stamens is wholly to be ascribed the existence of what are called unisexual flowers. In all plants it is normal that the number of parts in the corolla, or the stamens, or the pistil, should not be less than the multiple of the numbers in the calyx; and all exceptions to this are ascribed to abortion. Thus Lamium, the white Dead nettle, has a calyx with five teeth, a corolla which is reducible to five petals; but only four stamens; in this case one stamen is abortive, as is proved by plants like Pentstemon, in which that becomes developed which is usually undeveloped. A part of the petals in like manner is, in some instances, abortive; as in Cuphea, which wants a part in some species, and the whole in others; and in Daphne, in which all the petals are always abortive. This term is also applied to parts which, although once completely formed, nevertheless become abortive in the course of their growth, as is the case with part of the ovules and carpels of Cupuliferous plants, as is explained at p. 47, as is common in many Palms, and as usually happens in the Rose itself between the fertilization and maturity of its fruit.

Degenerations are a much more fertile source of alteration in appearance; they generally consist in a part being less highly developed than is usual; and may be considered—if viewed in their true light—as explanatory of the true basis of comparative anatomy in the vegetable kingdom (see p. 59). As instances of this, among leaves, may be quoted such plants as Ruellia amœnophylla, in which one of the leaves of each pair is minute and unformed; or as Monotropa hypopithys, the bird's-nest Orchis (Neottia), Scalewort (La-

thræa), and many others, all whose leaves are in the degenerate state of scales; the scaly coverings of leaf-buds are also imperfectly formed or degenerate leaves. The calyx is remarkable for the many shapes it assumes when degenerated; in the Elm and the Beech it is nothing but a thin, green, deformed membrane; in the fertile flower of the Fig it is a few unequal bristles; and in many Composite plants it consists of little more than hairs or sharp-pointed scales; and is often so entirely rudimentary as to be nothing but a narrow rim. In like manner the corolla is reduced to a few scales in Buckthorn (Rhamnus), and its interior petals to thread-like processes in the Passion-flower. The stamens again are in part not more developed than as little scales in Scitamineous plants; in Lopezia appear in the form of a spoon-shaped membrane; in multitudes of plants are little awl-shaped processes resembling filaments; and in a curious New Holland genus called Eupomatia, they altogether assume the appearance of petals (*fig.* 76*). Even ovules in a degenerate state are thought to be discoverable in the form of the glands which grow upon the edge of the leaf of a Peach-tree.

Fig. 76*.



But whatever deviations from normal structure may occur in consequence of abortions and degenerations, they are as nothing compared with what is produced by the adhesion or growth of one thing to another, a phenomenon on which depends the very existence of plants as organic beings. Their whole framework is constituted of minute organs in a state of adhesion; their stems may be understood, without doing violence to truth, as combinations of many systems of life; and we see perpetually the existence of this tendency evinced in accidental cases, such as the growth together of two Cucumbers, or of two Apples, or of two or more stems which have been developed in contact with each other. In the hedges, where branches are intertwined very closely, one branch frequently grows to that which is next it, forming a complete natural but accidental union.

This property, which exists thus extensively, is of great and continual operation in veiling the real nature of all the external parts of which plants consist, whether of vegetation or of fructification. Leaves, for instance, grow together by their bases (p. 28, *fig.* 32); the adhesions of stipules cause the production of ochreæ, and that of bracts is the explanation of the cupule or cup of an acorn (p. 33). So are most of the modifications of fructification produced by the agency of the same tendency. The calyx, for example, is normally composed of a certain number of sepals; they grow more or less together, and constitute a toothed cup, a tube, or even an undivided cylinder; the petals also adhere into parts of a similar nature, forming monopetalous corollas; the filaments combine into a sheath for the ovary (*fig.* 51, *f*); the anthers grow into a sheath for the style in Composite plants; the carpels, styles, and stigmas combine to form syncarpous pistils (*fig.* 55); calyx, corolla, filaments, and ovaries, all coalesce into one solid body to form an inferior ovary; and finally, in Orchis, the filaments, anthers, style, and stigma, are consolidated into one columnar mass.

These instances, and a volume might be filled with others such, are abundantly sufficient to show the prevalence of the law, *that all contiguous parts are liable to grow together*.

It must however be remarked, that in all cases of normal adhesion, the growing together seems to take place at a very early period of the formation of the organs; and to be altogether antecedent to their arriving at a perfect state.

Flowerless Plants.—It is probable, although it is not yet susceptible of proof in many cases, that all the curious deviations from typical structure which occur among flowerless plants, are owing to the operation of one or other of the foregoing causes. For example, there can be scarcely a doubt that the reproductive organs of Equisetum are degenerate stamens and pistils; that those which grow on the back of the leaves of Ferns are degenerate leaf-buds; and that the theceæ of Mosses are of a similar nature, although in an extremely different state. So in like manner the scales of Mosses must be considered degenerate leaves; the shining green horizontal expansions of Marchantia adhesions of degenerate leaves to degenerate stems; while the reproductive organs of both Lichens, Fungi, and Algæ are to be reckoned adhesions, abortions, and degenerations of well-known organs, all in one. We do not however propose in this treatise to meddle with this part of the subject, otherwise than in the most incidental manner possible.

Chapter XXV.

Of the Theoretical Structure of Flowers, or Morphology.

Notwithstanding all that has been said concerning the normal or abnormal state of the organs of plants, and the manner in which they are severally combined, there still is wanting some principle of combination by which the relation that they severally bear to each other can be determined, and consequently the existence of abortions or degenerations, which are in all cases interferences with regularity, be detected.

It does not appear that the old botanists, who in fact knew nothing whatever of the theory of structure in regard to the vegetable kingdom, ever suspected that the different organs of plants bore any fixed relation to each other; nor can it be said that Linnæus at all understood this, however near he approached to a discovery of the key of the theory. See *Lindley's Introduction to Botany*, p. 505. It was only after the poet Göthe promulgated the doctrine, that all external organs, of whatever nature, are metamorphosed leaves, that botanists gained a clue by which the mutual relations of plants could be determined, and a flower be proved to be analogous in its structure to a branch covered with leaves. For this grand discovery of necessity led to the conclusion, that if a flower be really a collection of metamorphosed leaves, and consequently a branch, the parts of a flower must of necessity bear the same relation to one another as the leaves of a branch. And this is the true basis of all ideas regarding the parts of fructification of plants. It may indeed appear ridiculous to assert that the fruit of a peach is nothing but a peach-leaf rolled up and thickened, an apple only the leaves in a similar state, and a grain of wheat a single leaf in a state of degeneration; and yet we expect to be able to set this matter before our readers in so clear a light, as to convince them that such an assertion, although startling, would be very nearly true. This is called the doctrine of morphology.

It has been observed, in a report made to the British Association at their meeting at Cambridge in 1833, when adverting to this doctrine, that when those who first seized upon the important but neglected facts out of which the modern theory of morphology has been constructed, asserted that all the appendages of the axis of a plant are metamorphosed leaves, more was certainly stated than the evidence would justify; for we cannot say that an organ is a metamorphosed leaf which, in point of fact, has never been a leaf. What was meant, and that which is supported by the most conclusive evidence, is, that every appendage of the axis, whether leaf, bract, sepal, petal, stamen, or carpel, is originally constructed of the same elements, arranged upon a common plan, and varying in their manner of development, not on account of any original difference in structure, but on account of special and local predisposing causes; of this the leaf is taken as the type because it is the organ which is most usually the result of the development of those elements; is that to which the other organs generally revert when, from any accidental disturbing cause, they do not assume the appearance to which they were originally predisposed; and moreover, is that in which we have the most complete state of organization. It might have been added that the leaf moreover can always be most distinctly traced by insensible gradations of structure into all the other parts. It is this which we now propose to prove; and being proved, it will show the truth of the axiom, that *all the parts of a flower must necessarily be equal to each other in number, and alternate with each other*., except in cases of abortion, degeneration, and adhesion.

The course we shall take is this; we shall prove, 1. The bract to be a modification of a leaf; 2. The sepal to be a modification of a bract; 3. The petal of a sepal; 4. The stamen of a petal; 5. The carpel of a leaf; and 6. The ovule of a leaf-bud; and we shall then have demonstrated the whole of them to be modifications of leaves. It is also to be remarked that if this can be proved of *any* normal plants, it must be true of *all* such; for as their parts are manifestly identical in nature, that which is true of one is necessarily true of all.

It must require but little evidence to convince the most sceptical render that a *bract* is nothing more than an imperfectly-formed leaf. Examine it in the Lilac; the most gradual transitions may be seen from the one to the other; or examine it in the Pæony, the ivy-leaved Speedwell, and the common briar Rose (Rosa canina). This being established, it follows that all modifications of bracts are also imperfect leaves, and that, therefore, the involucre of an Umbelliferous, or of a Composite, plant, and the cup of an acorn are also aggregations of half-grown leaves. This is step the first.

The transition from a bract to a *sepal* is very easy. In the Strawberry, the calyx is composed of five bracts alternating with the five sepals, and distinguishable from them in nothing but size; in the Pæony, the leaves insensibly pass into bracts, and the bracts into petals; and in the Carolina Allspice (Calycanthus), the same gradual transition is strikingly apparent. Add to this, that in the briar Rose, one of the sepals is always pinnated like the true leaves; that in the Tulip the sepals often become half leaf and half petal; and that in the Apple, Pear, and numerous other plants, a transformation of sepals into leaves is of common occurrence, and the point that sepals also are leaves may be considered established.

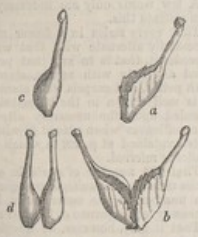
Difference organically between *petal* and sepal there is none, as has already been shown (p. 36); consequently what is true of the one is also true of the other, and petals also are leaves. We may as well, however, add to what has been stated in the place referred to, that petals will occasionally become leaves, or be half changed to them; the latter is common in the Apple and the Pear, it also occurs in some varieties of Rose, and has been seen by Du Petit Thouars in the Tropæolum, by the writer of this in Sieversia montana, and numerous other plants, and may be discovered by any one who will search diligently for it. The petal is, therefore, a modification of a leaf.

A stamen is less obviously like a leaf than any of the preceding parts. And yet if we examine it in the white Water-lily, its relation to a petal, and consequently to a leaf, is incontestable. In the white Water-lily, the innermost petals gradually narrow, and become callous at the point; their edges, also, like the point, become insensibly yellow and dilated; at last a cell full of pollen is formed upon their edges, and a stamen is the result; here it is impossible to distinguish any precise limit between the petal and the stamen, but one is clearly a modification of the other; the same may be said of the Carolina allspice. In double Roses, Pæonies, Tulips, Anemones, Ranunculuses, &c., all manner of transitions from stamens to petals may be detected; and in the Rose œillet of the gardens in particular, it is clear that the filament of a stamen answers to the claw, and the anther to the limb of a petal, consequently the filament is a modification of the petiole, and the anther of the blade of a leaf. The probability of this is further shown by the fact that the two lobes of an anther answer to the two sides of a leaf, and the connective to the midrib; and the fact is proved by accidental productions, such as occur now and then in Umbelliferous plants, where the stamens are replaced by small leaves on long stalks. In special cases of deformation, the stamens become genuine leaves, as in the Sieversia above referred to. The stamen, then, is a modification of a leaf.

That the *carpel* is of the same nature is very easily shown, not only by its constant tendency to revert to the form of a leaf, as is seen in double Roses, Anemones, Ranunculuses, and the like, but more particularly by the double Cherry, in whose flowers Nature has written her laws in a language so simple, and positive, that none but the willfully blind can misunderstand them. In this plant the centre of the flower is occupied by a small green leaf (*fig.* 77, *a*) stationed in the place of the carpel, and consisting of two sides folded together, along with a midrib which is longer than the leaf itself, and

slightly dilated at the summit. Upon comparing several of these leaves in different states, with the perfect carpel of a cherry (*fig.* 77, *c*), it is obvious that the two inflected sides of the leaf answer to the ovary, the midrib to the style, and the dilated summit of the midrib to the stigma; and if we compare the internal structure of the ovary with a section of the carpellary leaf of the cherry, it will also be obvious that the inside of the ovary answers to the upper surface of the leaf, the ventral suture to the line formed by the union of its two edges, and that the placenta is merely an expansion of a portion of the margin. In some instances two carpellary leaves occur in a flower of the double cherry, as at *fig.* 77, *b*; and then it is found that

Fig. 77.



they are placed directly opposite each other, the margins being nearly in contact; so also when by any accident the cherry has two real carpels, they also occupy the same position with respect to each other, the ventral sutures, and consequently the placentæ, being contiguous (*fig.* 77, *d*). That the carpel of a Cherry is a leaf, admits then of no further doubt, and consequently a Cherry fruit must also be a leaf, because the fruit is nothing whatever but the mature state of the carpel. Nor, indeed, are the changes that take place in the structure of the Cherry between its young and its full-grown state by any means incompatible with the anatomical structure of a common leaf. The stone of a cherry is the hardened lining of the fruit; it is also the upper stratum of the leaf, which consists, as has been already shown (p. 29), of little bladders placed in a different direction from those of the central and lower strata. The pulpy portion of the cherry will then arise from these latter, distended with fluid and altered in colour; the former phenomenon occurs habitually in the leaves of the House-leek, and of all leafy succulent plants, and the alteration in colour is analogous to what happens to the leaves of the purple Beech, the scarlet Maple, black-fruited Vines, Virginian creepers, and many other well-known plants, in the autumn, when they have reached their full maturity as leaves. That the carpel is a leaf is thus proved to demonstration; and as all compound fruits are collections of carpels, as has already been stated (p. 43), it follows that all fruits, of whatever kind, are modified leaves.

The last step in morphology is to show that ovules, and consequently seeds, are also alterations of leaves. As it appears from what has just been said that ovules grow upon the margins of a carpellary leaf, there will at first sight be a difficulty in reconciling such a function with the well-known fact that leaves do not in general bear anything analogous to ovules. But although it is not a general property of leaves to do this, yet it occurs in a sufficient number of cases to justify the conclusion that it may constantly occur in leaves whose ordinary functions are interfered with by their conversion into carpels. In a common Indian plant called Bryophyllum, the leaves are capable of forming young plants in the crenelling of their border; in the rare little Malaxis paludosa of our marshes, Henslow has shown that bulbs (*i. e.* buds, see p. 13), are constantly formed at the border of the leaves; Ferns often root at the segments of their leaves, in consequence of buds being formed there; so that the production of buds by leaves is not unknown. Now it is to buds, or bulbs, that ovules are to be compared; their integuments are to be considered rudimentary leaves, analogous to the scales of a leaf-bud, and they have actually been seen by Henslow, Engelmann, and others, to change into minute leaves in certain cases of malformation. It is no wonder, then, that bulbs, buds, and seeds (or ripened ovules), should all have a similar power of propagating plants, considering that they are all mere modifications of one common type.

It still remains to be proved that the scales of a leaf-bud, to which we have said that the integuments of an ovule are analogous, are themselves modified leaves. It is true that, if we compare the hard shining resinous scales of the Tacamahac poplar, or the brown woolly scales of the scarlet Horse-chestnut, with the leaves of those trees, we shall be at a loss to discover any resemblance between them; yet by watching them in their growth in the spring, when the leaves are first unfolding, we shall make out their identity in the clearest manner. Take, for instance, the scarlet Horse-chestnut, or the Sycamore. As soon as the buds are unloosened by the movement of the vital principle within them, the outer scales, which are dry and dead, are gradually forced asunder by others, which, although like them in form, still maintain their living powers; of these latter the most exterior lengthen a little, becoming green at their base, but remaining scale-like at their point; those next within them become greener, and have no hardness at the end, otherwise resembling them; the next that are formed produce a little leaf at their points, and themselves contract into a narrower compass, resembling a petiole; finally a greater degree of contraction at the base and of expansion at the point is produced, and a perfect leaf is the result. By this means we are able thus to trace in the clearest manner the identity in nature between the scales of leaf-buds and leaves themselves, and consequently to show that the former are a stunted form of the latter.

Thus by a process of reasoning, and of demonstration, in which no fallacy can be involved, and in which not a single flaw is to be pointed out, we are able to show that all the parts of a flower are modified leaves, analogous to modifications of another nature, which exist in the form of scales of a leaf-bud. Consequently a *flower is a collection of leaves placed in whorls, and therefore is a branch with a short axis.* This explains how it happens that one flower will grow out of another; how monstrous Pears are formed, in which tier upon tier of fruit rise, from a common stalk; for as the parts of a flower are leaves, they must have, like leaves, the power of forming buds in their axils; generally they do not form them, but if they do, the result may either be a common branch growing out of a flower, as in many Roses, or a new flower changing to fruit, as in malformations of the pear.

These principles being established, they are necessarily followed by certain results, which form the basis of the present theory of floral structure; and which may be considered to have conduced more to improve our knowledge of botany than any other circumstance that has occurred in its whole history. These results are:—

1. *That each series of floral envelopes must normally alternate with that which preceded it.*

2. *That the number of parts in every series must be equal to, or a multiple of, the number of parts in the first or outer series.* And

3. *That all exceptions are owing either to multiplication, abortion, or adhesion of parts.*

A few words only are necessary to demonstrate this.

That every series in a flower must necessarily alternate with that which precedes it, that is to say, that petals must alternate with sepals, stamens with petals, and carpels with stamens, as is well shown in the houseleek, is founded upon the necessary alternations of leaves when placed in whorls, as is explained at p. 22, to which the reader is referred.

That the number of parts in each series must be the multiple or equal of the number in the outer series, is a necessary consequence of the last rule.

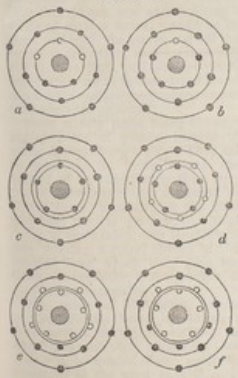
That it may, however, be interfered with by such causes as multiplication, abortion, or adhesion, may be easily conceived, and will be as easily understood by a few examples. First, as to *multiplication:* a Cherry (*fig.* 78, *a*) has a calyx composed of *five* sepals, a corolla of *five* petals, and *twenty* stamens; here four rows of stamens are considered to be present, all, however, blended into one whorl by the closeness of their origin. A Squill (*fig.* 78, *b*) has *three* sepals, *three* petals, and *six* stamens; that is, two rows of the latter, the first of which alternates with the petals, and the second with the first. This will be at once obvious if, in the above and succeeding diagrams, the outer circle is considered as calyx, the next as corolla, the following as stamens, and the centre of all as pistil; the black dots as indicating the position of organs, which are present in a perfect state, and the white dots those which are abortive.

Fig. 78.



Secondly, as to *abortion:* a Sage flower (Salvia) has a calyx of *five* sepals, a corolla, which, however irregular, is made up of *five* petals, and only *two* stamens (*fig.* 79, *a*); here three stamens are abortive; and upon looking attentively at the inside of the tube of the corolla, two little scales are often to be seen growing alternately with the petals, exactly in the place where the stamens themselves should normally have appeared; two of such scales are very often in other genera, otherwise constructed exactly like the Sage, developed as perfect stamens (*fig.* 79, *b*); and in some others even the fifth makes its appearance, exactly where it should normally be found. In the Primrose the stamens are equal in number to the petals, but opposite them (*fig.* 79, *c*); in this case the first row of stamens is abortive, and the second, which is the only one that developes, is in its true position; while in Samolus, a plant otherwise formed upon the same plan as the Primrose, five scales, which are degenerate stamens, appear in the situation of the first row (*fig.* 79, *d*). In the genus Bauhinia there are species in which, out of ten stamens five only are perfect, or even a smaller number (*fig.* 79, *e f*); the other parts remaining in a normal condition. In the carpels, deviation from the true number, in consequence of abortion or non-development, is so common as not to be worth reciting.

Fig. 79.



It is, however, after all, in adhesions more particularly that apparent deviations from normal structure take place. A papilionaceous flower consists of five petals (p. 38); the calyx should, therefore, consist of five sepals; but in the Lupine, and many others, only two sepals are discoverable. In reality there are five, although they are so combined that their true number is invisible; two uniting into an upper and three into a lower lip of the calyx (*fig.* 80); and in like manner petals adhere till their true number is lost sight of, as in the white Dead-nettle, the calyx of many Labiate plants, and a host of other things.

Fig. 80.



The reader may, however, be assured, that in all such cases the normal proportions are easily discoverable, and that the laws deduced from such morphological considerations as those which have been explained, are fixed and immutable.

In strictness it is in this division of our subject that we ought to treat of the structure of what are called the elementary organs of plants, to which we have already alluded under the name of bladders, air-vessels, &c. But as they may be considered the springs by whose united forces the functions of vegetation are exclusively regulated, and as it is through their agency that the powers of earth, air, and light are brought to bear upon the living system of a plant, and to produce all those curious phænomena of which we shall have to speak almost immediately under Physiology, we believe the plan of this treatise will be best preserved by deferring an explanation of the elementary organs till the appearance of the next part of our undertaking.

Part II.—Physiology.

Chapter I.

Of the Elementary Organs; Cellular Tissue; Woody Tissue; Vascular Tissue.

Although plants are furnished, as has now been seen, with many different organs, by means of which the various actions of their life are performed, yet it would be physically impossible for those organs to adapt themselves to the numerous atmospherical and other conditions to which they are exposed, and to feed, breathe, digest, or grow, deprived as they are of everything like the voluntary powers of animals, if it were not for certain small but highly organized parts, of which they, and all the organs of which they consist, are composed. These parts, the minuteness of which is such as to escape the observation except when aided by powerful microscopes, by adhering to one another in particular directions, now spreading into thin plates, now accumulating in solids of various forms, constitute the stem, and root, the leaves and all that to them appertain, and, consequently, the flowers, fruit, and seed of plants, which thus are to be considered masses of a highly curious mechanism, endued with the vital principle.

Such minute parts, being the organic elements of plants, receive the name of *elementary organs*. They may be described as being closed sacs, formed of an exceedingly thin transparent membrane, and assuming different forms, according to the duties they may have to perform, now thickening at their sides, now lengthening, now forming a spiral thread in their interior, from which they gain elasticity, extensibility, and a certain degree of impermeability.

The mode of illustration adopted in this treatise being by no means favourable to the representation of the appearance of such organs as these, they will be treated of very concisely; especially as the most general notion of their nature is sufficient to enable the botanist to understand their mode of action, provided his notion is accurate as far as it goes; all beyond general statements belongs to Vegetable Anatomy, of which we have no intention to treat in detail.

§ 1.—*Cellular Tissue.*

The most important and the most common of the elementary organs is CELLULAR, or, as the French better call it, VESICULAR TISSUE. When cut through, as in the path of the Elder, it appears something like fine honeycomb, the sides of whose cavities, although resembling a hexagon, are nevertheless exceedingly irregular. If a portion of it is put into water and looked at by transmitted light, it will be found nearly colourless and transparent; and if it be boiled for a short time in water, having a small quantity of potash dissolved in it, it may be easily rubbed between the fingers into exceedingly minute bladders. It was these bladders, or *vesicles*, the sides of which, when cut through, caused the honeycomb-like appearance that was first seen. In their natural state, they adhere firmly to each other; but boiling in a solution of potash destroys their adhesion and sets them free. The pulp of a Strawberry, in like manner, consists of cellular tissue; but instead of being empty, as in the Elder, each little bladder is filled with coloured fluid: in this instance the cells or bladders adhere so loosely that they may be separated by merely rubbing the pulp gently in water. In half-dry fruits, like the Jujube, the mealy matter in the inside of the dried pods of the Tamarind, or the Carob bean, the cells separate spontaneously. Cellular tissue is composed, then, of cellules or little bladders in a state of adhesion; and every partition in a mass of cellular tissue must be double, because it consists of the two united sides of two cellules in contact.

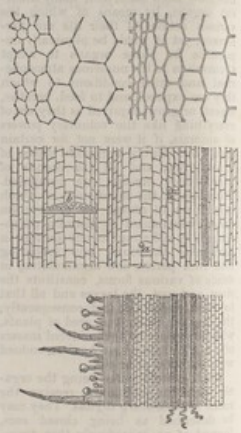
Cellular tissue is most commonly composed of an exceedingly fine transparent membrane; but this latter, in some cases, as on the outside of leaves, or in the bony parts of fruits, becomes so extremely thick, that its very cavity is closed up. In either case, it appears to the eye, even when aided by the most powerful magnifying glasses, to be perfectly homogeneous, without a trace of lines, or holes, or nettings, or of anything of the sort; but, as it has been shown by Lindley to tear with a ragged edge (*Introduction to Botany*, p. 2, t. 1, f. 6), there can be little doubt that its ultimate molecules are arranged in such an order, that they adhere more forcibly in one direction

than in another; and this is rendered the more probable by the tendency which this kind of tissue has to slit and tear in a definite manner when stretched, after being full-grown. An infinite variety of forms, in which this takes place, has been remarked by Purkinje, in the lining of anthers, and elsewhere.—(*See the same work*, p. 10, plate 2).

In size, the cellules of cellular tissue vary from the $\frac{1}{1000}$ to $\frac{1}{10}$ of an inch. In some Fungi they are so small, that it has been calculated that a sphere of the size of a large Gourd will contain forty-seven million millions; a number so large that it is difficult for the mind to comprehend it without something to compare it with: it will be more intelligible if it is remembered that if all the cellules of such a gourd are arranged side by side, and two hundred of them covered an inch, which is about their computed size, they would extend rather more than nine hundred miles.

The primitive form of a bladder of cellular tissue is supposed to be the dodecahedron, and it is thought that all other forms are produced by extension or compression. If, for instance, the two poles of such a solid were to be extended, a spindle-shaped bladder, or a prism, or even a cylinder, might be the result; if, on the contrary, its sides were pressed together, it might become a thin disc; and if both extension and compression act simultaneously, other forms might be the result. Thus we find, when the cells of plants are formed in a nearly unresisting, or in an equally resisting medium, they assume most nearly the form of some regular spheroid, as in the pith and the pulp of leaves and fruits. When they are generated in parts growing with great rapidity in some particular direction, as in the succulent stems of many herbaceous plants, the stalks of leaves, &c., they assume a prismatical or cylindrical form; and when they are jammed firmly between harder bodies, as in the medullary processes, they become thin plates. This is particularly conspicuous in the medullary processes, the cellular tissue of which is called *muriform*, because, consisting of regular thin parallelograms, it looks as if built up with bricks, as the wall of a house is (*fig.* 89). In some cases, as in the inside of leaves, the cellules look as if lobed, as is represented at page 29, *fig.* 34; this may in some measure arise from the unequal pressure of air upon them at the time of their development; but it is chiefly an optical deception, the lobes being nothing more than cells grown irregularly together.

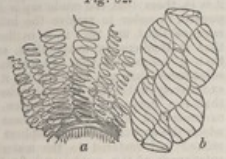
Fig. 81.



The kinds of cellular tissue which have now been described, however different from one another, are nevertheless very obviously slight modifications of one primitive type; besides these, there are others which are less easily reducible to it. These are *fibro-membranous* and *fibrous*, and what are called *dotted ducts*.

Fibro-membranous (or *reticulated*) *cellular tissue* (*fig.* 82, *b*) is common cellular tissue, with a spiral fibre generated in the inside of each cell or bladder. It has no elasticity, nor anything, as far as we know, to distinguish it, except this circumstance: its most usual situation is in the skin of seeds, in some of the winged kinds of which it is a most beautiful object, as in those of Eccremocarpus scaber; it constitutes the entire plant of the moss Sphagnum; forms the tubes called *elaters*, by means of which the spores of Jungermannias are dispersed; and is met with occasionally in the inside of the leaves of many plants. The particular use of this tissue is unknown.

Fig. 82.



Fibrous cellular tissue is more uncommon; it is formed by a fibre either twisted spirally, or arranged irregularly, *without any membrane*; by which circumstance it is immediately known from all other elementary organs. In the lining of the anther it is very common; and it also exists upon the surface of certain seeds, which, when moistened, become covered with mucilage, such as Wild Clary (Salvia Verbenaca) and Collomia linearis (*fig.* 82, *a*). If a seed of this latter be placed under a microscope in water, it will, in a few moments, project from its surface an immense multitude of little spiral threads, which expand in the water and surround the seed like a coating of the most delicate gauze. This appearance is produced by the liberation of the cells of fibrous tissue, which are set loose in consequence of the hard mucilage amongst which they lie being softened, and dart forward into the circumambient fluid, like so many little spiral springs liberated by the removal of a weight which confined them. Of this kind of tissue the use is undiscovered.

Dotted Ducts (*fig.* 83, *a*) are formed of series of short cylindrical cells, placed

Fig. 83.



end to end, so as to constitute slender columns, extending the whole length of many stems. These cylinders are more or less oblique at their extremities, and are always marked with rows of dots, which appear to be grains of green amylaceous matter; at first, the ends of the cylinders are imperforate, and, consequently, each column is composed of a vast number of closed cavities; but, after a time, the ends of the cylinders are torn open, and the cavities communicate freely with each other, so as to form a tube. At the places where the short cylinders join, oblique lines are seen externally, which are caused by the junction of the cylinders, and being usually more or less oblique, they give the dotted duct something the appearance of a modification of the spiral vessel: hence it has usually been referred to vascular tissue. It is, however, quite certain, from the inquiries of modern observers, that it is, in fact, such a modification of cellular tissue as we have described. Much uncertainty exists as to its real office; it appears, when first formed, to contain air; but after the rupture of the ends of the cylinders it certainly is filled with fluid at the time when the sap is most rapidly in motion; and afterwards it again becomes empty. It is exclusively found in the wood, of which it is one of the parts most early formed. When you look at a transverse section of a piece of Oak or Hazel, or Cane, the little holes which give those woods a porous appearance are the mouths of dotted ducts. They are unknown in Coniferous trees, are unfrequent in herbaceous stems, but may be found with great facility in thin slices of the wood of beech or oak.

Cellular tissue, of the common kind, bears the same relation to the vegetable as flesh to the animal frame. It is the basis of every part of which a plant consists; and very often, as in Mosses and the lower tribes of vegetation, it is the only kind of tissue that is formed. In trees, and other woody plants, it constitutes exclusively the pith, the parenchyma of the leaves, the sepals, petals, stamens and carpels, the cuticle, the stigma, and the ovules; in Exogens it forms the medullary processes, and the principal part of the bark; in Endogens it constitutes the whole of the spongy substance in the interior of their stems. It is absent only from the plates of pure woody matter of the stem, and from the veins of leaves, &c., which, in reality, are

an emanation of the woody system. (*See* page 21.)

Cellular tissue is supposed to be capable of performing, by itself, all the more important of the vital actions of vegetation; because there are many plants which live, grow, and propagate themselves, without possessing any other kind of tissue. When combined with other forms it has, however, certain objects in particular, for which it is destined. One of its greatest functions is *to absorb* moisture or gaseous matter, and to part with it again, acting as a sort of living filter. If you place a slice of Elder-pith upon a glass, and allow it to communicate by ever so small a space with water, the whole mass will be speedily saturated; and, on the other hand, it will as speedily part with its water if exposed to a dry atmosphere; not always, however; for in some cases, such as succulent plants, it parts with water very slowly; it, however, does lose it by evaporation through its membranous sides. The latter, then, are eminently hygrometrical, and as they permit mere water to pass through them readily, we must suppose them to be pierced with holes, although the latter are so fine, that the most powerful microscopes that have yet been invented have failed to detect them *.

Having the power of absorption in this high degree, cellular tissue will consequently be well adapted for *transmitting* the fluids of plants from place to place; and accordingly we find it evidently performing this office wherever a very rapid transmission is not required. Being in many cases composed of sacs of a spheroidal shape, it can allow fluids to pass indifferently, in whatever direction a higher-propelling force may exert itself; or when the sacs have an elongated figure, it will then serve to conduct the juices in the direction of the greatest diameter of the sacs. Thus, in pith, there is no particular direction in which the sap is conducted, but it is conveyed by the spheroidal sacs of that part to whatever portion of the contiguous tissue it is required to feed; in the medullary processes, on the contrary, in which the cells are flat parallelograms, with their principal axes directed from the bark to the pith, it is in that direction only that the mural cellular tissue is destined to convey the secretions.

Further, the sacs of cellular tissue being the sole recipients of the sap of plants, properly so called, are the parts in which all the elaboration of the fluid matter of vegetation takes place; it is in them that the crude sap is deposited, in order to receive the influence of light and air; it is in them that it thickens by evaporation, and that it assimilates the various fluid substances that are mixed in it; it is exclusively in the sacs of cellular tissue that the perpetual decomposition of carbonic acid is going on, by means of which the carbon of the atmosphere is refixed and restored to the material substances of the earth; and, finally, it is by the same power of transmission, of which we have already spoken, that the juices, altered and elaborated till they have acquired the properties peculiar to each species, are conveyed from the vegetable stomachs, as leaves may be called, to the bark, stem, and root.

Cellular tissue is moreover the grand agent, by means of which many of what may be termed the mechanical forces of plants are exerted. If, for instance, there are two parts to be torn asunder by contraction, as in the valves of the anther, it is by the shrinking of cellular tissue that it is effected; or if one part is to be burst by the swelling of another, as the Spirting Cucumber, it is to the same kind of tissue that this office is entrusted by nature. In fine, it is the most delicate, the most coarse, the most universal, the most pliable, and the most energetic of all the elementary organs of vegetation.

§ 2.—*Woody Tissue.*

This, which is also called *woody fibre*, consists of thick-sided transparent tubes, terminated at each end in a conical manner, and applied to one another in considerable numbers, so as to form bundles of great strength and elasticity. It is by some considered a mere form of cellular tissue; but it differs most essentially from that in three important circumstances—firstly, in its toughness; secondly, in its very great length; and thirdly, in its tapering extremities. Cellular tissue, when much elongated, usually forms truncated cylinders, as in Cotton, which is a good illustration of it in a lengthened state; when thick-sided it is rarely

* The old opinions concerning the presence of visible pores in the sides of cellular tissue were errors.

tough and elastic; and the longest specimens of tubular cellular tissue are shorter than the shortest specimens of woody fibre. The latter is little subject to variation, except in calibre, in which respect it is found between $\frac{1}{360}$ and $\frac{1}{150}$ of an inch: how slender its tubes usually are may be understood from this, that in hemp, which is a preparation of the woody tissue of the Hemp-plant, it is six times finer than a human hair; each of the filaments into which this substance is mechanically divided before being twisted into thread, consisting of a considerable number of tubes of woody tissue.

It is in Coniferous plants chiefly that the most important of its modifications occurs. In these plants, the sides of the tubes, which are of considerable diameter for this kind of tissue, are marked with large oval glands, which are placed either in single or in double rows, and which appear as if they had a hole or a pimple in their centre (*fig.* 84, *a*). Dr. Mohl, of Munich, has lately

Fig. 84.



endeavoured to show that these glands are shallow depressions or openings from one tube to another, as is represented at *fig.* 84, *c*—the central pimple being in reality a pore; and he represents the appearance of sections of such parts in considerable detail; but as no one has in this country been yet able to detect what this botanist represents, even when assisted by the finest instruments, we must be permitted to doubt whether he has not been misled by imperfect observations; especially as there is no such thing, in fact, as visible pores in any kind of tissue, as far as has yet been detected. What makes *glandular woody-fibre* more remarkable than it otherwise would be, is its exclusive occurrence in Coniferous plants, and genera related to them; on which account it has been found of considerable importance in determining the real nature of many mineralized trunks found imbedded in the early strata of the earth. The reader, who would like to obtain a clear view of it, has nothing more to do than to take a thin shaving of a piece of Pine-wood, such as a carpenter's plane will produce, and to place it in water, beneath a microscope that will magnify about fifty diameters. The great use of woody-fibre is to give strength to every part, and to protect certain of the more delicate organs: it may be considered at once the bones and sinews of vegetation. If it were not for it, the stem of a Willow would be as brittle as that of a Mushroom; but lying as it does across the cellular tissue, it binds it together, and renders all the parts tough by means of its own elasticity and strength. It occurs in the wood, of whose plates or bundles it constitutes the principal part; in the bark, in smaller quantity; in the stalks and veins of leaves, and in the husk of fruits. In the latter positions it forms a sheath to the vascular tissue (*fig.* 86, *c*), rendering the latter at once flexible and protected from injury. It appears highly probable, that in addition to these properties, woody fibre has the office of conveying fluids in certain directions; as, for example, up the stem from the roots, along the veins from the stem, and down the bark from the leaves. It is true that, from the impossibility of actually observing the march of fluids in parts so minute and easily injured as vegetable tissue, no one has been able to demonstrate this; yet one can hardly doubt that such is really its function, when we consider how rapidly the sap flows up the stem of a tree, which consists chiefly of woody fibre; and that, when coloured infusions are compelled to enter the system of a plant, they are uniformly found to pass to the very extremity of the veins, whither it would seem impossible that they should be conveyed, except by means of woody fibre.

§ 3.—*Vascular Tissue.*

Under this head is comprehended every form of tissue which does not belong to the cellular and the woody. The type of it may be considered the *spiral vessel*, from which the other forms probably are deviations produced by accidental circumstances.

A spiral vessel (*fig.* 85, *a*) is a cylinder, tapering to a cone at each end, composed of exceedingly thin membrane, in

the inside of which one or more fibres are rolled in a spiral manner, so closely

Fig. 85.



that the spires all touch each other. When at rest, it resembles a wire spring, and, like that contrivance, is so elastic, that it will contract, when extended by stretching the two ends.

The toughness of the fibre, of which a spiral vessel is formed, is quite extraordinary, when compared with its excessive fineness. If you pull the stalk of a Strawberry leaf asunder, gently, or the young shoot of a Dogwood, the spiral vessels will be unrolled in great numbers, resembling the threads of a spider's web; by stretching them gradually they may be broken, one after the other, till at last only two or three fibres remain; and they will be found tough enough to bear the weight of a considerable piece of the stem or leaf to which they belong.

Spiral vessels are generally seen by learners in an unrolled state, which is the most easy to obtain, but the worst calculated to give a correct idea of their real nature; for what notion can be formed of the original position of their parts by viewing a parcel of entangled silver threads, glittering in the light, as a mere object of curiosity? One of the best modes of seeing them is to take a piece of Asparagus, in the boiled state in which it is brought to table, and to tear it in pieces in water. By means of a little careful tearing and cleaning, you may extract from the pulp, which is cellular tissue, a quantity of fibrous bundles, which are in part woody fibre, and in part spiral vessels; the elasticity and disposition to unrol, in the latter, being destroyed by the boiling, they may be easily separated in an entire state, when their terminations and the true position of their internal fibre will be distinctly perceived.

Spiral vessels are confined to the veins of leaves, and of those parts which are modifications of leaves, such as sepals, petals, stamens, carpels, and fruit; and to certain places in the stem. In the stems of Exogens, they form the medullary sheath (see page 16 and fig. 13 *e*), from which they diverge into the leaves, &c. In Endogens they form the central part of every bundle of woody matter, and from these bundles pass into the veins of the leaves, which are mere external elongations of the bundles. They are absent from the bark of all plants (except Nepenthes), and are only found in the root of Endogens. In plants which never bear flowers, they are altogether wanting, except in the form of ducts; the nature of which will be explained presently.

If a stem is cut across under water, air-bubbles form immediately at the mouths of the spiral vessels. If a thin longitudinal slice of live vegetable matter is viewed under similar circumstances, its spiral vessels will be seen dark and distended with air; submitted to the action of the air-pump, proofs are furnished of a similar nature; hence spiral vessels are considered respiratory organs, and the French call them *tracheæ*. Bischoff has analyzed the air they contain, and found it contain 6 or 7 per cent. more of oxygen than atmospheric air. From what source the additional oxygen is obtained is as yet unknown; but it may be conjectured to be produced by the decomposition of carbonic acid in the tissue that lies in the vicinity of the vessels. There are those, indeed, who insist upon the spiral vessels being intended for the conveyance of fluid. But with reference to this opinion, it is sufficient to remark, 1st, that these writers evidently confound ducts and dotted vessels with the spiral, which is a most important error; 2nd, that even if fluids are occasionally found in old spiral vessels, that may only show that they admit water through their sides, when their aëriferous functions are over; 3rd, that the close coils of fibre which line their inside, seem well contrived for hindering the escape of air, and the introduction of water; and, 4th, that there appears to be no provision for the conveyance of air through the central

parts of plants, if that office is not performed by the spiral vessels.

Ducts are organs having a great resemblance to spiral vessels, and are probably a mere modification of them; they are chiefly distinguished by their want of elasticity, and of the power of unrolling. Like the spiral vessels they consist of a very thin cylinder, terminating in conical extremities, and having a fibre twisted, spirally in its inside; but the spires of the fibre are brittle, so that they snap when stretched, instead of unrolling. In the *closed duct* (*fig.* 86, *a*), the fibre is placed exactly as in the spiral vessel; in the *annular* (*fig.* 86, *b*), the spires seem broken into rings, which join at their extremities, and give the organ the appearance of a tube partially filled with rings lying irregularly in the inside; and in the *reticulated* (*fig.* 90 *d*), the spires of fibre touch, and grow together in so irregular a manner as to form a sort of netted bag, with very unequal meshes.

Fig. 86.



The closed duct is found principally in Acrogens, in which it represents the spiral vessel; the others are little known, except in the herbaceous stems of plants which grow with considerable rapidity. They occasionally occur in wood, especially of the Coniferous kind. One of the best plants to examine for the annular and reticulated duct, is the Garden Balsam, or the Touch-me-not (Impatiens), in whose stems they are abundant.

Their office seems to be to convey fluid at one period of their existence, whatever it may originally have been; for they are certainly filled with sap in such plants as those to which we have just referred. Considering their relation in structure to spiral vessels, one cannot avoid suspecting that to convey air was their original destination; but if so, this must have ceased soon after their first creation; for the thinness of their sides, and the very imperfect manner in which they are guarded internally by fibrous spires, are such that no resistance would be offered by them to the infiltration of fluid from the tissue that surrounds them.

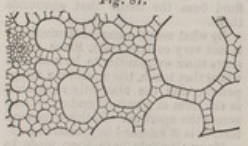
By what means vessels communicate is not very certain. Mr. Slack represents their extremities to be absorbed where they touch, the membrane disappearing, and the fibre only remaining in the form of a sort of grating placed across the aperture. Is this a general fact, or is it confined to special cases?

Many attempts have been made to determine the true functions of these and the other kinds of tissue by causing coloured infusions to ascend them; but the artificial and unnatural circumstances under which such experiments have been performed, the great difficulty of telling whether such minute organs are really coloured by matter that has introduced itself into their cavity, or are only apparently so in consequence of the colouring matter shining through their transparent sides, and more especially the impossibility of ascertaining that fluids do not rise through the *intercellular passages*, have rendered all such attempts so unsatisfactory that they are not worth describing here.

Intercellular passages are the spaces necessarily left between the sides of the vesicles or tubes of tissue when placed in contact. If those vesicles or tubes were regular polygons or prisms, they might be so fitted together that no spaces would be left between them; but being always irregular, and usually spheroids or true cylinders, they are, in fact, analogous to a heap of bladders, or bundles of straws packed together, between the component parts of which considerable spaces must necessarily be left. It is these which, under the name of intercellular passages, are supposed to assist materially in conveying the fluids of plants from one part to another. They are, therefore, not special organs, but only passages between other organs. Of the same nature are what are called *turpentine vessels, receptacles of oil, and air-cells.* The two first are mere cysts; the former fistular, the latter spheroidal, formed in tissue, into which the secretions of a plant are drained; the short irregular tubes in which turpentine lies in the bark of a Fir tree are an ex-

ample of the former: the numerous cavities containing essential oil, in the rind of an orange, of the latter. Air-cells (*fig.* 87) are cavities formed in the

Fig. 87.



leaf or stem, for the purpose of enabling a plant to float in water. They are built up with a degree of regularity which is most admirable: having their sides composed of cellular tissue in different forms, now round, now lengthened, now angular, according to the situation it occupies in the sides or angles of the cavity, and evidently contrived with the most careful foresight: those parts having forms adapted to stretching where any strain is likely to occur, and those being solid and unextensible where there is merely weight to sustain. Than these air-cells there is not one of all the works of the creation more richly deserving the attention of the philosopher, who seeks for illustrations of the design and skill of the divine Artificer of Nature. The leaf-stalk or stem of a floating Crowfoot, or the Duck-weed, obscure and insignificant weeds as they seem, exhibit an elaborate perfection of workmanship, employed merely to render such objects buoyant in water, infinitely beyond the most exquisite architecture of the most gorgeous temple in the universe.

Different as are the various forms of tissue which have been now described, it is the opinion of some distinguished vegetable anatomists that they are all mere modifications of the vesicle or cellule; this is, in particular, the view lately taken of the subject by Mirbel. This distinguished botanist, in a most curious paper on Marchantia, to which allusion has been made on more than one occasion, asserts that he has seen common rounded cells of cellular tissue develope into long slender tubes, tapering into each end; that those, which originally have "membranous, thin, even, transparent, entirely colourless sides, gradually thicken, lose their transparency, and become marked all round, from end to end, with two parallel streaks, which are very close together, and traced in a spiral direction. Afterwards they enlarge, the streaks become slits, which cut the sides of each tube, from one end to the other, into two threads, whose circumvolutions separate, after the manner of the thread of a gun-worm." He also makes some observations upon changes of another kind, by means of which cellular tissue becomes converted into annular ducts.

It must be obvious, however, that observations of this kind, however carefully made and faithfully recorded, are so liable to error, in some of the details, that they require to be repeated by several independent observers before they can be received as positive facts. Even as the case now stands, a different interpretation might be put upon the appearances described by Mirbel himself, admitting them to be described correctly; and as at all events, for all practical purposes, it is indispensable that we should distinguish correctly the three principal kinds of elementary organs which have been here described, it is not desirable to dwell longer upon this part of the subject.

We shall, therefore, conclude the explanation of the structure and functions of tissue with representations of the relative position of the elementary organs in those cases in which their action is the most likely to come frequently under our consideration hereafter. In all the three following figures, *c* signifies cellular tissue, *dd* dotted ducts, *f* woody fibre, *s* spiral vessels, and *d* vascular ducts.

Fig. 88 is a plan of their position in the stalk of a leaf, showing in what

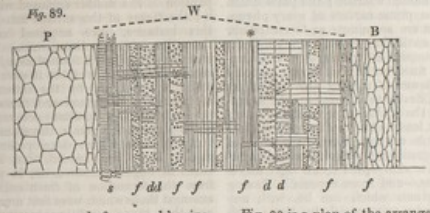
Fig. 88.



order they are respectively placed when the systems of the wood and bark become blended together.

Fig. 89 is a plan of the arrangement

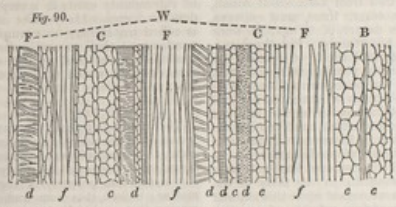
Fig. 89.



one year ceases and of a second begins, and the tissue lying in a horizontal direction across the wood being the muriform cells of the medullary processes.

Fig. 90 is a plan of the arrangement of the tissue in the stem of an Exogen: these details are taken from Von Martius' splendid work upon Palms; B is the cortical integument which answers

Fig. 90.



to the bark of an Exogen; W is the woody centre, consisting of bundles of fibro-vascular tissue marked F, and cellular substance marked C, analogous to the pith and medullary processes of an Exogen.

Chapter II.

General Considerations concerning the Nature of Plants, and the Means they have of performing their vital Actions.

Now that the reader is acquainted with the general nature of all the organs of plants, and that he understands the structure of those minute elementary parts by the united forces of which they are enabled to perform their functions, we may proceed to sketch out the latter in their principal outlines, here and there putting in the shadows, as a painter would say, for the sake of bringing certain objects more distinctly into view, but in all cases avoiding the minuter details; for which the inquirer is referred to works of a more extensive nature than the present.

In this department of the science, the difficulties which the philosopher has to overcome are of a very different character from those which may have embarrassed him in merely determining the organization of a plant. In the latter case good microscopes, manual dexterity in preparing the parts for examination, and sufficient patience for his task, are sure to bring the observer to conclusions, the general truth of which is often susceptible of exact demonstration; but when we come to consider the causes of vital phenomena, and the manner in which

they are brought about, we have obstacles of quite another kind to overcome. There is not a function of vegetable life which is not performed, as it were, behind a screen; the parts which are the prime movers of every phenomenon are so minute as to escape our view until they have been killed for the purpose of microscopic examination; fixed to the soil, having scarcely any power of moving any one of its limbs, destitute of passions, or sensations, the visible expressions of which might lead us to the discovery of their invisible causes,—having the whole of its organic mechanism concealed beneath a skin which seems inert and is opaque,—and more especially having no actions which can be, with any exactness, compared to those with which we are necessarily acquainted from their taking place in our own bodies,—we are compelled to trust for all our notions of Vegetable Physiology to induction from data, about which, in many cases, there must always, from the nature of things, be some kind of uncertainty. For these reasons, a great diversity of opinion has existed among physiologists concerning many of the phenomena of vegetable life; multitudes of erroneous theories have obtained belief almost without question; and when an old notion has been shown to be erroneous, the world has willingly adopted another in its place, which, perhaps, has not been less unfounded. In the midst of the confusion attendant upon this state of things, a certain number of seeming truths have been elicited, about which there is daily less dispute; and by taking them as guides, or as tests of the truth of other opinions, the whole subject is assuming a state which becomes daily more satisfactory. What will be principally adverted to in the following pages are the best-known facts and most generally received opinions of the present day. Before, however, we proceed to a systematic consideration of the subject, it will be useful to dwell for a moment upon some of the general properties of vegetable matter, independently of the special attributes of the organs of plants.

§ 1.—*Extensibility.*

One of the most obvious circumstances connected with the growth of plants is the power which the tissue possesses of stretching,—or, in a word, its extensibility. We see a branch increase from a line to half an inch in diameter in the course of a year, and its surface still extending with the expansion of the matter enclosed within it; the tissue of the surface must, in this instance, have acquired many times its original dimensions. The leaf of a Lime-tree is formed as a little scale; in a fortnight after it once unfolds, it will grow, by the extension of its tissue, to a thousand times its original size; a similar occurrence takes place in the petals, the stamens, and all parts where development is rapid. It is true, indeed, that such cases of augmentation arise, in part, from the formation of fresh cellules amongst those which were first created, and that, consequently, an increase in bulk is not owing to extensibility alone; and this is to a great extent the case with bark. Still there can be no reason to doubt that the power of extensibility exists in a very considerable degree. Many cases of what is called irritability, for example, depend, as we shall presently see, upon tissue being stretched up to a certain point beyond which it cannot give way.

§ 2.—*Elasticity.*

The bending of wood, the waving of branches in the air, the springiness of cork, the flexibility of the cane, are abundant evidences of elasticity being also a common property of vegetable matter: indeed, it is from timber possessing this quality that it is so valuable to man.

§ 3.—*Contraction.*

A power of contraction is inseparable from elasticity, which, in fact, depends upon the capability of parts when stretched of resuming their original size with rapidity when the straining power is taken off. Independently, however, of this, it exists in many instances where it could not be suspected by the casual observer. Many cases of what is called irritability are more immediately owing to contraction; as in the stamens of Pellitory (Parietaria officinalis). In that plant the filaments, before the flower expands, are curved inwards and downwards, so that the anthers are inverted at the bottom of the calyx; the face of the filament consists of a lax and soft tissue, which is easily extensible; their back is composed of a more compact and more rigid tissue; the latter is strained to the utmost in consequence of its forming the convexity of the curve, while the stamens are growing, till the segments of the calyx which keep the stamens down are unloosened: the moment this occurs, and the pressure is taken off, the tissue at the back of the filaments suddenly contracts, and the latter are bent outwards with violence; the anthers opening and scattering their pollen at the same time. Even this latter phenomenon is supposed to be caused by the contraction of the cells that form the case of the anther, which, simultaneously shrinking, exercise upon each other a strain which renders it necessary that something should give way; and as the tissue adheres more feebly at the suture of the anther than at any other part, it is there that the sides of the anther separate, and form an opening for the escape of the pollen. Other instances not less striking of the general power of contraction in tissue deserve to be mentioned. If you divide a stem of any common Spurge (Euphorbia), you will find the milky fluid in which that plant abounds run out of both wounds in whatever direction the pieces may be placed; here it is plain that the tissue is turgid with fluid, which keeps its sides in a state of extension; cutting through the tissue takes off the pressure upon its sides, which accordingly contract and squeeze out the fluid within them. With reference to this phenomenon, De Candolle justly observes, that if the fluid was emitted in consequence of an impulse from below upwards, or from above downwards, it would only run out at one of the two wounded ends; and that if it was discharged merely by virtue of its gravity, it would only flow out when the mouths of the wounded tissue were turned downwards; neither of which cases occurs. In fact, a curious experiment of Van Marum and Humboldt has shown, by something like a demonstration, that it must be contractibility that causes this phenomenon; it is known that animals killed by electricity lose their powers of contraction, and those observers found that Euphorbias, destroyed by that agent, equally lost the power of discharging their milk.

§ 4.—*Hygrometrical Properties.*

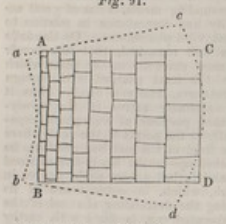
The hygrometrical properties of living vegetable matter,—that is to say, the power of abstracting moisture from surrounding media, is one of great activity and importance in relation to most vital phenomena. De Candolle has well remarked, that this power is most energetic in the parts which are the least charged with foreign substances, and *vice versâ*. Thus it is extremely active in the newly-formed portions of any plant, especially at the points of the root, where the fluid of the soil has chiefly to be sucked up—in the newly-formed wood—and in but a very slight degree in bark, which, in consequence of its being the descending channel of the elaborated sap, is filled with earthy and other matters. Owing, no doubt, to particular organic differences, the hygrometrical powers of particular parts act in very different ways; most capsules burst, and the beards of the Geranium or the Oat curl up, in dry weather; but those of Epilobium and the Fig Marigold (Mesembryanthemum), and most other plants, contract in dry weather, opening only in wet. The latter forms a beautiful object in some of the larger species, which are occasionally brought from the Cape of Good Hope as curiosities. When dry and closed, they resemble an almost-shapeless lump of wood; but placed in warm water they gradually unfold at the point, and by degrees assume the appearance of a star, which, when they are fully expanded, assumes the most perfect symmetry and regularity.

The Rose of Jericho, and the curious Lycopodium of Peru, are other instances of parts unfolding by the application of moisture. These plants are dried up by the burning sun and parching air to which they are periodically exposed, often are detached from the spot on which their slender roots had fixed them, curl up by the contraction of their branches into a round ball, which is blown about by the wind, and becomes the sport of storms. But the moment they are exposed to moisture, their hygrometrical properties cause them to unfold; they suddenly revive, and fix themselves by their own weight to the spot where they receive the influence of moisture.

The cause of the different effects of

moisture upon different plants, in regard to their contracting or expanding, may, perhaps, be understood by reference to the following figure.

Fig. 91.



Let the figure A B C D represent a section of the tissue of any vegetable body. Let the line A B represent the outside, and C D the inside of, we will suppose, the sides of a capsule, which only opens in wet weather, or upon the application of moisture. The cells next the inside C D being larger and thinner sided than those next the outside A B, will absorb moisture with the greatest rapidity and force, and becoming gradually distended will lengthen by degrees; but this will be resisted by the small, thick-sided, and consequently less permeable cells at A B, and the result will be, that as the cells C D lengthen, they will be pulled towards *c d*, while A B will at the same time be forced in the direction *a b* by the general distention of the tissue from C to A, and from D to B; and thus the opening of the capsule will be effected. Reverse the structure, and an opposite effect will be the result; and thus we may understand how it is owing to differences of an organic nature that some parts will unfold and others contract upon the application of moisture externally.

§ 5.—*Endosmose.*

The explanation just offered is that by which Dutrochet accounts for certain cases of what has been incorrectly called irritability. He ascertained by some ingenious experiments, that if liquids of unequal density are separated by animal or vegetable membrane, the thinner fluid will pass through the membrane towards the denser. This may be easily shown by a very simple contrivance: take a common half-ounce phial, the bottom of which has been ground off, and tie a piece of bladder tightly over the opening thus effected. Fill it with mucilage, such as thin gum arabic and water, and half immerse it in water. The denser fluid in the phial will slowly attract the water through the membrane, and the contents of the phial will run over. Reverse the experiment by filling such a phial with water, and plunge the lower end into milk, or sugar and water, or mucilage, and the water will pass out of the phial through the bladder, as will be shown by the water in the phial sinking. This phenomenon, Dutrochet called *Endosmose*.

The whole surface of a plant may be considered as a series of bladders, in a state of endosmose—that is to say, as containing fluid of a more dense nature than the aqueous particles that surround them in the atmosphere or in the soil. A plant is, therefore, a sort of endosmometric apparatus, which is incessantly in action, so long as it retains the vital principle, and the force of which is regulated by temperature. This peculiar absorbing power is by no means confined to the surface of a plant; on the contrary, it exists between the internal bladders of cellular tissue and the other elementary organs, wherever there is a difference in the density of the fluid in contiguous cavities; and Dutrochet conceives, with great appearance of truth, that the circulation, as it is called, of the sap, and the distention of one part more than others—or, in other words, the power which some parts have of attracting sap to themselves from the neighbouring tissue, depends essentially upon the phenomenon of endosmose. An instance or two of this will suffice for the present, as we shall return to the subject hereafter. When buds unfold, and grow in the spring, the cells part with some of their water by evaporation; the fluid that remains becomes denser than in those cells which, being more internal, are unable to perspire, and the action of endosmose, which is immediately established, fills the external cells at the expense of the internal ones, which, in their turn, abstract fluid from those which are still more interior. Again, a carpel is fertilized, and is to become a Plum; its cells gradually form in their interior

a fluid of a denser nature than the sap which is near them, and attract it by virtue of endosmose. The circulating system of the plant keeps perpetually supplying the loss thus occasioned, and the plum is thus enabled to become the succulent body which we see. Perhaps the most direct illustration of the effects of endosmose in vegetation may be obtained from the Balsam, a common plant, which any one may procure for experiment. Dutrochet gives an interesting account of his observations upon it, of which the following is a short abstract:—It is well known that the valves of the capsule of the Balsam, when ripe, separate from each other, and that each rolls up spirally, *inwards*—that is to say, that their convexity is outward, or on the side of the cuticle. If you straighten them, they regain their curved state spontaneously and smartly, when they are left to themselves. If they are thrown into water, they curve with greater force than ever; but if they are allowed to become half dry, they fall into a flaccid state, and lose their elasticity, which is however restored by placing them again in water. This shows that the presence of water in the tissue of the valves is at least one of the causes of their rolling up. Upon examining the tissue of a valve, it will be found composed of little bladders, the largest of which are next the cuticle, and the smallest next the inside, gradually diminishing in size from without inwards (or being as represented at *fig.* 91, taking C D for the outside). Considering what the effects of endosmose are in other cases, it may be conceived that the violent incurvation of the valves of the Balsam may be owing to this phenomenon acting principally upon the external vesicles, distending them with fluid attracted from the rising sap, and giving them, when thus distended, a curve outwards, in consequence of the resistance of the base and apex of the capsule; and that, whenever the valves become so turgid as to burst from the extremities of the capsule, which keep them in their place, they will immediately lengthen and curve inwards. To ascertain how far this may be true, take a little syrup and water, which shall be denser than the fluid in the cells of the Balsam-valves; place the latter in it, and they will first straighten, then curve backwards, and at last roll up in the opposite direction from that which is natural to them. This arises from the syrup abstracting the thinner fluid from the bladders of the tissue of the valve, when the valve rolls backward, because the bladders next the outside, being the largest, lose the greatest proportion of their contents, and moreover have the smallest quantity of solid matter within them; in consequence of which they not only return to their original size, but actually contract, and the valve rolls backwards. If these same valves are again placed in water, they attract it by the renewed action of endosmose, first straighten again, and finally curl inwards, resuming their natural state. Dutrochet says he repeated this nine times in five hours, after which they ceased to curve inwards when plunged in water; which he ascribes to their having, by such frequent exposure to the action of the syrup, been gradually robbed of their dense contents. But when placed in syrup, they still continued to roll backwards with an increased energy, because the fluid they still contained had gradually become less dense by the repeated dilutions with water which it had experienced. If a thin slice of the valve of a Balsam be placed under a microscope, the whole of this mechanism may be distinctly beheld. The cells will be seen to diminish rapidly in diameter, especially the larger ones, in consequence of their being emptied, and the valve will gradually reverse the direction of its curve.

Endosmose must be considered, then, as a phenomenon, to the effects of which the greatest importance is to be attached. This will be shown more completely hereafter.

§ 6. *Irritability.*

The various powers of which an explanation has thus been given, however important they may be, do not of themselves account for any one of the phenomena of vegetation. All of them may and, indeed, do, exist in dead matter; the living principle is still wanting to set them in action, to regulate their reciprocal efforts, and to modify them according to the special constitution of different plants.

It would be a waste of time to speculate upon what this living principle may be; and we should have no ambition to invade the province of the psychologist, unless we thought ourselves

likely to discover something more than the subtleties of metaphysicians have yet elucidated. It is sufficient for the world to know—what, indeed, is all that it can know—that the principle of life is a something which is dispersed through all organic matter, and which not only sets the organic elements in action, but preserves them from entering into that state which quickly leads to their return to inorganic substances.

It is under the names of *irritability*, *excitability*, and *sensibility*, that the more immediate effects of the vital principle have been discussed by physiologists. For all practical purposes these may be considered as the same; for even sensibility, by which is meant something analogous to sensation in animals, is not, in vegetable physiology, distinguishable from the two others.

There are those, indeed, who have endeavoured to show that sensation, properly so called, exists in plants; and they have founded their opinions upon certain curious phenomena. The singular power of motion, when touched, for which the Sensitive-plant is so celebrated, has been supposed to be an extreme instance of this; and Dutrochet has even attempted to show that the nervous particles, in which sensation specially resides, are visible to the eye. Great numbers of little green balls of amylaceous or resinous matter are discoverable by the microscope sticking to the tissue of most plants. In the Sensitive, at a little swelling at the base of the leaf-stalk, in which the greatest degree of motion resides, they are particularly abundant; and what is extremely curious, these balls, or granules, are found to be affected by certain chemical agents in the same way as the nervous particles, or what are so considered, of certain molluscs. Boiled for a short time in nitric acid, they become opaque, and regain their transparency upon being plunged in a solution of caustic potash;—but the same granules exist in an equal degree in plants which have nothing approaching to sensation; so that their function cannot be admitted to have anything to do with it. Secondly, poisons have been found by Macaire and Marcet of Geneva to act in the same way upon plants as upon animals; corrosive poisons stiffening the organs as if they produced a sort of vegetable inflammation; narcotic poisons relaxing the whole system, and causing something that has been considered analogous to stupefaction. Hence it has been concluded, that there must be something analogous to *the scattered elements of a nervous system* in plants. Brachet, a French physiologist, has even gone further, and has very recently endeavoured to prove that the pith is the seat of the nervous system in plants, and that the medullary rays are nervous branches. The statements of this writer do not deserve serious refutation; and with regard to the effects of poisons, I do not know that it is necessary to go so far as to admit the presence of a nervous system, in order to account for their effects, especially where there is so much reason to object to the opinion. Upon this subject we cannot do better than quote the words of De Candolle, the celebrated Professor at Geneva:—"The nervous system, which is very evident and distinct from all others in animals of the upper classes, gradually tends to divide; and finally one is forced to admit, that in zoophytes the nervous matter is diffused, as it were, throughout the whole body; so that the latter possess a kind of universal sensibility, without there being any where a nervous system distinct from the tissue. Hence, say they, we arrive at the vegetable kingdom, where the nervous system is incorporated with the whole tissue; but if this conclusion is to have any probability, it must be shown that the plants which have the greatest resemblance to zoophytes in structure are also those in which the symptoms of sensation are the most evident; which is not the case. All the plants in which it has been thought that it might be perceived, are at the other end of the scale of organization; and consequently the analogy deduced from the animal kingdom does not lead, with anything like force, to the admission of sensation in the vegetable kingdom. Let it also be remarked, that all the most constant and most common phenomena of vegetable life seem to be intimately connected with, and even are necessary consequences of, the absence of spontaneous motion. But spontaneous motion, wherever it exists, is evidently the result of sensation; whence one has a right to conclude, that where the former is wanting, the latter is wanting also."

It is to irritability that we are disposed to refer all the powers which the

organs of plants possess of performing their functions. We know that, in the absence of all stimulants, they are incapable of action. Under this name we would include, in particular, light, heat, and moisture; for all these being abstracted, plants are incapable of maintaining their existence. It is not often, however, that the effects of these agents are manifested by visible signs; it is only in cases where irritability is in excess that we perceive them. The leaves and flowers of all plants are excited by the stimulus of light; but it is only when the petals close or unfold, and that leaves droop or raise themselves erect, that this phenomenon strikes us—that is, when the irritability is excessive.

We feel the more justified in considering what are called cases of vegetable irritability to be merely the vital principle in a state of concentrated action, from this circumstance—that no one has yet been able to throw the smallest light upon the cause of the motions of plants, or to give us anything beyond an explanation of the mechanical means by which the vital principle is enabled to take effect; for we feel quite justified in asserting, that Dutrochet, after all his patient investigations and ingenious experiments, has not advanced one step beyond this.

For the sake, however, of those who may be interested in pursuing such an inquiry, we will mention a few cases which may be easily witnessed of vegetable irritability in excess.

If you touch the surface of the branches of a Lettuce plant in flower, milk will be immediately emitted by the cuticle at the place where it is touched. Here it is supposed that the cellular tissue below the cuticle is in a high state of irritability, and by its contraction forces the milk out through the stomates.

If you touch the filaments of a Kalmia or a Barberry with the point of a pin, near their base, in the inside, they will curve forward, and strike their anthers against the stigma.

The Monkey-flower (Mimulus) has a stigma with two broad thin lips, which stand apart in fine warm weather. Touch them at that time with a bristle, or any such thing, and they collapse suddenly with considerable force.

A plant found in Carolina, called Venus' Fly-trap (Dionæa), has long bristles proceeding from the edge of its leaves, and curving inwards like the teeth of a rat-trap. Touch the surface of the upper side of the leaf, the sides will collapse, and the teeth will close up with such force that it is difficult to separate them again.

A very common plant in the greenhouses of curious persons is the Stylidium, many species of which inhabit New Holland; it has a long column, composed of stamens and style united, springing from the centre of its flower: when at rest this column bends down over one side of the corolla, as if it wished to conceal itself; touch it, however, ever so lightly, and it starts up with a jerk, and rapidly swings over to the opposite side of the flower.

The Sensitive plant has its leaves divided into a great number of leaflets, which spread flat in the sunshine, and seem as quiet as other leaves; but only touch one of the leaflets, and the whole system of the leaf will be irritated; all the leaflets will rapidly collapse one after the other, till at last the impulse is communicated to the base of the leaf-stalk, which immediately curves downwards. After a time it rises again, the leaflets unfold, and the leaf resumes its original appearance and direction.

§ 7.—*External Agents.*

Light, heat, and water are the external agents which, acting upon the vital principle, set all the machinery of vegetation in motion. No one of these causes will by itself produce any effect, although their combined action is of the most powerful kind.

Light, as we shall hereafter see, causes the decomposition of carbonic acid, fixing the carbon in the interior of tissue, and thus solidifying the more delicate parts, or altering the chemical nature of others; it is the grand cause of the varied colours of vegetation, and may be considered as being in part what produces a motion of the fluids. In its absence plants are weak and sickly, and soon perish.

Heat, by drying the atmosphere, produces evaporation, which is one of the great means by which the crude fluids become inspissated and altered in their nature; it causes the expansion of the gases which plants contain, distends their tissue, and renders the latter more capable of performing its

contractile and hygrometrical functions.

Water relaxes all the parts, dissolves the soluble matters which are laid up in a plant in a state of torpidity, and softens the tissue till it is capable of receiving the influence of temperature. It is, moreover, the medium by which the nutritious principles that are deposited in the earth are absorbed by the roots, and conveyed from one part of the system to another.

To sum up, in few words, all that has thus far been stated, it is light, heat, and water, acting in concert upon an irritable membrane, which enable plants, by virtue of their extensibility, elasticity, and hygrometrical powers, to perform the phenomena of contraction and endosmose, by means of which they absorb and digest their food, circulate their fluids, develope their organs, increase in size, and reproduce themselves.

What are the more immediate causes of the principal vital phenomena will be explained, as far as we at present understand them, in succeeding chapters.

CHAPTER III.

Of the Food of Plants.

THERE are those who have insisted that pure water is the food of plants; others have believed that plants have the power of selecting their food from among the various soluble matters surrounding their roots; and others, again, have declared that the air is alone sufficient to maintain a plant in health. These opinions, founded upon imperfect or ill-conducted experiments, are none of them exactly correct; although they each have a certain quantity of truth. The fact seems to be, that what may be called more particularly the food of plants, because it is that without which they cannot exist, is atmospheric air and water, in which carbonic acid is dissolved; that this alone is sufficient for their support; but that, under natural circumstances, they receive into their system a great variety of other substances dissolved in water; apparently not possessing any power of refusing to absorb whatever soluble matter may be offered to them, whether it be nutritious or deleterious.

We shall not occupy our pages with a description of the proofs by means of which modern chemists have shown the fallacy of the old experiments to prove that pure water is the food of plants; nor is it worth entering into a discussion of the causes of the errors of another nature which have led to the adoption of the opinions that plants can *select* their food from the soil. All that we can pretend to do, is to show upon what evidence the doctrines we state to be now received are based.

It is well known that pure water, as it is furnished by distillation, does not exist in nature; but that it is constantly mixed with earthy, saline, and gaseous matters, which vary in proportion according to the circumstances under which the water is impregnated with them; such water as this is necessarily what is offered to plants as their food. From the decomposition of the various organic substances which are buried in the soil results a considerable formation of carbonic acid,—a principle readily soluble in water, and consequently forming a considerable part of all the fluid introduced into the roots of a plant. The saline and earthy matters which find their way into the system are gradually deposited, almost unchanged, in those parts where the water in which they are dissolved evaporates; namely, in the leaves or the bark, or in some other part of the surface. But the atmospheric air, water, and carbonic acid become decomposed, and their elements, recombining in new proportions, form the materials for new parts, and the gum, fecula, sugar, azotic products, and other immediate principles of the vegetable kingdom.

If the roots of a plant are placed in a close vessel, in distilled water, from which carbonic acid has been carefully expelled, the plant may increase a little in size, in consequence of the decomposition of the water and the combination of its elements with the vegetable system; but it is only when carbonic acid is added that the plant acquires its natural vigour and rate of growth.

It is only in the state of carbonic acid that carbon can enter into the system of a plant; the former is easily decomposed, the oxygen is liberated, and the carbon remains fixed. But if a plant is placed in solid carbon, and you water it with distilled water, it might as well be planted in powdered glass, until the carbon begins to combine with the oxygen of the air, and to form carbonic acid. Sir Humphry Davy placed a plant of Mint in water mixed with carbon, in a state of impalpable powder, and he found that not a particle could enter the roots. If we look to the effects of manures, we shall find that in most cases, except when their object is to alter the state of the soil mechanically, or to act as stimulants, as is probably the case with sulphate of iron, their energy is in proportion to their capability of forming carbonic acid. Yeast, for instance, which is one of the most active manures we have, is so from possessing, beyond all other substances, the power of exciting fermentation, and thus of causing the formation of carbonic acid among the vegetable matter which lies buried in the soil.

While, however, all experiments combine to prove that carbonic acid is the most essential of the elements upon which plants are nourished, it is necessary that the student should be aware that other species of matter are constantly taken into the system, and probably, therefore, contribute to their nutrition.

Water is one of these. Although we know that a very large proportion of all the water absorbed by a plant is lost again by evaporation, yet the experiments of Theodore de Saussure have shown that a portion of it is actually solidified. He found that when plants are grown in a close vessel, in an artificial atmosphere, containing a little carbonic acid, the weight which the plant acquired in a given time was augmented, not only by the quantity of carbon produced by the decomposition of carbonic acid, but to a much more considerable extent, which could only be ascribed to its having fixed a considerable quantity of water; thus plants of Vinca, which, in a vessel without carbonic acid, had gained 1¾ grain from water, acquired 5$\frac{1}{10}$, when they were at the same time able to procure carbon. The same excellent observer has computed, that if we calculate with the utmost care all the weight which a plant can gain either by fixing carbon, or by depositing earthy, saline, alkaline, and metallic matter which they borrow from the soil, or by respiring oxygen, or from the soluble matter of soil, we shall not be able to account for more than a twentieth part of the real weight of such a plant. The other nineteen-twentieths must, therefore, be fixed water. Whatever errors there may be in calculations of this nature, there cannot be a doubt that they are correct to so considerable an extent as to oblige us to admit that water forms a considerable part of the solid tissue of plants; so that it would appear that, like minerals, plants have a water of crystallization independently of their water of vegetation.

As it has been pretty well made out that all the oxygen given off by plants is produced by the decomposition of carbonic acid, and as no one has ever been able to detect the emission of hydrogen by any plants except Mushrooms, it is inferred that, if the water which is consumed by plants is ever decomposed, it is in the formation of the various secretions which contain more oxygen (acids), or more hydrogen (oils), than water; but as the greater part of vegetable substances, such as gum, sugar, fecula, &c., contain oxygen and hydrogen in the same proportions as water, it can hardly be doubted that the greater part is undecomposed and simply fixed.

It was formerly thought that nitrogen, or azote, has nothing to do with the nutrition of plants, and that in those cases where it was met with it was merely in a state of separation from the atmospheric air which had been inhaled and deprived of its oxygen and carbonic acid. But its constant presence in combination with the tissue of Mushrooms and of Cruciferous plants, in gluten, and what chemists call vegetable albumen, and also in vegetable alkalies, seems a sufficiently strong proof of its contributing, in some way or other, to the nutrition of the vegetable system.

We might stop here in explaining the nature of the food of plants, if it were not for the great quantity of metallic, earthy, and other matters which are taken up by them from the soil, and afterwards deposited in their tissue; matters which possibly do not contribute to their nutrition, but about the real nature of whose action we have no evidence.

One of the most remarkable of these is silex, which is secreted by certain plants in prodigious quantity. All Grasses abound in it; usually it fixes itself in their cuticle; but in the Bamboo it is also deposited in considerable

quantity in their hollow joints under the form of the substance called Tabasheer. The skin of the Rattan Palm abounds so much in silex that it will strike fire with a piece of steel; the same substance exists in Teak and other kinds of wood, to which it gives a peculiarly gritty texture; and in the genus Equisetum, or Horsetail, one species of which is used for polishing wood, in consequence of the whole surface being composed of compact silicious particles. It was once thought that silex must be actually formed by the action of the vital principle of vegetation; but Berzelius has proved that newly-forming silex is soluble in water, and consequently it is more probable, as has, indeed, been recently proved, that it is in a state of solution that it enters the system, and is afterwards separated from the water. Considering the immense quantity of water that passes through a plant in the course of its growth, there is no difficulty in conceiving the possibility of the largest amount of silex which is ever met with in vegetation originating in this way; but there is still one circumstance to be accounted for. If we grow a Pea and a grain of Wheat in the same soil, the plant which results from the latter will abound in silex, while that from the former will not. Now we have no reason to suppose that these two species have any special power of selecting their food, and that the silex passes freely into the one while it is stopped by filtration in the other case: on the contrary, all that we know of the functions of roots leads us to believe that both absorb the silex equally. What then becomes of it in the Pea? This is a question still to answer.

Lime, and many of its salts, especially the sulphate and phosphate, magnesia, potash, soda, sulphur, phosphorus, several metals, and a number of other species of matter, occur in plants, in greater or less abundance, all evidently taken up from the soil. Of these soda is the best known and most abundant, existing to the amount of as much as fifty-five per cent. in the state of a carbonate in the ashes of Salsola sativa in Sicily (*Fée*); and copper the least suspected and most curious. This metal is stated by Sarzeau, according to De Candolle, to form eight parts in a million in coffee, and about four parts and a half in a million in wheat; whence this chemist has calculated that we annually import into Europe more than 1200lbs. weight of copper in our coffee, and that the French annually consume nearly 8000lbs. in their bread.—(*Journal de Pharmacie*, 1830, p. 505.)

By what means plants are enabled to procure the various kinds of matter which we have seen to enter into their system, is the next subject of consideration. The roots are no doubt the organs which are specially destined for this office; it is they which are placed in the most favourable situation for such a purpose; and which, from their organization and mode of growth, seem also to be the best adapted to it. When young they consist of a sheath of thin and exceedingly hygrometrical cellular tissue (*fig.* 92, *a a*), surrounding a

Fig. 92.



bundle of woody and vascular matter, *b b*. At this period they contain mucilaginous matter, which enables them to attract fluids from the soil that surrounds them, and having obtained it, they send it upwards into the general system. The power of suction which is thus given to them is incessantly in action, and with a force that is almost incredible, considering the smallness of the means by which it is effected: this will be evident when it is seen with what force the sap of a plant is impelled upwards at certain periods of the year (*see* Chapter VI.), and when it is mentioned that Hales found a Sunflower, three feet high, lose twenty ounces of water daily, to supply which the roots must have obtained from the soil not twenty, but thirty ounces of fluid daily; for, according to Senebier, a plant retains, on the average, one-third part of all the water that enters its system, and fixes it in a solid form.

It is only, however, in their youngest state that the roots have this extraordinary power; as soon as their tissue becomes charged with earthy matter, deposited by the entering fluids in their passage from the soil, their power of suction is diminished, and seems in the end to cease altogether. Thus, if you take a carrot and place the point

of its root in water, it will suck up the moisture as well as if the whole root were immersed; and on the other hand, if you place the whole root in water, except the point or newly-formed part, it will not suck up the fluid in any considerable quantity. For this reason the young tips of the roots are of the utmost importance to a plant, and its well-being depends in a greater degree upon their preservation than upon any other circumstance. In consequence of the great importance of the tips of the roots, they have received the special name of *spongioles* or *spongelets*, and are sometimes spoken of as if they were really distinct organs; they are, however, nothing more than the young and tender extremities of the roots. As fast as they solidify, they lose their power, and cease to be spongelets; but as the roots, when growing, are incessantly forming new matter at their points, spongelets are perpetually present, notwithstanding that they are perpetually disappearing.

If we take this circumstance in connexion with the fact, that, in general, *roots* do not *lengthen* except by the addition of new matter to their points, we shall find that the function of feeding in plants is one of the most beautiful instances of contrivance in the whole vegetable kingdom. Growing, as they do, in a solid resisting medium, if they lengthened by a general extension of previously formed parts, they would be constantly interfered with by the uncertain nature of the earth in which they are developed; as the degree of resistance offered by soil to any solid passing through it, is, from its very nature, most unequal and uncertain, it would be impossible that the force with which the roots push forward could be ever proportioned to the resistance opposed to their advance, and, consequently, they would become so twisted and knotted, that their fluids would no longer circulate through them with the regularity required by the exigencies of the stem and leaves. And if they absorbed fluid from every part of their surface, the soil round a tree must become so dried up, that, as the roots cannot stir from the place where they are first formed, they would speedily perish from the consequences of their own action upon the earth that surrounds them. Providence has, however, so contrived them, that they are exposed to no such effects. Increasing by constant additions of young matter to their delicate points, they are able to insinuate themselves between the solid particles of the soil with the greatest facility, in which they are much assisted by the softness and pliability of their newborn tissue; thus we find them able to pierce the little cracks in a stone till they have passed beyond it, when their power of expansion will often enable them to burst it; and we often see them insinuating themselves into the crevices of walls, and penetrating solid masses of brickwork. If, however, the rootlets insinuate themselves into a crevice to which there is no outlet, they are merely arrested in their advance; and the facility with which they subdivide into other branches, enables them immediately to counteract the inconvenience produced by their stoppage, by emitting from their sides a number of little sprouts, each of which will advance into the soil in search of moisture. The same property prevents their exhausting the soil of the moisture that surrounds them, for they are all their lives long removing from the exhausted point to new and untouched soil; and this so effectually, that animals, with their powers of movement to aid them, are not better able to roam in search of fresh pastures, than the seemingly motionless roots are to seek incessantly for new feeding places. Some plants will send out their roots, under particular circumstances, to great distances in search of food; and their length will be amazingly disproportionate to the height of their stems. The Lucerne plant has a stem about two feet high; its roots have been taken from below the face of the escarpment of a sand-pit, as much as thirty feet in length; so that many of the little leaves had to be supplied by a living well three hundred and sixty times deeper than themselves. Powerful and important as the action of the roots must be, we must not suppose, on that account, that it is the sole medium by which nutritive matter passes into the system of a plant. Orchideous plants, and certain species of the Fig, have been suspended in the air, and they have continued to live, although their roots were destroyed; a species of Tillandsia is tied to the iron balconies of the houses in Buenos Ayres, and there it

lives and flowers; the Dodder clings round the stems of the Heath and Furze, and grows, flowers, and fruits during the greater part of its life without any communication with the soil; Mistletoe has been made to sprout upon the surface of a cannon-ball; and other instances might be mentioned in which plants have grown without roots. If plants which have withered are syringed, they recover their freshness; and if the atmosphere of a badly managed greenhouse is saturated with moisture, the starved and dying plants recover. In all these cases it seems impossible to doubt that a certain quantity of moisture, and consequently of food, is absorbed by the surface of a plant, independently of roots; for we cannot ascribe all the cases just referred to, to the prevention of evaporation. Nor, indeed, does one see why we should; for any soft and succulent tissue is, as we have seen, capable of absorbing moisture through its sides in a greater or less degree, and such tissue exists on the bark and leaves of all plants. It must, however, be remembered, that whatever power we may ascribe to the leaves and stems of plants of keeping up the nutrition of the system in the absence of roots, yet that their power is as nothing compared with the efficiency of the roots themselves.

If, then, it is by the roots that plants are enabled to feed, and if it is more especially by their young and tender points, the importance of preserving those delicate organs must be obvious, while the mischief that will of necessity result from their mutilation or destruction will be readily appreciated; for although they may be renewed when destroyed, yet their replacement is a slow operation, and, in many species, is performed with difficulty, except under very favourable circumstances. The reader who is acquainted with gardening or planting will not fail to perceive the immense importance of these considerations as connected with transplanting trees; and that the violence and carelessness with which plants are frequently torn out of one place and thrust into another, are anything but calculated to ensure a successful result.

Chapter IV.

Of Digestion; or the means by which the crude Sap is converted into the peculiar secretions of Plants.

When the food of a plant enters the roots it passes upwards, undergoing some kind of chemical change, and dissolving whatever soluble matters it meets with in its course; so that, without having been exposed to any of those conditions by which it is ultimately and principally affected, it is considerably altered from its original nature before it reaches the leaves. If the trunk of a Birch tree be tapped in the spring, near the ground, it will discharge in great abundance a whitish limpid fluid, which is the rising sap; but if the sap be obtained from an aperture five or six feet higher, it will be perceptibly astringent; and at a higher point still, its difference from that near the root will be still more apparent.

It has already been remarked, that a portion of the water which plants suck up, combines with the tissue, and enters into the general constitution, where it becomes fixed, as the water of crystallization in minerals. This apparently takes place in the course of the ascent of the sap, before the latter reaches the leaves and becomes exposed to that sort of decomposition and alteration which is here called digestion, and with the phenomena attendant upon which we are best acquainted. Under what influences, except that of the vital principle, a decomposition of the sap takes place before it reaches the leaves, we are ignorant. But when it has reached the leaves, and thus becomes exposed to the effect of light, its action is less removed from our powers of observation; and physiologists have succeeded in ascertaining, to a great extent, the exact nature of the changes it undergoes.

What we find it most necessary to insist upon in this place, are the three following axioms, to which the experiments of careful observers and skilful reasoners have led:—1. *The quantity of water lost to a plant by evaporation, and its power of absorption from the soil, is in proportion to the quantity of light.* 2. *Light causes a decomposition of the carbonic acid of vegetation, and consequently, by solidifying the tissue, renders the parts most exposed to it the hardest.* 3. *The digestion of plants chiefly consists in a loss of water by evaporation, and in an acquisition of carbon, by the decomposition of carbonic acid.*

That the quantity of water lost to a plant by evaporation is in proportion to the quantity of light is easily proved by the following experiment, mentioned by De Candolle:—"If you select three plants in leaf, of the same species, of the same size, and of the same strength, and place them in close vessels, one in total darkness, the other in the diffused light of day, and the third in the sunshine, it will be found that the first pumps up very little water, the second much more, and the third a great deal more than either. These results vary according to species and circumstances; but it uniformly happens that plants in the sun absorb more than those in diffused light, and the latter more than those in darkness; the last, however, pumping up something. If, again, we take three similar plants, and, preventing their absorption by the roots, after weighing them carefully, place them in three similar situations, we shall find that that exposed to the sun has lost a great quantity of water, that in common daylight a less amount, and that which was in total darkness almost nothing." Hence it may seem proved, that the action of solar light is the great exciting cause of suction at the one end, and of evaporation at the other end of a plant; and that, in the night-time, plants gain weight, while they lose it in the day-time. It is not, however, clear, that, to speak rigorously, although we may talk of light as being the sole cause of these phenomena, it is not rather the dryness of the atmosphere, caused by the heat of sunlight, as compared with the moisture of the air in the absence of the sun. Thus, plants in a dry sitting-room, to which the sun has no access, undoubtedly perspire by their leaves, and absorb by their roots, more than if they were exposed to the sun in a moister atmosphere.

Whatever doubt there may be concerning the precise causes of evaporations, there can be none whatever as to the power which sunlight has to cause the decomposition of carbonic acid, the fixing of the carbon, and the giving out of oxygen.

"If," says De Candolle, "two plants are exposed, one to darkness and the other to the sun, in close vessels, and in an atmosphere containing a known quantity of carbonic acid, and are removed at the end of twelve hours, we shall find that the first has diminished neither the quantity of oxygen nor of carbonic acid; and that in the second, on the contrary, the quantity of carbonic acid has diminished, while the quantity of free oxygen has increased in the same proportion. Or if we place two similar plants in closed vessels in the sun, the one in a vessel containing no carbonic acid, and the other in air which contains a known quantity of it, we shall find that the air in the first vessel has undergone no change, while that in the second will indicate an increase of oxygen proportioned to the quantity of carbonic acid which has disappeared; and if the experiment is conducted with sufficient care, we shall discover that the plant in question has gained a proportionable quantity of carbon. Therefore, the carbonic acid which has disappeared has given its oxygen to the air and its carbon to the plant, and this has been produced solely by the action of solar light."

However varied experiments may be, they all lead to the same result, and compel us to acknowledge the great importance of light to plants, in enabling them to digest the crude matter which they gain from the soil. In fact, there is nothing of which we have any certain knowledge that interferes with these conclusions. We see in practice that the more plants are exposed to light when growing naturally, the deeper is their green, the more robust their appearance, and the greater the abundance of their odours or resins; and we know that all the products to which these appearances are owing are highly carbonized. On the contrary, the less a plant is exposed to sunlight, the paler are its colours, the laxer its tissue, the fainter its smell, and the less its flavour. Hence it is that the most odoriferous herbs are found in greatest perfection in places or countries in which the sunlight is the strongest—as sweet herbs in Barbary and Palestine, Tobacco in Persia, and Hemp in the bright plains of extratropical Asia. The Peach, the Vine, and the Melon, also, no where acquire such a flavour as under the brilliant sun of Cashmere, Persia, Italy, and Spain.

This is not, however, a mere question of luxury, as odour or flavour may

be considered. The fixing of carbon by the action of light contributes in an eminent degree to the quality of timber—a point of no small importance to all countries. It is in a great degree to the carbon incorporated with the tissue, either in its own proper form, or as resinous or astringent matter, that the different quality in the timber of the same species of tree is principally owing. Isolated Oak trees, fully exposed to the influence of light, become a tougher and a more durable timber than the same species growing in dense forests; in the former case its tissue is solidified by the greater quantity of carbon fixed in the system during its growth. Thus we have every reason to believe that the brittle Wainscot Oak of the Black Forest is produced by the very same species as produces the tough and solid naval timber of Great Britain. Starch, again, in which carbon forms so large a proportion, and which, in the Potato, the Cassava, Corn, and other plants, ministers so largely to the nutriment of man, depends for its abundance essentially upon the presence of light. For this reason, Potatoes grown in darkness are, as we say, watery, in consequence of no starch being developed in them, and the quantity of nutrition or amylaceous matter they contain is in direct proportion to the quantity of light to which they are exposed. For this reason, when orchard-ground is under-cropped with potatoes, the quality of their tubers is never good; because the quantity of light intercepted by the leaves and branches of the orchard-trees prevents the formation of carbon by the action of the sun's rays upon the carbonic acid of the Potato-plant. Mr. Knight has turned his knowledge of this unquestionable fact to great account in his application of the principles of vegetable physiology to horticultural purposes.

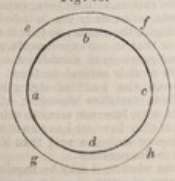
It is to the power which the sun's rays possess of decomposing carbonic acid, and fixing the residual carbon, that many of the directions which the parts of plants assume are ascribable. When, for instance, a branch first quits a stem, its own weight would give it a tendency downwards, if it were not for the effect of light from above, which solidifies the parts exposed to it. Let any one expose a green branch in such a manner that light strikes it only on one side; the tissue of that side will fix most carbon, will become harder, and will lengthen less; while the opposite will fix less carbon, be less hard, and will lengthen more; the consequence of which will be, that the illuminated side will contract, and pull the branch towards the light. This, if rightly considered, will of itself explain the uniform tendency of the green parts of plants to turn towards the light; and if it will not account for such phenomena as that of the Sunflower turning its flowers constantly to the sun, and following him in his course, as we find repeated by author after author, that circumstance is ascribable not to any defect in the explanations that have just been given, but *to the alleged phenomenon having no existence in nature.*

What, then, with the evaporation of the watery parts, the fixing of a part of the water, and the decomposition of carbonic acid, the crude sap of plants is changed from its original nature to the secretions which are peculiar to different species; but by what other means, unless by the specific action of the vital principle, are established the new proportions of oxygen, hydrogen, and carbon, and occasionally of nitrogen, which are necessary to form the acids, resins, gums, sugars, amylaceous alkaline, and other forms of matter which are met with in plants, is still unknown.

The deposit of these substances, and of the earthy, metallic and other extraneous materials which pass into the system of a plant, along with its fluid nutriment, gradually consolidates the tissue, cases over its sides, chokes up its intercellular passages, and prevents the organic membrane from performing its functions. When this happens, the part in which it occurs dies, or at least ceases to be capable of further action; and thus wood and bark become incapable of conveying fluid, and leaves fall from the branch that bears them. This, which is called the fall of the leaf, has always been a puzzling circumstance to account for. One man has assigned it to the rupture of the spiral vessels which connect the leaf with the stem; another has called it analogous to the sloughing of parts in animals, without pretending to explain the organic cause; others have simply said that leaves fall off because they are dead. Perhaps the following explanation may not be far removed from the truth. The space where the

base of a leaf is connected with a stem may be represented by the circle *a, b, c, d, fig.* 93. When both the leaf and stem are in a state of health, they continue to grow equally, the base of the leaf stretching and increasing in diameter as the circumference of the stem is enlarged in consequence of its distention by the wood which is forming within it; and it is obvious, that so long as this mutual adaptation goes on, the organic connexion between the leaf and stem will not be interrupted. But let the base of the leaf, *a, b, c, d,* lose its power of growth, in consequence of being killed by the deposit of foreign substances in it, the growth of that part of the stem which answers to this circle will not therefore be interrupted, but will go on growing, and in time will occupy the space described by the circle *e, f, g, h.* To effect this, all the parts inclosed within the circle *e, f, g, h* must become disjoined from those of the leaf comprehended within the circle *a, b, c, d,* and the inevitable consequence will be the separation of the two, when the leaf will drop off. What gives this explanation the greater appearance of probability is the well-known fact, that leaves do not drop off the stems of Endogens, which never increase in diameter; in such cases they simply perish and rot away. It must, however, be remembered, that whatever value there may be in this explanation of the fall of the leaf, it will by no means account for other instances of disarticulation between different organs, or different parts of the same organ; such as the separation of the upper half of the capsule of the Pimpernel (*fig.* 65 *b*) from the lower, the dropping in pieces of a

Fig. 93.



lomentaceous legume, the separation of the valves of a Cruciferous pod from their frame (*fig.* 63 *c*), and the like. The causes of these things are totally unknown.

Chapter V.

Of Respiration, and of the Effects of Vegetation upon the Atmosphere.

Under the name of respiration we shall include all that is connected with the inhaling and giving off of gaseous matter by plants.

This function is chiefly connected with the absorption of oxygen and carbonic acid, and their expiration. By a vast number of experiments, chemists have determined that the green parts of plants placed in the sun absorb carbonic acid from the atmosphere, and decompose it, giving back the oxygen; and that, at night, they absorb oxygen from the atmosphere, giving off carbonic acid; it is also probable that they part with a small quantity of carbonic acid during the day.

When the first observers remarked that, if green leaves were placed in water in the sunshine, bubbles of air were produced, it was not clear whether the gas originated from the leaves or the water; nor was it known that the bubbles might not be produced by air adhering to the leaves. None have conducted their researches into this curious subject with more care than Theodore de Saussure, Senebier, and De Candolle; the result of whose investigations is briefly this. Three conditions are necessary, in order to secure the disengagement of oxygen by leaves: firstly, the parts must be green; secondly, they must be exposed to the direct action of the solar rays; and, thirdly, there must be carbonic acid in the water.

The circumstance that green parts alone, with a few exceptions, are capable of giving off oxygen, sufficiently proves that it cannot result from what atmospheric air may adhere to the leaves under experiment; and Senebier ascertained that, if the green parts are exhausted of their air by the air-pump, they will nevertheless emit air-bubbles as usual when placed in water in the sunshine. That this is, in fact, a vital action, is proved by dead leaves, still green, having no power of emitting gaseous matter until they begin to decompose.

It is not sufficient to place leaves in bright light to procure the emission of

oxygen by their leaves in water; it must be under the direct rays of the sun. De Candolle found the purest daylight, the brightest lamplight, insufficient to produce the phenomenon: a very curious result, when we consider how large a part of vegetation is seldom exposed directly to the solar rays. Of course nothing like emission of oxygen would occur at night.

It is not even any kind of water in which oxygen will be evolved in the sunshine; neither boiled water, nor distilled water, nor that in which nitrogen, hydrogen, or even oxygen have been dissolved, will produce the result. But if a small quantity of carbonic acid is dissolved in the water, the green parts, stimulated by the sun, disengage oxygen. Various ingenious means have been contrived to prove this fact, and to show that the quantity of oxygen given out is proportioned to the quantity of carbonic acid decomposed; one of the prettiest experiments is the following, by De Candolle: He placed in the same cistern two inverted glasses, of which one (A), as well as the cistern itself, was filled with distilled water, and had a plant of Watermint floating in it; the other glass (B) was filled with carbonic acid. The water of the cistern was protected from the action of the atmosphere by a deep layer of oil. The apparatus was exposed to the sun. The carbonic acid in the glass B diminished daily, as was obvious from the water rising in it; and at the same time there rose to the top of the glass A a quantity of oxygen, sensibly equal to the quantity of carbonic acid absorbed. During the twelve days that the experiment was continued, the Mint plant remained in good health; while, on the contrary, a similar plant, placed under a glass, filled with distilled water only, had disengaged no oxygen, and exhibited manifest signs of decomposition. The same experiment having been tried, only employing oxygen in the place of carbonic acid, no gas was disengaged in the glass that contained the Mint plant.

This is sufficient to show that the green parts of plants exposed to the sun decompose carbonic acid. By others, not less ingenious, it has been ascertained that the carbon which is the result becomes fixed in the plant itself. It has been found that Periwinkles growing where carbonic acid had access to them, gained carbon; while similar plants, in a situation cut off from the access of carbonic acid, not only gained no carbon, but lost a part of what they previously possessed.

If the green parts are placed in the dark, in a receiver full of atmospheric air, we find that the quantity of oxygen is perceptibly diminished. From this, and many other considerations, we are forced to conclude that oxygen is absorbed by plants at night. This gas does not, however, remain in the system of a plant in an elastic state, for neither the air-pump nor heat will disengage it; but it appears to incorporate itself with the tissue, since solar light readily disengages it. The inference therefore is, that it is absorbed at night, and combines with the carbon already existing, forming carbonic acid, and that the latter is decomposed by the sun, as has before been shown.

Other experiments show, that although the absorption of oxygen and the decomposition of carbonic acid are the principal phenomena of respiration, yet that a small quantity of carbonic acid is given off by the leaves both day and night. Hence Professor Burnet has suggested that, under the name of respiration, two distinct functions are confounded, and that respiration, properly so called, which consists in the extrication of carbonic acid, is incessantly in action; while digestion, which is indicated by the decomposition of carbonic acid and extrication of oxygen, takes place exclusively in daylight.

That the direct beams of the sun are not indispensable to it under ordinary circumstances is proved by the power of plants to form green matter, which is fixed carbon, without being exposed to the sun, as we daily see in individuals growing in the shade; so that it would appear that, in our experiments, plants are not precisely in a condition equivalent to what is natural to them. The paleness, the want of strength, the scentless, tasteless character of such plants may, however, serve to convince us that they have far less power of decomposing carbonic acid than if they grew in the sunshine.

From whence, it may be inquired, is the large quantity of carbonic acid obtained which is thus necessary to the support of plants? Certainly not from the atmosphere alone, for it does not

usually contain more than one part in two thousand of carbonic acid. There can be no doubt that this gas is supplied principally by the earth, in which it exists in great quantity; that a part is obtained from the atmosphere; and that a certain other portion results from the combination of the oxygen of the atmosphere with the carbon of vegetation; and it would seem as if a repeated decomposition and recomposition of carbonic acid was the principal phenomenon in respiration. When we consider how essential it is for roots to be near the surface of the soil, that is, within reach of atmospheric air, and that in all plants the principal part of the roots has a horizontal direction below the surface, we shall see at once the probability that this tendency, when we connect it with the preceding facts, is given them, in order that they may be favourably situated for the access of the carbonic acid, either formed in the soil by fermentation, or produced by the combination of the oxygen of the atmosphere with the carbon of the soil. Theodore de Saussure's experiments completely prove this.

Hence it appears, that while animals vitiate the atmosphere by respiring carbonic acid, plants purify it by absorbing it. It may be said, indeed, that they also deteriorate it by abstracting its oxygen: but it is to be remembered, that if they inhale it at night, they return it in the day-time; and Dr. Daubeny has ascertained that the slight diminution of oxygen, and increase of carbonic acid, which takes place during the night, bears no considerable proportion to the degree in which the contrary effect is observable during the day. Thus Providence provides a living check upon miasmata, and has admirably arranged that one of the kingdoms of nature should render and maintain the world in a state habitable by the other.

It has, indeed, been supposed by some French botanists, that in the beginning, the world had an atmosphere so highly charged with carbonic acid, as to be unfit for the respiration of any animals of a higher order than molluses; that plants gradually purified it, depositing in the earth the carbon thus abstracted in the form of coal, till the air became fit to be breathed by reptiles, then by mammals, &c., and last of all by man. But although it is certain that carbonic acid is in so great a degree the nutriment of plants, and although Theodore de Saussure ascertained that, in the sunshine, plants thrive in an atmosphere containing twelve per cent. of carbonic acid, yet the same observer found that, in the shade, the smallest dose added to what is ordinarily present in the atmosphere was deleterious.

As plants part with carbonic acid and inhale oxygen at night, some persons have fancied that they must render the air of a room unwholesome; but if we remember that a single human being will vitiate the atmosphere infinitely more than a hundred plants, we shall not attach much importance to this opinion. If it is vitiated at all by flowers, it is by their powerful odours, which in many cases act upon the nerves, and so prove inconvenient to delicate persons.

What we now have seen of the action of the leaves and green parts of plants, will enable us to appreciate the adaptation of their internal structure to perform their functions. We have found them to consist of a number of little cells or bladders, so loosely cohering, that the air has room for free circulation between them; and that by the way in which they are arranged, they present the greatest possible surface to the action of the atmosphere. Although they are inclosed in a thick cuticle, yet they are provided with openings through it, called stomates, by means of which free admission for air is secured, and through which it may be expelled again with facility; when they are submersed, and are, consequently, neither exposed to irregularities of temperature nor of dryness in the air, they have no occasion for either cuticle or stomates, for the water in which they float carries the air dissolved in it to every part; and, consequently, submersed plants have neither. It is true that M. De Candolle entertains doubts whether the stomates are not rather organs of evaporation; but when we consider the relation they bear to the air-cavities in leaves, we can scarcely doubt that they are really respiratory organs; nor does it appear clear why they should not, in fact, perform the functions both of perspiration and respiration. If we hold a leaf of Laurustinus over a candle, so as to heat the air contained in it, without burning the

leaf itself, the air will be expelled through the stomates with such force as to extinguish the flame.

With regard to parts not green, which botanists usually call *coloured*, their function seems to be to absorb oxygen without fixing it, and they appear to possess no power of decomposing carbonic acid when they have formed it. Such is said to be the case with roots, old trunks, petals, stamens, ripe fruits, Mushrooms, and certain Lichens. A part of their carbonic acid escapes into the air, a part is dissolved in their fluids, especially in the roots, whence it passes upwards into the system. Flowers are said to replace a small part of the oxygen they abstract by an exhalation of nitrogen.

Chapter VI.

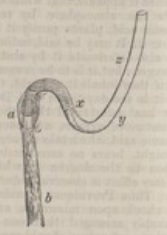
Of Circulation; or the Movements of Fluids in Plants.

Compared with that of animals, there is no such thing as a circulation in the fluid matter of vegetation; that is to say, a movement throughout the system from and to one common point has no existence. This would be impossible from the absence of any common seat of life, and from the exceedingly compound nature of a plant, which does not consist of a single system of growth, but, like a Polype, must be considered as composed of myriads; for each bud has a system of circulation, growth, respiration, and digestion of its own, and a plant is nothing but a great number of such systems combined under one common cuticle, and living in concert.

But although we cannot compare the movement of vegetable fluids to the circulation of the blood, yet it is undoubted that a constant, and sometimes a very powerful, motion takes place, by virtue of which the sap absorbed by the roots rises up the stem, passes into the leaves, flows back in an altered state into the bark, and thence descends towards the roots. Otherwise there would be no means by which the roots could support the leaves at such considerable distances as the spongelets and the tiny foliage are sometimes separated. In the Pines of North West America, for instance, leaves are supplied with food by spongelets which, by calculation, must be four hundred feet distant; and as such leaves are often not more than half an inch long, the force of motion in the sap must be very great, which will enable the leaves to derive support from a distance nearly ten thousand times greater than their own length. In fact, if we wound a tree during the leafing season, the rapid manner in which the sap will flow from the lower lip of the wound brings the phenomenon distinctly before our eyes.

The force with which the sap rises has been the subject of some curious experiments, one of the most instructive of which is the following of Hales, which we give in his own words:—"April the 6th, at 9 A.M., rain the evening before, I cut off a Vine on a southern aspect at *a* (*fig.* 94), 2 feet 9 inches from the ground; the remaining stem *a b* had no lateral branches, it was ¾ inch diameter; I fixed on it the mercurial gage *a y*. At 11 A.M. the mercury was risen to *z*, 14 inches higher than in the leg *x*, being pushed down at *x* by the force of the sap which came out of the stem at *a*.

Fig. 94.



"At 4 P.M. it was sunk an inch in leg *z y*. April 7th, at 8 A.M., was risen very little, a fog; at 11 A.M. 'tis 17 inches high, and the fog gone. April 10th, at 7 A.M., mercury 18 inches high; I then added more mercury, so as to make the surface *z* 23 inches higher than *x*; the sap retreated very little into the stem, upon this additional weight, which shows with what an absolute force it advances; at noon it was sunk one inch. April 11th, at 7 A.M., 24+¼ inches high, sunshine; at 7 P.M. 18 inches high. April 14th, at 7 A.M., 20+¼ inches high; at 9 A.M. 22+½, fine warm sunshine; here we see that the warm morning sun gives a fresh vigour to the sap. At 11 A.M. the same day, 16+¼, the great perspiration of the stem makes it sink. April 16th, at 6 A.M., 19+½, rain; at 4 P.M. 13 inches. April 17th, at 11 A.M., 24+¼ inch high, rain and warm; at 7 P.M. 29+½, fine, warm, rainy weather, which made the sap rise all day, there being little perspiration by reason of the rain. April 18th, at 7 A.M., 32+¼ inches high, and would have risen higher if there had been more mercury in the guage; it being all forced into the leg *y z*. From this time to May 5th, the force gradually decreased. The greatest height of the mercury being 32+½ inches; the force of the sap was then equal to 36 feet 5+¼ inches height of water. Here the force of the rising sap in the morning is plainly owing to the energy of the root and stem. In another like mercurial guage (fixed near the bottom of a Vine which ran 20 feet high), the mercury was raised by the force of the sap 38 inches, equal to 43 feet + 3 inches +½ height of water, which force is near five times greater than the force of the blood in the great crural artery of a horse; seven times greater than the force of the blood in the like artery of a dog; and eight times greater than the blood's force in the same artery of a fallow doe."—*Vegetable Statics*, p. 105.

Through what routes the sap passes is a more easy question to resolve. If we cut a stem through about the leafing season, we shall find the albumen, or sap-wood, discharging a great quantity of fluid; the heart-wood less; and the bark none at all. If we simply make an incision into a tree, the sap-wood will give out sap in abundance from the lower lip of the wood; the bark none whatever. But if we examine the same parts in the same way at a later period of the year, the upper lip of the wounded bark will discharge a quantity of fluid, but the lower none. Vary these experiments as we please, and the result is always the same. Hence we are forced to conclude, that in Exogens the sap rises through the sap-wood, and descends through the bark; not, however, through the sap-wood exclusively, but through all the parts of the wood which are not absolutely choked up with deposited matter. Of its course, in Endogens and Acrogens, we know nothing worth stating.

But if we cut through the wood of a growing tree obliquely, so as to form a tangental line within its circumference, we shall remark a quantity of fluid oozing from the face of the wound, especially on the face next the bark; and if the tree is preserved in health, the matter from the latter part will continue to ooze out during the remainder of the season, forming a crust of elaborated matter. Hence we must conclude, that, independently of the ascent through the sap-wood, and the descent through the bark, there must be also a lateral transmission from the bark inwards.

What has just been stated belongs to the unquestionable facts in Vegetable Physiology; through what particular forms of tissue sap moves is far less certain. It is not to be doubted that the sap ascends by the woody tissue, as is proved by coloured infusions which are forced to ascend by artificial means; but whether through the tubes of woody fibre, or by the intercellular passages, has not been, and probably cannot be, decided. It is also a question whether it ascends or not by the dotted ducts and the vessels; there can be no doubt that these parts, with the exception of the spiral vessel, appear to be filled with fluid when the sap is in its most rapid course; but it is equally certain that the dotted ducts, at least, are empty afterwards: are we to conclude that these forms of tissue perform one function in the spring, and another in the autumn; or are we rather to suppose that the appearance of being filled with fluid, which they exhibit in the spring, is owing to the wounded vessels in their neighbourhood overflowing into them when cut through? There is no satisfactory answer to this as yet upon record. In its downward descent it may be reasonably assumed that both the fibrous and cellular parts of the tissue assist in its conveyance; but it is to be suspected, that although we speak of them in this general manner, yet that in reality these two forms of tissue do convey different kinds of fluid; because we find certain secretions most abundant in the bark, such as gum, and others, such as astringent matter, equally abundant in both the wood and the bark. Perhaps the woody fibre, which is not directly connected with the medul-

lary processes, brings downwards gummy and similar matters, while others pass freely down the cellular tissue. The medullary processes undoubtedly carry on the horizontal transmission, and are the means by which the circumference communicates with the centre of a tree. This their position, the direction of their tissue, and their appearance during the growing season, render sufficiently manifest.

From the latest experiments, and the best conducted arguments, it would seem that the cause of the movement of the sap upwards is, as far as we have any means of assigning an immediate cause to the phenomenon, the development of the buds and leaves. When a young bud, or a leaf, is first excited to growth in the spring, the fluids it contains are increased in density by evaporation; endosmose immediately takes place between it and the tissue below it, which latter parts with the thinnest portion of its contents, and then acts by endosmose upon the tissue below it, and thus the whole chord of vegetation is set in vibration, if we may so express it, from the extremity of the branches to the points of the root; the moment the spongelets are affected, the fluid in the soil is attracted through their sides, and thus a complete motion throughout the system is established. Hence the leafing of trees is not the effect of the ascent of the sap, as it is usually thought to be, but the cause of it. It may be supposed that the mere effect of gravitation will carry downwards the sap in its densest state after it has ceased to obey the attraction of the leaves, and that it will descend by simple filtration till it reaches the roots; but how we are to account for its lateral transmission through the medullary rays is still unknown.

The sap of plants then ascends in its crude state through the sap-wood, and reaches the leaves; is there finally decomposed, assimilated, and inspissated; is discharged back into the bark; settles downwards towards the roots; and passes off laterally by the medullary passages into the heart-wood. Heart-wood is, in truth, nothing but sap-wood consolidated by the addition of secreted matter, and may always be restored to the state of sap-wood by any solvent of the secreted matter. Ebony, for example, is jet-black; when young it is whitish, and it only gains colour as the black substance is generated in the leaves discharged into the bark, impelled into the medullary processes, and by them deposited in the wood. Plunge a piece of ebony into hot nitric acid for a few minutes, the colouring matter will be discharged, and the tissue will be restored to the state of sap-wood.

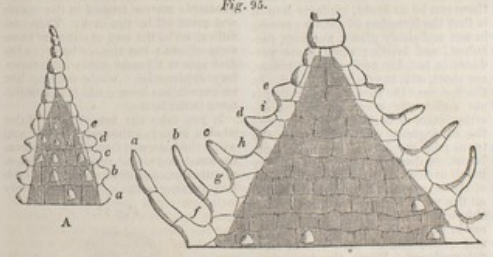
Besides this kind of general motion, which seems indispensable to the very existence of a plant, and which our reason would have told us must exist, if our experiments failed in revealing it to our sight, there is another which no force of reasoning could have led us to expect, and which is altogether of a local and partial character. It was originally ascertained by Amici, that in the Chara plant there is a curious rotatory motion in the fluid of each cell of which that plant consists. It may be described as a revolving movement round the inside of each cell, ascending on one side and descending on the other, with an occasional irregular interchange of matter between the sides; and, what is very curious, the ascending current is uniformly on that side of each cell which is most remote from the axis of growth, and consequently the descending current is on the side nearest the axis. Some excellent observations upon this phenomenon, by Messrs. Solly, Slack and Varley, will be found in the *Transactions of the Society of Arts*, vol. xlix. to which we would especially direct the attention of the reader. After finding it in Chara, and its kindred genus Nitella, it was discovered in the cells of the Frogbit (Hydrocharis Morsus Ranæ), a common water-plant, and in the hairs of so many species, that we are led to suspect it to be a phenomenon by no means confined to the cases in which it has been observed, but of universal occurrence; and that it may be connected with the assimilations of fluid and gaseous matter by the tissue: it may, in fact, be a movement of digestion, going on by night as well as by day. A vial-microscope, for the express purpose of showing these motions, has been ingeniously contrived by Mr. Varley, and may be procured from the optical-instrument makers. It is fully described in the 50th volume of the *Transactions of the Society of Arts*.

Chapter VII.

Of the Growth of Plants.

Concerning the precise manner in which new cells or tubes of tissue are generated, little very satisfactory is known. By some it has been fancied that they were produced by the extrication of gaseous matter in solidifiable mucus; others have hardily asserted that the minute green globules, which we find sticking to the sides of tissue, are young cells or tubes, and that they grow from their mother-cells as seeds grow from their placenta; suffice it to say that these are mere *assertions*. All that we really know about the matter is this: that in Chara and Nitella, young cells appear like buds at the point, or axils of older cells, and gradually lengthen out into the tubular form peculiar to those plants; and that in Marchantia polymorpha they have been seen, by Mirbel, to form in a somewhat similar manner. He states that a lobe of that plant, such as is represented at *fig.* 95, A, changed to such a lobe as is shown at B, which he explains in the following manner. The young lobe, A, presents on its surface, at its widest part, five rows, *a, b, c, d, e,* of cells, arranged parallel to its basis. The two cells which terminate each row, one to the right, the other to the left, are inflated and conical, and, consequently, form two marginal projections. The five rows, *a, b, c, d, e,* are united without intermediate tissue. The older lobe, *fig.* 95, B, shows nine rows, *a, f, b, g, c, h, d, i, e,* of cells, placed parallel with its base. Five of these rows, *a, b, c, d, e,* terminate, right and left, by a marginal cone, formed of a single cell, or, which is more usual, of two, three, or four cells attached end to end. The four other rows of cells, *f, g, h, i,* are placed between the first, so as to alternate with them, and they have no marginal appendages. It is evident, notwithstanding the augmentation of the number of the cells, that the five rows, *a, b, c, d, e,* of *fig.* 95, B, and their conical appendages, represent the five rows of cells, *a, b, c, d, e,* of *fig.* 95, A, with their marginal projections. But the four alternate rows, *f, g, h, i,* of *fig.* 95, B, have no representatives in A; and as the latter is the younger of the two, we must conclude that the four alternate rows of the other lobe were developed subsequently to the formation of the five rows with appendages.

Fig. 95.



We have quoted this at full length because it appears to be the most important, the most clearly demonstrated, and, it might be added, the only tangible observation that has yet been made concerning the development of tissue. If it does not explain the increase of solids, such as stems and the like, it seems to be, at least, applicable to leaves and all their organs; the unevenness of whose edges, *in all cases* seems to increase the probability of their really being developed upon this plan.

When a branch or a young plant first begins to lengthen, it is merely a bud, reposing upon a certain quantity of cellular tissue, which in Exogens is pith, and which is always highly charged with fluid. The moment light

and heat are sufficiently powerful to produce a decomposition of carbonic acid and a thickening of the fluids, endosmose is set in action, and produces a current from below upwards, which is variable in intensity in different species, but which always acts as a force from behind, impelling the tissue in the direction of its own current. The tissue of the buds, young and soft, and scarcely at all solidified by the deposit of carbonaceous, earthy, or other matters, yields freely to the impulse, stretches, lengthens, and grows, preserving its rectilinear direction, so far as is practicable, considering the action of the light upon it, and the unequal carbonization of its sides. But the instant the leaves begin to develope, they decompose carbonic acid, assimilate the fluids sent into them from the stem, evaporate the superfluous moisture, and returning the inspissated sap downwards, gradually harden the tissue of the circumference. Thus, as De Candolle well remarks, a branch, during its increase in length, is under the influence of two opposing forces; the one, from below, softening its tissue and forcing it to lengthen; the other, from above, solidifying it and rendering it incapable of elongation. This fact, about which there can be no doubt, explains how it is that the branches of plants growing in wet and shady places, are long, succulent, and brittle; while those produced in hot, dry, and sunburnt places, are short, stiff, tough, and stunted. In the first case the force of elongation is not sufficiently overcome by the decomposition of carbonic acid, &c., and the consequent solidification of the tissue; in the latter, the force from below, in itself is feeble, and is very much overcome by the powerful action of the leaves, and the degree in which all the parts become hardened. It is only when neither shade nor sunlight are in excess that the pliable, tough, and evenly-formed branches of trees are produced. When the force from below is entirely overcome by the force from above, branches cease to grow.

In general, plants increase but little in diameter till their full annual length is nearly attained; but as soon as that has happened, they enlarge sensibly, and often rapidly, forming woody matter. In what manner this is brought about has been a fertile subject of controversy, in which physiologists have scarcely been unanimous in anything till lately, when they seem to agree in admitting this, that wood is sent downwards from the leaves. If you tie a ligature round the branch of an Exogen, the diameter above the ligature will increase, that below it will remain without alteration. And if you wound an Exogen by cutting off a large patch of its bark, new woody matter will form upon the upper lip of the wound, and no where else.

Fig. 96.



This point being settled, opinions have been pretty generally divided between two inferences; the one, that wood is organized matter, sent directly downwards from the leaves and buds; the other, that it is produced by the organizable matter formed in the leaves and given off by the bark. There are difficulties in the way of either of these suppositions; but those relating to the first appear all susceptible of satisfactory explanation; while nothing like an answer has been made to the objections to the latter.

If you take the branch of a Lilac when it is just clothed with leaves, and while the bark will freely separate from the wood, and peel it, you will find ridges of tubes passing downwards from each leaf, turning aside (*fig.* 97) at every

Fig. 97.



little obstruction, re-uniting after the obstacle is passed, and, together, forming a firm fibrous case to the subjacent

wood of the previous year. In others, the fibres may be traced in like manner from the leaves; but instead of running parallel with each other, they cross each other diagonally, and form a sort of lozenge work. This is wholly inexplicable upon the supposition that wood is deposited by the bark; but it is clearly intelligible if the wood is regarded as an organic emanation from the bases of the leaves. Again, in Endogens, the woody fibres may be distinctly traced into the leaves, from which it is plain that they originate; and in this case, at least, it is manifest that the woody bundles cannot be organized matter deposited by the bark; for they are in the centre, while the bark is at the circumference. We therefore cannot resist the conclusion that wood is organic matter emitted from the bases of the leaves, passing partially down the bark, and rendering the liber fibrous, but principally confined to the wood.

Du Petit Thouars, indeed, went so far as to assert that wood is, in fact, composed of the roots of buds and leaves, inclosed below a common bark, and that plants are, in fact, communities of individuals, each having an independent existence, although combined in one common system. When we consider that buds have the power of emitting roots when cut off the plant on which they grew; that in the Dragon tree if one bud vegetates, upon a trunk otherwise dead, as sometimes happens, the bud, having no longer a series of vital systems with which it may combine, sends out undoubted roots beneath the bark, instead of the woody fibres that it would have emitted under ordinary circumstances; and that, in other cases, when wood has died, the living buds have formed a sort of entangled sheath of roots by the fibrous matter they have sent downwards; when we seriously consider these things, it is impossible not to admire the genius which led Du Petit Thouars to advance so bold a doctrine, and difficult not to assent to its truth.

Without, however, embarrassing ourselves with this speculation, which is not of much practical importance, it may be safely asserted that there is no possibility of accounting for all the phenomena connected with the formation of wood, without understanding it to be produced by organic matter proceeding directly from the buds and leaves.

We must, then, adopt the following theory of vegetable growth, which, we believe, will be found conformable to admitted facts, in all the divisions of the vegetable kingdom. A plant is a mass of cellular tissue, capable of expansion and growth in all directions. When there is no leafy system, growth is indefinite, and not carried on in any particular direction, and no woody system is formed; but when leaves are developed, they send their organic fibres down through the mass of cellular substance, and arrange them sometimes in one way, sometimes in another, according to the specific powers of a plant. Upon this supposition the stem of a woody plant will be composed of two essentially distinct systems; the one cellular, constituting the pith, the principal part of the bark, and the medullary processes (if an Exogen), and capable of growth in all directions; the other fibro-vascular, comprising the wood and a part of the bark, and capable of growth longitudinally only. It will be found that this will answer all the objections which have been made to wood being an organic emanation of the leaves.

The following is a favourite argument with those who believe wood to be a superficial deposit from the bark. If, say they, a ring of bark is removed from a maple-tree, whose wood is white, and its place is carefully supplied by a ring of bark from a maple whose wood is red, the new bark will adhere to the old wood, uniting organically with it, so that, externally, the wound will be scarcely seen. Let a tree thus treated be allowed to grow for a year or two, and a quantity of wood, generated in the leaves, will be found beneath the ring of the red-wood maple; and being the produce of leaves and buds furnishing white wood, it should be white also, if, indeed, those organs really have the power of generating wood as is supposed. But it will be found that red wood will have been formed below the red bark; therefore wood is a deposit from the bark. This is one of those forms of fallacious reasoning which are the best calculated to catch the unwary, but which will not bear examination. The facts stated in it are true, but the inference is false, as will be intelligible from the following

diagram:—Let the letters *a*, *b*, *c*, *d* (*fig.* 98) represent a section of a tree, round whose wood (*a c* and *b d*) a ring of red bark (*e e*) has been made to grow. As soon as the diameter of such a piece of wood commences to increase, it is by a double action; the first arising from the *horizontal* expansion of the cellular system of the bark and medullary processes, which will remove the bark, *a*, *b*, *c*, *d* to *f*, *g*, *h*, *i*; and consequently the red ring *e* will advance to *k*; the second depends upon the introduction of the fibro-vascular system of the wood *longitudinally* among the horizontal system, to make room for the former of which, the latter is constantly growing. Now the colour of young wood depends entirely, and of old wood in a great degree, upon the colour of the medullary processes or horizontal cellular system; and consequently as the ring of red bark, which is a part of the same system, has grown outwards (that is from *e* to *k*) as the tree has increased in diameter, it would necessarily form a zone of red matter below it: and this would not be in the least interfered with in appearance by the new wood descending from above, because the latter, being colourless, would derive its colour from the horizontal system of the medullary rays, through which it would pass in its descent.

Fig. 98.



In like manner all other objections, however plausible, which have as yet been made to this view of the origin of wood, are to be answered with equal facility.

It is not, perhaps, of any practical importance to ascertain which theory of the origin of wood is the most correct, now that physiologists are, at all events, agreed upon its being produced in some way by the action of leaves freely exposed to sun or bright light. And this is abundantly sufficient to show the cultivators of trees the great importance of thinning their plantations carefully, without having recourse to severe pruning, which necessarily diminishes the power of the plant to form wood, because it deprives it of the leaves by which exclusively wood is generated.

Chapter VIII.

Of the Relation of Vegetation to Seasons.

Repose from growth seems periodically necessary to most plants, and accordingly we find there is no country without a season of growth and a season of rest—whether they are called by the name of winter and summer, or rainy season and dry season. This fact is connected with several considerations to which we have not yet adverted. What is about to be said has reference to the seasons of the North of Europe: it is left to the reader to apply the observations to the climate of other parts of the world.

In the winter, we commonly say that all vegetation is at rest, that the sap ceases to flow, new parts to be developed, and old parts to enlarge. But this is not exactly true. It appears, from experiment, that vegetation is at all times more or less active; and that we ought to say, that it is languid in winter, and energetic in the spring and summer. The fact of many plants retaining their leaves, of others swelling their buds, and of all forming an addition more or less considerable to the points of their roots during winter, sufficiently attest the movement of the fluids, and the existence of vegetation even at that season. This is further proved by the well-known fact, that trees planted in the autumn become turgid with the fluid absorbed by their roots during winter; and as it appears from the French newspapers, by some recent experiments of M. Biot, who is represented to have succeeded in obtaining a flow of the sap from certain trees in mid-winter.

But whatever power of attracting sap by its roots a plant may possess during winter, it is obvious that it has little means of parting with any part of it again by evaporation at that period of the year; so that during the winter the whole of the tissue must gradually acquire a state of turgidity which will go on increasing till the leaves and new branches are developed

and carry off the sap, or decompose and assimilate it.

This turgid state is eminently favourable to rapid growth when vegetation once resumes its activity; for it acts as a force from behind, which continually presses upon the new-born tissue, and causes it to expand. It is well known that after very long winters, or when a plant has been prevented by artificial means from shooting at its usual season, its branches and leaves are developed with extraordinary vigour; a circumstance which has been ascribed to *accumulated irritability*, but which is in fact owing to the turgid state of the tissue.

It is when the temperature of the air is raised sufficiently high, that the vital energy of a plant is excited, and buds are developed with their leaves. Light has certainly nothing to do with this phenomenon, although it afterwards colours and consolidates the young parts; for if a plant is exposed to an elevated temperature, in total darkness, its growth takes place as if in the light. The common experiment of introducing into a hothouse the branch of a Vine growing in the open air, is another familiar illustration of this fact: the temperature of the hothouse excites the buds into action, they immediately attract fluid from beneath them, and thus the whole system is put in motion, although the Vine-plant may be exposed beyond the house to all the inclemency of winter. De Candolle has proved by a simple experiment, that in such a case as this the fluid consumed by the young leaves is really attracted from out of the cold earth, and not absorbed from the atmosphere of the hothouse. If you select a tree with two principal branches, and two principal roots to correspond with them, and adapt to each root in the earth a bottle of water, you will find that the bottle that corresponds with the branch in the hothouse will be quickly emptied, while that which is connected with the branch in the open air remains nearly full. It may be supposed that in a natural state of things a corresponding effect is produced upon the roots by the warmth of the surface of the soil, and that they also are stimulated into activity: but it is doubtful whether this amounts to much, if, indeed, it is of any importance whatever: for provided only the earth is not frozen, it appears from experiments that heat applied to the branches alone is quite sufficient to determine and maintain all the phenomena of growth.

Once set in action, the branches of a tree go on growing according to the laws which have now been explained. They and their leaves, by degrees, gain their full growth; bark and wood separate, and cambium deposited between them; the leaves decompose the fluid they receive, send their fibres down within the substance of the branches, gradually secrete the substances peculiar to each particular species, and transfer them to the bark; and finally, becoming clogged at every pore by the earthy and carbonaceous matters that are deposited during the processes of digestion and evaporation, cease to act efficiently as leaves. In this state they are principally protectors of the young buds in their axils. If the latter have been formed very early, they are so far advanced in their growth by the middle of the summer, that they have already arrived at the same state as later-formed buds will be in at the commencement of another spring. Acted upon by the temperature of the season, they develop and call into play the same class of phenomena as took place in the beginning of the spring: the sap, which had become languid as the leaves became impotent, is again stimulated to a rapid movement, and is secreted anew in increased quantity. This is indicated by what gardeners call the running of the bark; that is to say, the bark and wood of Exogens separate spontaneously as in the spring, depositing a layer of cambium between them. Thus are formed what are called Midsummer-shoots, which only occur in plants which bud very early in the spring.

In the course of the autumn, the increased and prolonged heat and drought complete the destruction of the leaves, which had already begun to languish: all their vital actions are destroyed by the quantity of foreign matter with which their cells, their stomates, their vessels, and their intercellular passages are filled, and they drop off.

At this time a plant is nearly exhausted of its fluid sap, the watery portion of which had exhaled during the summer and autumn: all the parts are dry and solidified, so as to suffer little from evaporation; and the roots themselves, having for some time

been but feebly in action, are firm and not liable to be easily broken; everything is in a state of languor, and prepared to renovate the enfeebled powers of the plant by the slow and gradual absorption of fluid during the winter.

It is in the autumn, then, that both theory and practice direct us to transplant trees. At that season every circumstance concurs to render the operation practicable; but if we wait till the spring, the spongelets which form during winter are likely to be destroyed, and many causes may call the already turgid plant into growth, before the roots have had time to form new spongelets.

The seasons of growth and repose are so essential to vegetation, that, as is familiar to all gardeners, it is scarcely possible to prevent plants preparing themselves for their annual changes, whatever artificial means may be employed to maintain them in a uniform atmosphere, and to protect them from those causes which usually bring about repose; and this is certain, that if we can succeed in preventing the cessation of growth, the plants which are the subject of the experiment uniformly, in the end, fall victims to the forced and unnatural condition in which they are maintained.

If annual changes in their condition are requisite to the well-being of plants, so in like manner are the diurnal changes of light and darkness. If plants were kept incessantly growing in light, they would be perpetually decomposing carbonic acid, and would, in consequence, become so stunted, that there could be no such thing as a tree, as is actually the case in the polar regions. If, on the contrary, they grow in constant darkness, their tissue becomes excessively lengthened and weak, no decomposition of carbonic acid takes place, none of the parts acquire solidity and vigour, and finally they perish. But under natural circumstances, plants, which in the day become exhausted by the decomposition of carbonic acid, and by the emptying of their tissue by evaporation, repair their forces at night by inhaling oxygen copiously, and so forming a new supply of carbonic acid, and by absorbing moisture from the earth and air without the loss of any portion of it.

Such being the case, we must conclude that plants grow chiefly by day, and this is conformable to the few observations that have been made upon the subject. Meyer found the stem of a Belladonna Lily, and plants of Wheat and Barley, grow by day nearly twice as fast as at night: and Mulder states that he has arrived at a similar result in watching the development of other plants.

Chapter IX.

Of Vegetable Secretions.

One of the most important consequences of the decomposition and assimilation of their sap by plants is the formation of various secretions which are often peculiar to particular species. The production of these we must of necessity ascribe to the varied powers of the vital principle, for we cannot otherwise conceive in what manner the unelaborated fluids of the earth, or the gases mixed with the atmosphere, are converted to such a prodigious number of different products, by the uniform action of phenomena which are common to all plants.

These secretions are what give hardness and durability to wood, (while their absence renders it perishable,) flavour to fruit, and odour to flowers; which form the bitterness, acidity, or acridity of some, and the mucilaginous, farinaceous, saccharine, and other qualities of other species. Occasionally they may be perceived by the eye, assisted by the microscope, formed in regular crystals, having an acicular or prismatic figure, when they are called *raphides* (*fig.* 91); but most commonly

Fig. 91.



they are amorphous and confounded with the tissue, or exist only in a fluid state. The nature and chemical proportions of these substances concern botany but little, and therefore a detailed account of them must be sought in the works of chemists. They are, however, in some things so intimately mixed up with physiological considerations as to require a short notice.

Pure vegetable secretions, of whatever kind, must, as has been already

shown, be the result of the combination of water and carbonic acid; that is, they must consist of the elements of water, with the addition of a variable amount of carbon; to which must be added nitrogen in some cases. And thus of an hundred and sixty-three distinct principles, which chemists have analyzed in the vegetable kingdom, there is not one of which oxygen, hydrogen, and carbon are not the elements; twenty-eight of them only having been found to contain nitrogen. In many cases the proportions in which these elements are combined are so similar in different principles, as in gum, starch, sugar, and lignine, that a very little change in the circumstances under which they are produced will suffice to convert the one into the other, so that they have even been considered as being all varieties of sugar itself. It is probable that all of this class, which De Candolle calls *hydrocarbonates*, are principally destined as nutrients of the young parts, and that they ought to be distinguished in regard to their functions from the acids, resins, alkalies, oils, and other secretions, which have apparently nothing to do with nutrition. They will accordingly be treated of separately in this place.

§ 1.—*Nutritious Secretions.*

Of the hydrocarbonates *gum* is the most common; it is found in the bark and wood of all plants in some proportion, and in many in great abundance. In the Cherry, the Arabian Acacia, the Tragacanth plant, and all those others which are called gum trees, it flows out in plenty when their bark is wounded, or when the surface of it cracks. The mucilage with which the sap is mingled immediately upon its introduction into the roots, and which is perhaps universal throughout the vegetable kingdom, and the jelly of the Grape, the Gooseberry, and other succulent fruits, are mere forms of gum. In short, the substance, being in reality nothing more than condensed water and carbon, is exactly what would be formed in common by all leaves, independently of the special power which different species may possess of secreting peculiar substances in addition.

Fecula or *Starch*, different as it is vulgarly considered, seems to be really little more than gum divided into minute portions, each of which is inclosed in a cell of tissue; and it is said to be the latter only which is coloured blue by iodine. It is converted into grape-sugar by the addition of acids, and alkalies render it soluble. While gum itself may be considered the nutrient principle of vegetation, lying freely among the system of a plant, and constantly in action, starch is apparently the same substance stored up in such a manner as not to be readily soluble in the water of vegetation; and this, as De Candolle well observes, appears to agree very well with the office that starch has to perform in the vegetable economy, namely, that of forming a reservoir of nutritious matter, which is to be consumed in supporting a plant at particular periods. Thus we find it stored up—1. in the albumen of Corn, of the Buckwheat, and of a multitude of other plants; 2. in fleshy cotyledons, such as those of the Bean and the Pea, which like albumen are magazines of food for the support of the embryo plant; 3. in tubers intended to nourish young shoots, as in the Potato, the Jerusalem Artichoke, the Arrow-root plant, &c.; 4. in all fleshy roots which have to furnish food to the young stems when they first begin to grow, as in Briony, and in the Inula Helenium, which furnishes the starch called inuline; 5. in all bulbs, or root-stocks having a similar destination; 6. in the centre of the stems of endogens, as in the Sago palm, which is a reservoir of food for the leaves when they first begin to grow; 6. in the receptacles of such plants as the Artichoke, where it acts as food for the young flowers; and in the liber of some trees, as the Pine and the Birch, and in the rind of certain fruits, such as the Date, the Bread-fruit, &c.

In all these cases the starch is either capable of supplying food to the young parts of the plant, or may be supposed to be provided for the sustenance of man. That the former is its more immediate destination is probable from its continuing to increase during the latter part of the year when the plant is preparing a fresh supply, reaching its maximum when the plant has ceased to grow, remaining stationary during winter, and rapidly diminishing with the growth of the young shoots in spring. Thus it is stated in a French agricultural work, that 100lbs. of Potatoes contained the following proportions of starch:—

August . . .	16lbs.
September . .	14½
October . . .	17

March . .	17lbs.
April	13½
May	10

In what way starch is adapted to the power which plants possess of absorption is not by any means clear. We know that it is only soluble at a temperature little below that of boiling water, when the organic integument of each little grain bursts, and allows the gummy matter it contains to flow out; but we have no such temperature in nature, not even in germination. De Candolle suggests that the action of several substances which exist along with starch, such as tannin and alkaline matters, may, in particular cases, cause a rupture of the integument, and liberate the gummy matter.

Sugar may be considered as starch, with an addition of oxygen, and consequently we find that the simple absorption of oxygen by seeds, when germinating, is sufficient to change their starch into sugar. Thus Barley is converted into Malt, by being forced to grow in the dark; and we find the fæcula that is present in flowers before they expand, converted into honey by the excessive absorption of oxygen which then takes place (see Chapters X. and XIII.) Like most of the secretions of plants, it is produced in greater quantity in southern than in northern latitudes. The Sugar-cane is scarcely sweet in our stoves, the richest Figs and Grapes that can be produced by artificial means in England will bear no comparison with those of the Mediterranean; and while the Chestnuts of the south of France contain as much as fourteen per cent. of crystallizable sugar, those of the north of Europe are almost sugarless. Is this owing to temperature? We think not; for the mean heat of a forcing-house in England is greater than that of the Levant. It is rather to the subtle and incomprehensible agency of light, which we have no means of imitating, that those important differences are to be ascribed. Sugar, like starch, appears to be intended for the nutrition of young organs; we find it abundantly in the ascending sap, whence it is transferred to the leaves; it is formed out of starch during germination for the support of the embryo plant, and during flowering for the food of the fertilizing organs; and it is carried off from the roots of herbaceous plants by the new leaves when they sprout in the spring. The Beet-root, for instance, rich as it is in sugar at the end of autumn, contains scarcely any after the leaves have been growing a short time in the spring; and the same is the case with Turnips and similar roots.

As gum, starch, and sugar seem to be the great nutrient principles of vegetation, it would be supposed that *lignine*, which is the result of their organization, must be extremely similar to them in composition. And such is really the fact, as will be obvious from a comparison of their chemical analysis as furnished by Gay Lussac and Thenard.

	Carbon.	Oxygen.	Hydrogen
Gum	42·23	50·84	6·93
Starch	43·55	49·68	6·77
Sugar (of the cane) . . .	42·27	50·63	6·90
Lignine . . .	52·00	41·25	5·75

Lignine, therefore, differs from gum, starch, and sugar, principally in its elements consisting of a larger proportion of carbon; and it is not improbable that the quality of timber depends, to a considerable extent, upon the amount of its carbon; for although but few researches have yet been made into this curious question, yet as far as they go they seem to indicate such to be the fact. De Candolle gives the following proportions of carbon from the works of Gay Lussac and Thenard, and of Prout:—

Cormonna Wood .	55	per cent.
Iron Wood . .	53·44	
Oak	52·53	
Beech	51·45	
Box	50	
Willow . . .	49·80	

From these and similar considerations of the nature of the nutritious secretions of plants we may draw the following conclusions:—The rising sap passes into the leaves charged with carbonic acid, or matter capable of being converted into it; it loses a large proportion of its water by evaporation, and of its oxygen by the decomposition of its carbonic acid, and thus becomes reduced to carbon and water in an inspissated state, which is gum when free, and lignine when fixed. From the lignine is organized the tissue, among which the gum circulates for its support and consolidation, and within which it is also enclosed, and elaborated into various other principles, remaining as starch when but little changed. A portion of the gum settles

downwards through the stem: that part which is in the bark, being intercepted by no opposing current, finds its way down into the roots; such other part as finds itself in the alburnum is caught by the ascending current of sap, dissolved in it, and carried again into the leaves, there to undergo changes similar to what it had previously experienced. Whenever the gum meets in its course with cells that are empty, it is absorbed by them, and becomes subject to their special vital powers, changing to the principles which each particular species or organ has the property of elaborating, and the most readily to those which, like sugar, have the greatest chemical resemblance to itself.

§ 2.—*Special Secretions.*

Besides the secretions just spoken of, there are many others which are diffused through the system of certain plants, but which neither appear to contribute to the process of nutrition, nor enter into the general plan of vegetation, but are confined to particular species. They may be classed under the heads of milky fluids, resins, volatile oils, and fixed oils.

Milky fluids are generally characteristic of certain natural groups of plants, existing in every species, if in any; as is the case in Euphorbiaceous, Apocyneous, Papaveraceous, and other plants. When such are wounded, the milky fluids are forced out from both lips of the wound, showing that it is discharged in consequence of a contraction of the tubes or cavities in which it lies. These latter are of various kinds: sometimes they are long, thin-sided tubes, resembling the intestine of an animal; and sometimes they are rows of thick-sided cubical cells, such as are represented at *fig.* 90 *c*. By Schultz and Meyen, indeed, they are described as vessels of a particular kind, which the former calls *vital*; but there is every reason to believe that some error of importance is connected with their observations; for no one in this country has yet been able to discover what those gentlemen talk of having seen. Milk is usually white; but it is frequently orange, as in Celandine and the Gamboge tree; and it is occasionally crimson: in common Purslane it is said to be brownish-green. De Candolle distinguishes three sorts of milky fluid:—1. That in which caoutchouc is present. This is most common in plants of hot latitudes, hardly existing in the temperate zone under natural circumstances. It is most abundant in certain Apocyneous plants, such as Urceola elastica and Vahea Madagascariensis, which furnish the India rubber of India; and in some Euphorbiaceous species, such as Hevea Guianensis, or Artocarpeous ones, like Ficus elastica, from which that of other tropical countries is obtained. These are usually acrid and poisonous, although they are occasionally wholesome when the parts are young and have been exposed to heat. 2. Narcotic milk, in which opium is an essential ingredient, such as is met with in Poppies; and 3. A sort, of which fibrine is a principal component. This substance, which is very like animal fibrine, is characteristic of the milk of the Papaw-tree, and of the Cow-tree, whose milk is said, besides fibrine, to contain half its weight of vegetable wax.

When plants whose juice is milky are employed for food, any method which either prevents the formation of the milkiness, or by which it is removed when formed, is found effectual to render them then a safe aliment. Blanching, in particular, is attended to a certainty with the effect of removing noxious qualities, inasmuch as milk, like all other secretions, can only be formed when the leaves are fully exposed to light: the same thing happens when plants are very young, when they have not had time to elaborate their secretions, by attending to which the peasants of Languedoc are said to eat young Wild Poppies with impunity; and further, as it is through the bark that such secretions descend, any part of the wood will be harmless in plants whose milky bark is poisonous. Thus the peasants of Teneriffe are enabled to suck the cooling lymph from the wood of a highly poisonous plant called Euphorbia Canariensis, by first stripping off its bark.

Resins are common in the bark of several natural orders, especially of coniferous plants; they are also met with in the wood, and even in the pith. They have no tissue specially provided for their reception; but form for themselves, by their own proper weight, irregular fistular cavities. It appears as if a small quantity of resin first collects, and having formed a cyst, attracts more of the same substance to itself; and then acquiring volume and weight,

settles down among the cells or tubes, forming what are called turpentine vessels.—(*See* page 71.)

Volatile oils are found nowhere but in the leaves, flowers, or bark of plants, where, like resins, they form little cysts for themselves. Occasionally they are present in the pericarp or the seed, as in Anise and Coriander in the former case, and in the Nutmeg in the latter. They are said to be composed of two distinct principles—*elæoptine*, or the volatile, and *stearoptine*, or the concrete portion. These two are usually intimately combined in nature, so that they can only be separated by artificial means; but De Candolle thinks that, in the case of Camphor, we have the stearoptine in a separate state in nature. This substance is of by no means uncommon occurrence. Combined with a volatile oil it exists in Rosemary and Marjoram to the amount of 10 per cent., and in Lavender of 25 per cent; but in a naturally concrete state it occurs only in certain Laurels, such as the Laurus camphora and Sumatrensis; and in a large tree of the Malayan Archipelago, called Dryobalanops camphora, in whose bark, roots, and wood it is secreted in tears varying in size from a pea to that of a grain of sand.

Fixed oils have neither special forms of tissue nor irregular cavities within which they are deposited; but, like starch, they occupy and fill the interior of common cells. It is neither in the leafy nor cortical organs that they occur, but chiefly in the seed, as in the Flax; or occasionally in the pericarp, as in the Olive. They are more especially common in albumen, as in Palma Christi; and may probably be considered as a secretion which concurs, in some unknown manner, to the nutrition of the embryo plant. As there is scarcely any vegetable product more extensively useful than fixed oil, nor one which is more generally sought for mercantile purposes, it will not be without interest to know in what proportions it has been found to exist in the various seeds from which it has been pressed for profit. For this reason we borrow the following table from De Candolle:—

Seeds of the	Per cent. in weight.
Hazel Nut	60
Garden Cress	56 to 58
Olive	50
Walnut	50
Poppy	47 to 50
Almond	46
Common Spurge (Euphorbia lathyris)	41
Colza Rape	39
White Mustard	36
Tobacco	32 to 36
Plum	33
Common Rape	33
Summer Rape	30
Woad	30
Gold of Pleasure	28
Hemp	25
Fir	24
Flax	22
Black Mustard	18
Sunflower	15
Buck-wheat	12 to 16
Grape	10 to 18

§ 3.—*Local Secretions.*

Besides the two foregoing classes of secretions, there is a very considerable number which never enter into the general system of vegetation, and which have no particular situation, being found indifferently in many different parts of a plant. Many of them are very imperfectly known: they have nothing to do with the functions of vegetation, so far as we know; and it will be quite sufficient if we enumerate them in lists, under the heads of Acids, Alkalies, Neuter, Resinous, Tanning, and Colouring Principles.

Acids.—1. Ulmine, Ulmic, or Humic, which is also considered, with great probability, as being nothing more than the carbonaceous remains of dead vegetable matter; 2. Gallic; 3. Acetic, or Pyroligneous; 4. Malic; 5. Citric; 6. Pectic; 7. Rheic; 8. Krameric; 9. Ginkoic; 10. Glamic; 11. Lichenic; 12. Selenic; 13. Oxalic; 14. Tartaric; 15. Equisetic; 16. Moric; 17. Kinic; 18. Meconic; 19. Igasuric; 20. Abietic; 21. Pinic; 22. Sylvic; 23. Benzoic; 24. Kahinsic; 25. Phocenic; 26. Stearic; 27. Hydrocyanic, or Prussic; 28. Aspartic; and 29. Fungic.

Alkalies.—1. Delphine; 2. Aconitine; 3. Picrotoxine; 4. Morphine; 5. Sanguinarine; 6. Corydaline; 7. Violine; 8. Esculine; 9. Guaranine; 10. Brucine; 11. Conceine; 12. Quinine; 13. Cinchonine; 14. Strychnine; 15. Strychnochromine; 16. Solanine; 17. Nicotine; 18. Atropine; 19. Hyoscyamine; 20. Daturine; 21. Daphnine; 22. Rhabarbarine; 23. Buxine; 24. Veratrine; 25. Smilacine.

Neuter Principles.—1. Gluten; 2. Vegetable Albumen, or Glutine; 3. Pollenine; 4. Berberine; 5. Asparagine; 6. Amygdaline; 7. Emetine; 8. Coffeine; 9. Narcotine; 10. Gentianine; 11. Plumbagine; 12. Amanitine; 13. Fungine; 14. Osmazome; 15. Adipocire; 16. Gelatine; 17. Fibrine.

Resinous Principles.—1. Polygaline; 2. Hesperidine; 3. Aurade; 4. Zanthopicrite; 5. Busurine; 6. Quassine; 7. Cathartine; 8. Coumarine; 9. Glycyrrhizine; 10. Caryophylline; 11. Coloquintine; 12. Elaterine; 13. Olivine; 14. Jalapine; 15. Digitaline; 16. Laurine; 17. Piperine; 18. Salicine; 19. Populine; 20. Corticine; 21. Abietine; 22. Seillitine; 23. Zeine.

Tanning Principle.—Tannin.

Colouring Principles.—1. Hematine; 2. Breziline; 3. Santaline; 4. Morin; 5. Fustel; 6. Quercitrine; 7. Orcanettine; 8. Alizarine; 9. Purpurine; 10. Xanthine; 11. Dragon's Blood; 12. Curcumine; 13. Luteoline; 14. Indigotine; 15. Pittacul; 16. Chromule; 17. Carthamine; 18. Polychroite; 19. Rheadine; 20. Violine; 21. Oreine.

Chapter X.

Of Vegetable Excretions.

All the secretions hitherto spoken of are found in the inside of plants, and may be supposed to be innocuous, at least, if not useful, in the process of vegetation, as no attempt is ever made by plants to rid themselves of them, unless by accident.

There is another class, consisting of matters of various kinds, which would seem to be incompatible with the healthy being of vegetation, as we find them constantly thrown off on the outside of the root, or the stem and leaves, sometimes in the form of solid concretions, sometimes as viscid, or glairy, or other discharges, or most frequently as volatile emanations, which cause the various odours of the vegetable kingdom. These may be considered analogous to those parts of the food of animals which are voided, after having been deprived of their nutritious principles, and are therefore called excretions. We shall pass these rapidly in review, dwelling principally upon those of the roots, which seem to be the most important to man.

§ 1.—*From the Stem or Leaves.*

There is a plant common in gardens, called Fraxinella, whose leaves and stem are covered with little brown resinous glands, emitting a powerful balsamic odour. This plant, in warm weather, is surrounded by an inflammable atmosphere, formed by its own vapour, which will take fire when a light is applied to it, and produce a bright, rapid flame, which does no injury to the plant. It has been ascertained that this vapour is not hydrogen, but a volatile oil suspended in the atmosphere. Chenopodium vulvaria and several fragrant flowers have been found to give off pure ammoniac, and maritime plants are said to exhale chlorine.

Acid excretions are formed by the hairs of the Chick Pea, the Stagshorn Sumach, and some other species; and it is supposed that the singular property possessed by certain Lichens of immersing themselves in the calcareous rocks they inhabit, is owing to their excretion of oxalic acid.

The stinging power of the Nettle and similar plants is produced by an acrid matter which their hairs have the power of emitting when pressed, and which varies in intensity in different species. The Nettles of Europe simply produce an uneasy sensation, but some of those of India have brought on lock-jaw, and even death itself in torments; for the effect of their sting is represented to resemble boiling oil flowing over the part affected.

A discharge of *sticky* matter by the hairs, or simply by the surface, is of very common occurrence, especially by the former, which will be seen with minute drops of the excretion hanging from their points. It is this which gives their viscidity to such plants as the Rose Acacia, to the buds of the Horsechestnut, and the Tacamahac Poplar, and to the young leaves of the Birch tree. It is said to be in many cases chemically analogous to Birdlime.

Wax, or substances analogous to that production, and so called, is, in one shape or another, of very common occurrence on the surface of plants, and it exists even in their substance, as in pollen, some barks, &c. It forms the bloom of such fruit as the Plum and the Cucumber; it causes the glaucous appearance of Cabbages and Seakail, and produces the powdery efflorescence that is found on the surface of many Chenopodeous plants: in these cases it constitutes a coating which repels

water, so as to protect the parts from which it is excreted from the effect of humidity. In some instances wax is thrown off by plants in such considerable quantity, as to render the collection of it an object of trade. The Candleberry Myrtle (Myrica cerifera) has its berries guarded by a thick coat of vegetable wax; if thrown into boiling water, the wax is melted and floats, when it is skimmed off, and converted into candles of good quality; they are, however, green. The berries of this plant have been stated to furnish about one-ninth of their weight of wax. The Wax Palm (Ceroxylon Andicola) has its trunk covered with a thick coating of wax, which seems to ooze out from all parts of the surface both of the bark and leaves.

Sugar, or at least saccharine matter in a liquid state, is too well known in the form of the honey of flowers to require more than to be pointed out; in a solid form it is less common. We have it however in a crystalline state, secreted by the upper lip of the flowers of the Rhododendron Pontieum, and in the beak of Strelitzia; it exists upon the surface of a kind of Sea-weed called Fucus saccharinus, and it appears in large solid concretions as Manna. This substance, which is discharged in Europe chiefly by the Flowering Ash (Fraxinus ornus), either in consequence of wounds artificially inflicted on the branches, or of the punctures of insects, is produced by other plants in other countries. The Manna of Scripture is yielded by a species of Tamarisk, and by the Camel's-thorn (Alhagi Maurorum); it distils in India from a kind of Celastrus, and the common Larch furnishes a particular kind of Manna in no inconsiderable quantity.

In addition to the foregoing instances of excretions from the leaves or stems or flowers, there remains to be noticed the saline efflorescence of marine plants; a glairy substance which clothes the surface of submersed plants apparently for the purpose of protecting them from immediate contact with so active a solvent as water; discharges of insipid fluid from the points of the leaves of certain plants, especially of the Cæsalpinia pluviosa, a Brazilian tree which is said to produce a shower of drops of water resembling rain, and finally the pulpy matter which occurs in the inside of the seed-vessels of many fruits: the last-mentioned substance is an austere and acid fluid in Sophora Japonica; an opaque sub-acid pulp in the Tamarind, and an odoriferous stimulating juice in the Balsam of Tolu plant (Myrospermum toluiferum); in Cathartocarpus fistula it is a viscid purgative extract; in the Arnotta fruit it is a coloured powdery matter; in the common Quince it is a mucilaginous secretion, which covers the seeds; and there is a great many other kinds.

§ 2.—*From the Roots.*

That roots give off in some cases a peculiar matter, has been known for some time. Brugmans was the first to observe it in the Heartsease, and it was afterwards remarked in the Elm and some other plants. No one, however, seems to have suspected this to be a general function of vegetation before M. De Candolle, who as long ago as the year 1805 called attention to this curious subject. It now appears from experiments conducted by M. Macaire of Geneva, that to throw off excretions by the roots is a general property of plants, and one of their most important vital actions; that the matter so thrown off is in most cases deleterious to the species ejecting it, although it may be harmless to others, and that particular species discharge by their roots a matter so deleterious as actually to poison the soil. He found that Leguminous plants produce a substance analogous to gum, and a little carbonate of lime; grasses a minute quantity of matter containing certain alkaline and earthy muriates and carbonates, but very little gum; that Chicoraceous plants exude in abundance a brownish bitter excretion analogous to opium, and containing tannin, a gummy extractive brown matter, and certain salts; Papaveraceous plants a substance of a similar nature; Euphorbias a gummy resinous secretion of a yellowish white colour, and of an acrid flavour, and so on.

This fact probably explains why a plant will not generally succeed if planted in the earth which has been previously occupied by the same species. An apple-tree will not grow on the spot where an apple-tree has previously grown; wheat will not follow wheat, nor an oak-tree an oak; and this not from the soil being exhausted of nutritive principles, for the same effect will take place whatever the quantity of manure that is employed. This circumstance had always been inexplicable till the discovery of secretions from roots; for the old supposition that each plant was able to select its peculiar food from the soil, and so to exhaust it for itself, although not for others, was perfectly gratuitous. It now appears that, as roots absorb indifferently everything sufficiently fluid which is presented to them, when one species immediately follows another in the same soil, it is placed in the same situation as an animal compelled to feed upon its own excrement; and we know from experiment that they cannot bear that. For if you place a plant of Belladonna in a weak solution of extract of Belladonna, it is rapidly killed. The faculty indeed which plants possess of getting rid of the excretions of the roots would seem to be a necessary condition of their life; for if they had not such a power, the fæcal matter which they now part with would be redissolved by the ascending sap, and carried back into their system to their own destruction. Macaire showed by a simple experiment that a plant, if poisoned, will disembarrass itself of the offending matter by its roots if it has the opportunity. He took a plant of Mercury (Mercurialis annua), and divided its roots into two parcels, one of which he introduced into a weak solution of acetate of lead, and the other parcel into pure water; at the end of a few hours the water which was originally pure had become perceptibly impregnated with acetate of lead, which had therefore been taken into the circulation by the roots on one side of the plant, and thrown off again by the roots on the other.

Until a greater variety of experiments shall have been tried upon the nature and mutual action of excretions of this nature, it will be impossible to determine to what extent the discovery is of practical application. In the mean while it remains highly probable that it explains the cause of certain plants being considered weeds, or, as the French say, *mauvaises herbes*, that is, injurious to their neighbours; and that it will enable the scientific agriculturist to reduce to some intelligible laws the practice of farmers in regard to the succession of their crops, which is as yet entirely empirical. It moreover appears certain that it explains the cause of plants grown in pots, notwithstanding the quantity of manure that is given them, becoming unhealthy, unless their soil be frequently changed.

Chapter XI.

Flowering.

The foregoing Chapters will have explained by what means plants are nourished, and what the general result is of their nutritive action. The phenomena attendant upon flowering and fruiting have next to be considered.

The act of flowering or of expanding the flower is that which appears the most striking to ordinary observers; but it is in reality a mere preparation for the far more important act of reproduction. A great many highly-curious and interesting facts have been collected concerning it, but they are so little understood, their mutual connexion is so little apparent, and we are so far from comprehending their value in relation to other functions, that we shall occupy but little space in this treatise with their explanation.

Flowers are always prepared in the centre of the buds, or embosomed among the leaves for a considerable time before they expand. It is probable that the causes which conduce to dispose their parts to become sepals, petals, &c. instead of leaves, take effect at a very early period, when they are extremely rudimentary; but what the exact nature of those causes is we do not know. In general they are formed so rapidly, that a few months are sufficient to pass them through their larvæ state, but in certain Palms some years appear to be required. It is said that the rudiments of flowers may be discovered in the central bud of these plants as much, in some instances, as seven years before the perfect flowers expand. To watch the gradual change of the organs in such cases as these would be at once one of the most instructive and amusing inquiries in which a Botanist with leisure, opportunity, and good faith, could engage.

To what causes the production of flowers is owing is uncertain; it must generally be referred to the specific nature of plants, or what is called their idiosyncracy. Annuals, for instance, flower in a few weeks after their seeds are sown; what are called biennials demand some months; perennials a longer time, and trees several years: we know no more of the cause of this,

than of the cause of their being annuals, biennials, perennials, and trees. Some, again, blossom in the winter, as the Chimonanthus, the Christmas Rose, and the fragrant Coltsfoot; others in the earliest spring, as the Snowdrop, Adoxa, and the Crocus; while others, like certain species of Michaelmas Daisy, and the Chinese Chrysanthemum, cannot be made, by any known artificial means, to advance their autumn flowering even a few weeks. Plants, in short, have a periodicity of flowering varying in different species, which appears inherent in their own proper nature, and not capable of explanation upon any hypothesis worth mentioning.

The same is true of the hours at which they open their blossoms; one expands at dawn of day, another species a few hours later, a third at mid-day, some in the early evening, and a few when darkness has established her dominion. Hence, what are called the *Watches of Flora* have been constructed; tables in which every hour of the day is filled up by the expansion of some flower; but however useful these may be for comparing climate, they assuredly conduce in no degree whatever to elucidating the causes of the singular phenomena they represent.

Certain facts there are, however, which are deserving of notice, because they have a general application, and serve to throw light upon some of these obscure and unintelligible phenomena.

It would seem to be a general law that the quantity of flowers which a plant produces will be in proportion to the quantity of nutritious matter which that plant may be able to accumulate. If a Hyacinth is deprived of its leaves one year, it will not blossom the succeeding year; but if its leaves are so fully exposed to light and air that they go through their growth in uninterrupted health, and the flowers are destroyed for one year, the bulbs will blossom more finely than ever the succeeding year in consequence of the great quantity of nutritious matter that will have accumulated; for, in this case, not only is a sufficient quantity secreted by the leaves, but the stock prepared the previous year remains unexhausted in consequence of the flowers, which would have consumed it, having been destroyed. After hot and bright summers, when leaves have been in uninterrupted action, and a great quantity of solid matter has been deposited, as is obvious in the stunted state of the branches, a most abundant crop of blossoms is invariably the result; while the reverse takes place after cold and gloomy summers, which produce weak and watery shoots. Or if a tree is sterile, its branches may be made fertile by depriving them of a ring of bark near their insertion; this interrupts the backward flow of the sap, causes the nutritious secretions to collect above the annular incision, and thus brings on the formation of flowers. It is not improbable that this may be explained upon the supposition that when plants are in a state of slow growth, as in hot and dry summers, the appendages of the axis are retarded in their growth, fixed in whorls, and receive a tendency to imperfect development which will inevitably produce flowers; while, on the contrary, no arrestation of growth, nor any fixing in whorls, will take place when plants are in a state of constant and rapid growth, and consequently nothing but leaves will be the result. This will be the better understood by a reference to the laws of Morphology (Chap. XXV., Part I.); and is, to a certain extent, illustrated by a fact well known to all observing gardeners, that, in wet and warm springs, a great number of the blossom buds of Pears and Apples are converted into leaf-buds by the excessively rapid development which they undergo breaking up the whorls of their flowers, throwing an excessive quantity of sap into the organs which had been destined for flowering purposes, and thus converting them into leaves.

There is also another fact which seems to show that flowering depends upon the accumulation of a sufficient quantity of nutritive matter in the part which is to flower. An Apple when raised from seed, and left to unassisted Nature, will not flower in less than on an average seven years. But if a cutting of it, one year old, be grafted upon an old bearing tree, which is able to infuse into it a large quantity of nutritive matter, it will bear the second year after being grafted; so that by this means in three years at the latest a plant may be artificially made to bear, which, under ordinary circumstances, would not flower in less than seven at the soonest.

The mere act of flowering is a preparation for fertilization, with reference to which it is principally important, and in relation to which some other circumstances will be spoken of. As soon as fertilization is accomplished, a new being, the embryo, is called into existence, which attracts to itself all the nutritive matter that was before conducted to the sepals, petals, and stamens; the latter then shrivel up, and the act of flowering is accomplished. There are, however, some curious exceptions to this rule. In many plants the sepals continue to grow after fertilization has taken place. In others, as the Burmese Varnish Tree (Melanorrhœa) the petals become excessively enlarged; but the stamens uniformly perish.

For the amusement of those who are interested in such matters, we subjoin a *Watch of Flora*,—that is, the hour of expansion of various flowers, as it is recorded by Linnæus for Upsal, and by De Candolle for Paris:—

Name of Plant.	Upsal.	Paris.
Convolvulus nil and sepium	..	3–4 a.m.
Tragopogon pratense	3–5 a.m.	4–5 a.m.
Other Cichoraceous plants	4–5 do.	do.
Matricaria suaveolens	...	do.
Crepis tectorum	4–5 a.m.	...
Papaver nudicaule	5 a.m.	5 a.m.
Moist Cichoraceæ	..	do.
Momordica elaterium	...	5–6 a.m.
Lapsana communis, and many Cichoraceous plants	5–6 a.m.	do.
Convolvulus tricolor	...	do.
Hypocharis maculata	6 a.m.	6 a.m.
Solanum, several species	...	do.
Convolvulus Siculus	...	do.
Sonchus, different species	6–7 a.m.	6–7 a.m.
Hieracium, do.	6–7 a.m.	do.
Nuphar and Nymphæa	7	7 a.m.
Lactuca sativa	...	do.
Camelina sativa	...	do.
Prenanthes muralis	...	do.
Mesembryanthemum barbatum	...	7–8 a.m.
Specularia speculum	...	do.
Cucumis anguria	...	do.
Calendula pluvialis	7 a.m.	do.
Anagallis arvensis	8	8 a.m.
Dianthus prolifer	8	...
Nolana prostrata	....	8–9
Hieracium chondrilloides	9	...
Calendula arvensis	9	...
Mesembryanthemum barbatum, &c.	7–8	...
Mesembryanthemum crystallinum	9–10	9–10
Arenaria	9–10	...
Mesembryanthemum nodiflorum	10–11	10–11
Portulaca sativa	...	11
Ornithogalum umbellatum (called on that account Dame d'onze heures)	..	11
Tigridia pavonia	...	do.
Most Ficoideous plants	...	12
Scilla pomeridiana	...	2 p.m.
Silene noctiflora	9–10	5–6
Mirabilis jalapa	5	6–7
Pelargonium triste	6	...
Cereus grandiflorus	9–10	7–8
Mesembryanthemum noctiflorum	...	do.
Œnothera tetraptera	...	do.
——— suaveolens	...	do.
Convolvulus purpureus	...	10 p.m.

Chapter XII.

Fertilization.

Upon looking to the writings of ancient authors, we find that, from a very early period, the world was acquainted with two cases in which the presence of flowers of a particular kind was necessary to ensure the fertilization of another kind borne by the same species, ultimately bearing fruit if fertilization was effected; but remaining sterile provided the flowers of the first kind were not permitted to exercise their influence. One of these cases was the Date Palm, the other was the Fig.

Man had learned from experience that those flowers of the Date, in which the beginning of a fruit was discoverable, would never arrive at maturity unless sprinkled with the powder secreted in the flowers of other individuals of the same species of Palm: and hence they considered the latter to be males and the former females; which was true. Wild Figs again were found to be necessary, by coming in contact with it, to enable the fruit of the cultivated Fig to mature; and hence they also supposed the former to be males and the latter to be females, which, however, was *not* true. Caprification, as this latter phenomenon was termed, did not depend upon the powder of the wild Fig coming in contact with the young fruit of the cultivated Fig, but upon a totally different circumstance; for both kinds of Fig are in reality perfect in themselves. What makes the act of caprification necessary is this,—that the flowers of a Fig are inclosed in a fleshy case, which finally becomes the fruit, and, from some unknown cause, does not readily ripen unless injured by the puncture of an insect.

The Wild Fig abounds in a little fly called a Cynips; and, consequently, when the former is brought into the vicinity of the cultivated Fig, the latter is attacked by the Cynips, and so enabled to mature. It is clear from their having confounded, under the same idea, two phenomena so essentially different as these, that the ancients had no real knowledge of the sexes of plants; and it is probable that all their notions were deduced from hypothetical considerations arising out of the comparison drawn by their philosophers between plants and animals, than from any exact knowledge which they possessed.

Nor, indeed, is there any reason to believe that the discovery of the sexes in plants, as a general fact, can be traced farther back than the time of Sir Thos. Millington, Green, Malpighi, and Ray. The latter said in express terms, in the year 1694, that the points of the stamen are the most essential parts of a flower, as they contain pollen, which, in his opinion, is endowed with a prolific power, and serves to fertilize the seeds. From this time the question was settled among botanists, notwithstanding the captious objections of a few writers whose names and opinions have alike sunk in oblivion. It was Linnæus, however, who brought the subject more particularly before the world, in consequence of his having employed the sexes of plants as the basis of his classification; and although, in point of fact, this writer added little or nothing to what was before known, and even by his speculations upon hybrid plants rather tended to weaken the theory in the eyes of men of science, yet the attractions of his style, and the skill with which he embellished the subject, were such, that the vulgar believe him to have been the discoverer of the existence of vegetable sexuality. From his time to the present every succeeding observation has tended to confirm this curious fact; and the mass of evidence is now so great, that no one thinks of calling its truth in question as a general law of Nature.

In fact, if the thing is considered a little, we find on all sides the clearest evidence that seeds cannot be fertilized without the contact of pollen and stigma. We select a few of the most striking. Maize is a kind of corn, the anthers of which are formed in the loose panicles that terminate the stem; the styles, with their stigmas, are the long silken tassels which hang down from the short branches near the base of the stem. If the panicles are destroyed, the stigmas are not fertilized, and no grain is produced. Take an Apple-blossom, and cut out the anthers before the anthers burst; no apple will be formed. Let the stamens be all converted into petals, as in double flowers, and the pistils are barren, however perfect they themselves may be. In a Cucumber plant some of the flowers bear nothing but stamens, and others contain nothing but pistils. If the former are carefully cut away, the latter, instead of swelling immediately after the flower has withered, will become yellow, cease growing, and suddenly drop off. We are therefore surrounded by proofs of the necessity of the anthers to fertilize the pistils.

Nevertheless, as in some animals, so in some plants, it appears that parts analogous to flowers produce fertile bodies, resembling seeds in their power of reproducing the species, without there being any trace of anthers. This occurs in Ferns, Fungi, Lichens, Seaweeds, and, in all probability, in every tribe of flowerless plants. This fact has led some botanists to deny the necessity of anthers in species where they are regularly produced. It has been asserted that the Basil (Ocymum), Hemp, and Spinach will produce fertile seeds without coming in contact with the pollen; but while this is asserted by one observer it is denied by another, and appears altogether so contrary to common sense as to be undeserving any further remark than this, —that in those species anthers are regularly produced, as perfect in their structure as in any plants whatever; and that it is not probable they would be so produced unless they had their usual office to perform. Are we to believe that no sexes exist in the animal kingdom because the Aphis is increased without their aid? Passing by, then, these speculations, let us look at the highly-curious phenomena of fertilization, as understood by the best observers.

When the flower unfolds, the anther is a tolerably solid, moist body, filled with moist pollen. The grains of the latter contain a fluid more dense than the tissue that forms a covering for them, and rapidly absorb its moisture from the anther case. As soon as this has happened to any great extent, the tissue of the anther case contracts, and at first rends into grated cells of various forms; as the dryness is increased, these latter contract still further, and exercising a general power over the whole surface of the lining, would, in the end, be rent into still finer portions, if it were not for the slight degree of cohesion which exists between the valves of the anther at the sutural line. Here, then, the lateral strain of the contracting cells compels the anther to open, and the pollen is enabled to fall out.

At the same time that this is going on in the anther, the tissue of the stigma is becoming more and more lax, and secreting a viscid fluid between its cells; so that by the time the pollen is discharged from the anther, the stigma has become an uneven, clammy surface, with prominent cells, between which any foreign matter can be easily insinuated.

Upon the stigma thus prepared the grains of pollen either drop or are cast, or are conveyed by wind, insects, or other means; and there they are secured by the clamminess of the organ.

When the grains of pollen have lain upon the stigma for several hours they open at their angles, or upon certain definite points of their surface, and the thin inner lining, which is of a highly-extensible nature, is gradually prolonged into extremely slender intestines, called *pollen-tubes*, which sink into the tissue of the stigma, burying themselves within it, just as the roots of a plant bury themselves in the soil.

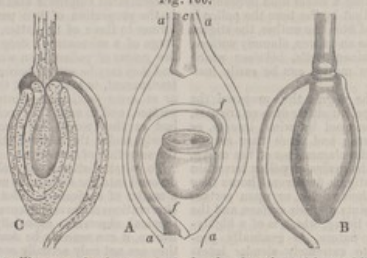
By means of the pollen-tubes the matter contained in the pollen-grains is conveyed into the interior of the style, whence it is supposed to pass into the ovule. This matter has been already (p. 42) described as consisting of round and oblong minute particles floating in liquid; and it is believed that the fertilizing principle, be it what it may, resides in those particles,—perhaps only in the larger kind, perhaps in the smaller—possibly in both. In general, it is very difficult to see the pollen-tubes; for if the pollen rubs freely from the surface of the stigma, the tubes are not emitted; if it is removed with difficulty, the tubes are broken off. They may, however, be easily seen in any Gesnera, by scraping from off the stigma pollen that has been in contact with it at least forty-eight hours. The Crocus also parts with its pollen-tubes easily; and if a minute portion of the stigma of Crocus vernus is pressed gently in water between two plates of glass till it is transparent, the pollen-tubes will be distinctly seen buried in the stigma, with the turbid matter of the pollen lying in unequal quantities in their inside. Amici recommends the Althæa frutex for the same observation; but that plant is not well adapted for examination, because in this northern climate its pollen is rarely perfect. Should a difficulty be after all experienced in witnessing these singular phenomena, it may be brought about artificially by the following simple means. Place a drop of a solution of concentrated sulphuric acid and water, in the proportion of two parts of the former to three of the latter, upon the stage of a microscope; drop into it a few grains of pollen, then watch them, and they may be seen to become rapidly transparent, to give way at the angles, or at some particular points of their surface, and to emit their pollen-tubes just as they would, only much more slowly, under the natural stimulus of the secretion of the stigma.

To what distance the pollen-tubes descend into the style is, in most cases, a matter of conjecture. But from the observations of several accurate microscopical observers, especially of Dr. Brown, it can scarcely be doubted that they are not only actually conveyed to the placenta, but are introduced into the ovules. This distinguished Botanist confirms the statement of Du Petit Thouars, that a cord developed in the stigma of Orchideous plants may be traced to the placentæ and consequently to the ovules; and he declares that this cord is entirely composed of pollen-tubes. He found the branches of the cord scattered over the whole surface of the placentæ in Orchis Morio; and he even succeeded in tracing in several, though not in many instances, a single tube to the foramen of an ovule. He was also so fortunate as to witness the same phenomenon in many cases in Habenaria viridis. Adolphe Brongniart also describes the pollen-tubes in the Rock Rose (Helianthemum) as entering the cavity of the ovary, and descending from its summit till they reach the ovules.

In connexion with these phenomena, there is another class of actions on the part of the ovules which it is important to be aware of. In many cases it has

been seen, and it is probable that in all cases it happens that at the time when pollen-tubes are plunged into the stigma, the ovules adjust themselves so as to present their foramen either to the placenta, or else to that point of the lining of the ovary by which the pollen-tubes afterwards enter. This is plainly the case in the Rock Roses just referred to; in Euphorbias it may also be witnessed; and the very act of curving which takes place in so many ovules, as has already been mentioned (p. 46, *fig.* 61), is no doubt for the purpose of effecting the same object. If we examine the ovule of the Spurge Laurel (Daphne Laureola), before the pollen falls upon the stigma, we shall find its foramen turned towards the dome of the ovary, but far from touching it. Soon after the pollen has acted upon the stigma the ovule approaches the dome, a short process in direct communication with the stigma is at the same time protruded from the dome, and finally closes up the foramen, thus bringing the nucleus of the ovule in direct organic communication with the stigma. A similar case of rather a more complicated kind, and not so easily witnessed as the last, occurs in the Thrift plant (Armeria vulgaris), *fig.* 100.

Fig. 100.



Let the ellipse *a a*, *fig.* A, represent a section of the ovary of this plant. From its base there arises an umbilical cord *f f*, which curves after reaching about half the length of the cavity, and bending down upon itself again turns partially up, bearing an ovule at its apex. When very young this ovule is a sort of cup, the mouth of which is closed by a little cone, and is turned towards the apex of the ovary. From all access to the dome of the ovary the ovule is cut off, notwithstanding its position, by the cord which over against the aperture of the ovule spreads into a kind of strap. It is from the point of the ovary *c*, that the stigmas arise; and from immediately below their origin a short cylinder projects down into the cavity of the ovary. Matters being thus arranged, the pollen falls upon the stigma, and pollen tubes are forced into its tissue and gradually find their way into the cylinder; at the same time the ovule lengthens, contracts at its aperture, and is brought near the cylinder by the elevation of its umbilical cord; at last the strap is slipped aside, the cylinder lengthens, the ovule rises, and with its aperture embraces the point of the cylinder, which is somewhat conical, and which is thus brought into contact with the nucleus. At this time the parts are in the position represented at *fig.* B; and if cut through longitudinally, as at C, they will be seen to be placed in the most favourable position that can be imagined for enabling any fertilizing matter that may have been communicated to the stigma to find its way into the interior of the ovule.

What the nature is of the communication thus made by the pollen to the ovule through the medium of the pollen-tubes, the result of which is fertilization, we have no means of knowing. It may either be a peculiar stimulus which is required to call into existence an embryo germ of life residing in the point of the nucleus; or it may be the act of conveying such a germ to the

nucleus from out of the pollen grains. Opinions are divided upon these points, and they are likely to remain so; for we can conceive no means of solving the problem. It may, however, be remarked, that Dr. Brown declares that he could not discover the pollen-tubes of Orchideæ, even in their earliest stage, while in length hardly equal to the diameter of the grain, to contain distinct granules; and that when, with a magnifying power of 300 or 400, minute and very transparent granular matter came into view, it was extremely different from the granules of the pollen-grains. As it is not improbable that this may be a special and not a general case, and that it is connected with the peculiar structure of Orchideous plants, we do not think much stress ought to be laid upon it in the present state of our knowledge; especially as pollen-tubes do, in other instances, most unquestionably contain the molecular matter of the pollen-grain, whatever the functions of that matter may be considered to be.

The principal difficulties in the way of admitting actual contact between the pollen and the stigma to be indispensable to fertilization, exist in Orchideous and Asclepiadeous plants; in both which Nature seems to have taken infinite pains to prevent such contact. In the former, in particular, there are many cases in which actual contact seems physically impossible, and there are others in which it is very improbable; and although the pollen when placed upon the stigma is undoubtedly capable of producing its tubes, yet as molecular matter cannot be detected in them, it may be doubtful whether the pollen-tubes when developed are not rudimentary organs. Several botanists, and particularly Mr. Bauer, believe that fertilization takes place in these plants by some peculiar mode of internal communication; but whatever may be the fact with regard to Orchideous plants, none can now remain in regard to Asclepiadeous plants, after the luminous explanations of the manner in which it is effected which have appeared within these few years, especially from Ehrenberg, Brown, and Adolphe Brongniart.

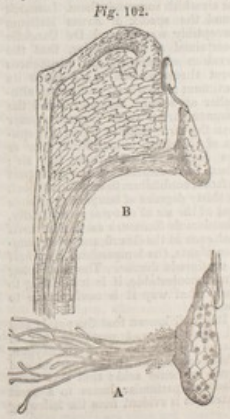
In these plants the stigma is a fleshy five-cornered disk, having a gland (*fig.* 101, *d*) at each angle. To each gland is attached a pair of yellow bags (*b*) containing the pollen, and called *pollen*

Fig. 101.



masses; which are more convex on one edge than on the other. The stigma itself has no visible secreting surface; and as the pollen masses had never been seen to discharge the pollen grains, it was supposed that fertilization must be in this case effected by some internal communication through the glands. But Ehrenberg proved that the grains of pollen produce pollen-tubes all directed towards the most convex edge of the pollen mass, which is also the thinnest, and that they are eventually forced through it. Brown and Brongniart, pursuing this fact, instituted some very careful observations upon the sub-

Fig. 102.



ject, the result of which proved not only that pollen tubes are emitted by Asclepiadeous plants, but that they bury themselves in the stigma just as in other plants, and as is represented at *fig.* 102, where A represents a pollen mass with its pollen-tubes protruded, and B shows the manner in which they are introduced into the stigma.

From these circumstances we may conclude, that in the fertilization of plants pollen falls upon the stigma and inserts a tube into its tissue; that the tube reaches the aperture of the ovule; and that unless this happens fertilization is not accomplished. We must here dismiss this curious subject, leaving many most interesting facts untold, and proceed at once to other matter.

Chapter XIII.

Of the Temperature of Flowers.

If we test the temperature of a flower, however large it may be, it is extremely probable that we shall discover no difference whatever between it and the external air. And yet it appears certain from well-attested observations, and probably from theory, that flowers have at certain periods of the day a temperature much elevated above that of the air which surrounds them. Lamarck found the spadix of Arum Italicum perceptibly warm; and De Candolle ascertained at Montpellier, that the elevation of temperature commences about three o'clock P. M., gains its maximum at five P.M., and ceases altogether at seven. Senebier found the common Arum seven degrees warmer than the air. Schultz found the spadix of Caladium pinnatifidum four or five degrees warmer than the air; others have ascertained the same part in Arum cordifolium to acquire as much as thirty degrees of temperature above that of the air at sun-rise; and finally, Theodore de Saussure assured himself that even in the Gourd, and other common plants, the temperature rises half a centigrade degree. The fact being thus incontestable, it is interesting to see in what way it is conformable to theory.

It is well known that the petals and all other *coloured* parts (p. 90) of plants deprive the air of its oxygen, which combines with their carbon and forms carbonic acid: that this takes place at particular hours to a great extent, as is evident from the following table of the result of some experiments made by Theodore de Saussure upon the proportion of oxygen consumed by plants in proportion to their volume, when placed in receivers of atmospheric air over mercury; the experiment lasting twenty-four hours, and the external temperature being between 18° and 25° centigrade.

	Oxygen consumed by Flowers.	Leaves.
Common Stock, single red var.	11	4
Ditto, double	7·7	
Tuberose, single	9	3
Ditto, double	7·4	
Brugmansia arborea	9	5
Passiflora serratifolia	18·5	5·25
Hibiscus speciosus	8·7	5·1
Gourd, sterile Flowers	12	6·7
White Lily	5	2·5
Typha	9·8	4·25
&c. &c. &c.		

It was also ascertained that the stamens and pistils are still more rapacious of oxygen. Those of the Stock consumed 18 times their volume instead of 11½; of the Nasturtium, 16·3 instead of 8·5; and of the Gourd, 16 instead of 7·6. But it was found that this takes place to the most considerable extent in Arums. While the spathe of the common Arum consumed only 5 times its volume of oxygen, its spadix destroyed 30 times, and that part on which the stamens and pistils are placed as much as 32 times.

Hence it would seem that the high temperature of flowers is owing to the combination of oxygen and carbon, which produces a kind of combustion; and if so, we ought to find signs of disengagement of caloric by all flowers. It is, however, to be remembered, that in by far the greater number of flowers the heat is carried off by the atmosphere the instant it is disengaged, and that it is only where flowers are collected in great numbers within cases which act as non-conductors and confine the heat, as happens in Arums, that the elevation of temperature becomes appreciable.

Chapter XIV.

Of Fruiting.

Immediately after fertilization has taken place, all the parts of the ovary swell, the ovule closes its aperture, the stigma loses its humidity, the vessels of the style collapse, and the latter organ either drops off or hardens upon the ovary as a rigid process; while at the same time an embryo plant developes in the inside of the ovule. This latter occurrence never supervenes unless the act of fertilization is accomplished; all the others may take place, the ovary may grow, and even the integuments may acquire their mature dimensions, in the absence of it.

In by far the greater number of cases, the pericarp becomes more and more leathery, woody, cartilaginous, or membranous, and gradually changes from green to brown or white; and in such cases the world is scarcely conscious of the production of fruit. But in some instances the pericarp acquires a greater volume, becomes succulent instead of drying up, often acquires the gayest colours, and in time becomes what we popularly term fruit, that is, a body which may be eaten, or looks as if it might. It is said that, in the former of these cases, the surface of the fruit abounds in stomates, which enable the fluid matter of the pericarp to be freely evaporated, and that in the latter an absence of stomates causes the fluid matter to accumulate; but it is to be suspected that there is more hypothesis than truth in this speculation. Be that however as it may, it is with the latter class of fruits that the world is most conversant, and in which it is most interested, and to which it is therefore most desirable that we should turn our attention. We will consider them, firstly, as to their action upon the atmosphere, and secondly, as to the nature of the changes which lead them, from being acid, austere bodies, to become the rich, sweet, fragrant, and often luscious productions, which we find in the Peach, the Orange, the Fig, the Grape, and the like.

With reference to the first of these considerations, the words of Theodore de Saussure are the only ones which it is necessary to quote. "Fruits, while green, whether leafy or fleshy," says this great observer, "act much as leaves either in the sun or in shade, and differ from those organs principally in the intensity of their action. In the night they destroy the oxygen of their atmosphere, and replace it with carbonic acid, which they partially absorb again. This absorption is generally less in the open air than under a receiver; and their volume remaining the same, they consume more oxygen in darkness when distant from ripeness than when they are approaching that state. If exposed to the sun, they disengage altogether or in part the oxygen which they inspired during the night, and preserve no trace of this acid in their own atmosphere. If many fruits are detached from the plant, they thus add oxygen to air which contains no carbonic acid. When their vegetation is very feeble, or extremely languid, they vitiate the air under all circumstances, but less in the sun than in the shade. Green fruits detached from a plant, and exposed successively to the action of the sun and of darkness, change it but little or not at all either in purity or in volume. The trifling variations that may be remarked in this respect depend either upon the greater or less faculty which they have of elaborating carbonic acid, or in their composition, which is modified according to the degree of their ripeness. Thus Grapes in a state of verjuice appear to assimilate in small quantity the oxygen of the carbonic acid which they form in the air where they vegetate both day and night; while, on the contrary, Grapes nearly ripe give back almost entirely during the day to their own atmosphere the oxygen of the carbonic acid they have formed in darkness. If there is no deception in this circumstance, which, although feeble, appears to have been constant, it marks the passage from the acid to the sweet state by indicating that the acidity of verjuice depends upon the fixing of the oxygen of the air, and that this acidity disappears when the fruit no longer seeks for carbon in the air or in carbonic acid. Green fruits decompose either entirely or in part not only the carbonic acid they have produced during the night, but in addition such quantity as may be artificially added to their atmosphere. When this last experiment is tried with fruits which are not watery, and which, like Apples and Grapes, elaborate but slowly carbonic acid, one sees that they absorb in the sun a much larger proportion of gas than the same volume of water in a similar mixture; afterwards they disengage the oxygen of the carbonic acid absorbed, and thus appear to elaborate it in their interior.

"They appropriate to themselves during their vegetation both oxygen and water, compelling the latter to lose its liquid state.

"These results are often not observ-

able in volumes of air less than from 30 to 40 times that of the volume of the fruit, and by diminishing the heating power of the sun. If such precautions are neglected, many fruits will vitiate the air even in the sun by forming carbonic acid with the ambient oxygen; but even in the latter case, the simple comparison of their effect in light with what they produce under the influence of night and darkness, demonstrates that they decompose carbonic acid."

With regard to the alterations which the constituent parts of fruit undergo during the action of the preceding phenomena, and in the course of maturation, we cannot do better than reproduce the results obtained by De Candolle, from the observations of Bérard of Montpelier.

If we examine the modifications which the flesh of fruits undergoes in ripening, we shall at first remark that their fibrous or cellular tissue (which varies very much in quantity in different species) is merely lignine. In most cases, especially in very fleshy fruits, lighter, less tough, and more easily soluble in alkaline solutions than common lignine; but presenting characters of an opposite kind in other parts of the same fruit, such as their stones.

The liquid which fills the flesh of succulent pericarps consists of sap placed in the inter-cellular passages and of the matter contained in the cells. This liquid of the flesh, or of the fleshy endocarp, contains, besides a great quantity of water, sugar, gum, malic acid, malate of lime, colouring matter, a vegeto-animal substance, and an aromatic secretion peculiar to each fruit: there is, moreover, in certain cases, the tartrates both of potash and of lime, as in Grapes; and citric acid in the Lemon, and even in small quantity in the Gooseberry.

A comparison of the analysis of certain fruits before they are ripe and at that period gives some curious results. In the first place there is a disappearance of water in a liquid state, viz. per cent.—

	Water before ripeness.	Water at ripeness.
Apricots	89·39	74·87
Currants	86·41	81·10
Duke Cherries	88·28	74·85
Green Gages	74·87	71·10
Melting Peaches	90·31	80·24
Jargonelle Pears	86·28	83·88

This diminution appears to depend in part upon the fruit absorbing less water as it approaches maturity, and in part upon the combination with its tissue of a portion of the water it has received. Sugar, on the contrary, appears to be continually on the increase, as indeed the taste would tell us; thus we find, per cent.,—

	Green.	Ripe.
Apricots (a trace when young, afterwards)	6·64	16·48
Red Currants	0·52	6·24
Duke Cherries	1·12	19·12
Green Gage Plums	17·71	24·81
Melting Peaches	0·63	11·61
Jargonelle Pears	6·43	11·52

This sugar is sometimes in a state more or less concrete, as in the Grape, the Fig, and the Peach, sometimes in a liquid state. It seems to be formed at the expense of other matters, the proportion of which diminishes. Thus the quantity of lignine per cent. is found—

	Green.	Ripe.
Apricots	3·61	1·86
Currants (including the seeds)	8·45	8·01
Duke Cherries	2·44	1·12
Green Gage Plums	1·26	1·11
Melting Peaches	3·01	1·21
Jargonelle Pears	3·80	2·19

It is possible, indeed, that the lignine formed in the green fruit did not in reality diminish, but that the dilatation of the cellular tissue, and consequently the augmentation of the aqueous products rendered it proportionably less, without its being absolutely so. But the gummy, mucilaginous, or gelatinous matters, appear very susceptible of changing into sugar: thus, M. Couverchel has found that if we treat apple jelly with a vegetable acid dissolved in water, we obtain a sugar analogous to that of Grapes; that the gum of Peas, placed with oxalic acid, in a temperature of 125° (Réaum.) changed to sugar; that gum extracted from starch, if mixed with the juice of green Grapes, rendered the latter saccharine; and finally that tartaric acid will produce the same effect by aid of heat: this is the reason why most fruits become sweet when cooked.

Other matters offer remarkable disparities between one fruit and another: thus malic acid keeps diminishing in Apricots and Pears, augmenting in Currants, Cherries, Plums, and Peaches. Gum keeps diminishing in Currants, Cherries, Plums, and Pears, and augmenting in Apricots and Peaches. Animal matter keeps diminishing in Apricots and Plums, and increasing in Currants, Peaches, Cherries, and Pears. Lime, which never exists except in small quantity, seems generally to diminish, probably because evaporation becomes less with maturity.

With regard to the alterations which fruits undergo after ripening, in most instances decaying and in others bletting, there are several circumstances deserving of attention. These two states of decomposition cannot, according to Bérard, take place except by the action of the oxygen of the air, although he admits that a very small quantity only is sufficient to cause it. He succeeded in preserving for several months, with little alteration, the fleshy fruits which were the subjects of the foregoing experiments, by placing them in hydrogen or nitrogen gases. All fruits at this extreme period of their duration, whether they decay or whether they blet, form carbonic acid with their own carbon and the oxygen of the air, and moreover disengage from their proper substance a certain quantity of carbonic acid.

Bletting is in particular a special alteration; it appears that the more austere a fruit is before this is brought on, the more it is capable of bletting regularly. It has been found that a Jargonelle Pear in passing to this state loses a great deal of water (83·88 reduced to 62·73), pretty much sugar (11·52 reduced to 8·77), and a little lignine (2·19 reduced to 1·85); but acquires rather more malic acid, gum and animal matter. Lignine, in particular, seems in this kind of alteration to undergo a change analogous to that of wood in decay.

With regard to the ripening of seeds, it may be remarked that in all cases the first thing that occurs after fertilization is the closing up of the aperture of the ovule; next to which comes the appearance of the embryo, which is originally an opaque speck near the apex of the nucleus, and which at that time is surrounded by a mucous fluid, from which it seems to derive its nutriment. Although in many cases no trace is finally discoverable of a chord connecting the embryo with the point of the nucleus, yet in some instances such a communication is plainly visible, as in Zamia and Cycas, and according to Brown in Orchideous plants. As the embryo advances in size, it projects forwards into the cavity of the ovule, absorbing the fluid-matter which bathes it, till, when it is finally ripe, there is no longer any water in an unfixed state. During the solidification of its parts it gradually exchanges its saccharine quality, which seems common to all seeds when young, for the amylaceous, oily, resinous, and other secretions which are peculiar to it. It also deposits among its tissue a variable quantity of earthy matter, and of carbon, which contributes to give it a certain degree of hardness, which in some instances is of a stony consistence. All this accomplished, it acquires a greater weight than water, and consequently if ripe seeds are thrown into that fluid they will sink if they are properly matured, unless, as happens in some cases, the integuments of the seed contain air-cells, or there should be a cavity in the centre of the seed itself.

Although the deposition of earthy or other solid matter is what marks the complete maturity of a seed, yet it appears that this condition is not necessary to secure germination, for Senebier found that unripe Peas vegetated more freely than ripe ones. It rather appears to be a provision of nature to protect them from accidents, and to enable them to resist in safety the many vicissitudes they are likely to experience, after having once separated from their parent plant.

It appears, indeed, as if the longevity of seeds, that is to say the length of time they can preserve their vegetative powers, depends very much upon the completeness of the protection afforded the embryo by its integuments. Gardeners know how impossible it is to preserve very delicate seeds with thin skins more than a few weeks or months; while, on the other hand, hard, bony seeds have been known to germinate after the lapse of a great number of years. When land is cleared, or ancient ditches emptied, or earth broken up to a considerable depth, as in well-digging, it not unfrequently happens that plants spring from the mould, whose seeds must have been buried for many years or ages. Even when exposed to the vicissitudes of climate, seeds will often grow after many years; seeds of melons have been known to grow after forty-one

years, Indian Wheat after thirty years, Rye after forty years, Sensitive Plant after sixty years, and Kidney Beans, taken from Tournefort's herbarium, a hundred years after they were gathered.

It is extremely difficult to say what the conditions are under which the vitality of seeds is thus preserved, so conflicting are the statements of cultivators, and so little apparent connexion have the instances of seminal longevity with each other. It may, however, upon the whole, be inferred from the duration of seeds buried in the earth, and from other circumstances, that the principal conditions are, 1. uniform temperature; 2. moderate dryness; and 3. exclusion of light. And it will be found that the success with which seeds are transported from foreign countries in a living state is in proportion to the care and skill with which these conditions are preserved. For example, seeds brought from India, round the Cape of Good Hope, rarely vegetate freely; in this case the double exposure to the heat of the equator, and the subsequent arrival of the seeds in cold latitudes, are probably the causes of their death, for seeds brought overland from India, and therefore not exposed to such fluctuations of temperature, generally succeed. Others, again, which cannot be conveyed with certainty if exposed to the air, will travel in safety for many months if buried in clay rammed hard in boxes; in this manner only can the seeds of the Mango be brought alive from the West Indies; and it was thus the principal part of the Araucaria Pines, now in England, were transported from Chile. It may therefore be well worth consideration whether, by some artificial contrivance, in which these principles shall be kept in view, it may not be possible to reduce to something like certainty the preservation of seeds in long voyages. Such, for instance, as by surrounding them by many layers of non-conducting matter: as case over case of wood; or by ramming every other space in such cases with clay in a dry state. These means seem more likely to answer their end than the usual modes of putting seeds in bottles, packing them in charcoal, or surrounding them by coats of wax—all of which, it is well known, are absolutely prejudicial, instead of beneficial to the seeds. In illustration of what we have recommended, we may add that seeds are well known to travel best in their own pods, or pericarps; may we not suppose that their vitality is preserved in such instances by the non-conducting quality of the air which the cavities of the fruit contain?

Chapter XV.

Of Germination.

When a plant has ripened its fruit and fully formed its seeds, it has, to a great extent, fulfilled its destiny, and it has accomplished the important act of reproducing its like. It will by that time have gone through all the phases of growth, and to whatever number of years it may afterwards exist, its life will be only a repetition of phenomena that have already occurred to it.

The act of germination, therefore, which is the springing into life of a new individual, is to be considered the first period of growth, and the commencement of a future system, not the termination of an old one, as might be supposed from the subject being mentioned thus late in the present sketch.

A seed when beginning to grow presents the following remarkable features. If placed in a humid medium, and exposed to a moderate degree of warmth, it absorbs the ambient fluid, distends, bursts its integuments, protrudes a root downwards into the earth, and shortly after elevates a stem into the air. This is all that strikes the ordinary observer; but if the seed be examined more carefully, it will be found to absorb oxygen from the air that surrounds it, and to give off carbonic acid in considerable quantity. By this means it gets rid of the carbon of which it originally consists in a high degree, and its parts are softened by water and rendered more capable of extension and expansion. If a seed is made to germinate in light this happens in a less degree; but in light or in darkness it happens always. Such being the case, and such the struggle on the part of the seed to get rid of its carbon by converting it into carbonic acid, we may conclude that whatever favours or impedes the destruction of carbon during germination will be advantageous or the contrary to the function. And this explains the cause of seeds buried at great depths beneath the soil, where they are cut off from communication with the oxygen of the atmosphere,

remaining for so many years without germinating. In fact it has been ascertained by experiment, that if seeds are placed either *in vacuo*, or in an atmosphere of nitrogen or hydrogen, they will not germinate; and still less in carbonic acid. It is a remarkable circumstance, and one which is of no little interest in pointing out the wonderful foresight with which every part of the creation is adapted to mundane conditions, that after many trials it has been found that seeds germinate most freely in an atmosphere consisting of one part oxygen and three parts nitrogen, which is nearly the proportion of the air we breathe. If the quantity of oxygen is increased, the carbon of the embryo is abstracted too rapidly, and the young plant is feeble; if the proportion is smaller, carbon is not lost in sufficient quantity, and the young plant is scarcely capable of being roused into life. These facts lead us to doubt the accuracy of those experiments which seemed to prove that germination might be accelerated, or even death arrested in seeds by excess in doses of oxygen; and it is well known that, although the name of Humboldt has been enlisted in the support of such speculations, they are by no means conformable to experience.

The consequence of the destruction of the oxygen of the air by the carbon of the seed produces a sensible heat in germination, just as a similar cause produces a like effect in flowers. Hence the heat of the masses of Barley, which are made to germinate in darkness in order to become malt. And it can scarcely be doubted that the change of the starch of that grain into sugar, is equally owing to the abstraction of a proportion of its carbon, and the addition of some other proportion of oxygen.

There can be no reasonable doubt that everything that has been created has been destined for some important purpose, and consequently one would expect that every part of a seed is important to the well-being of that seed. Nevertheless, it has been found possible to deprive an embryo of many of its parts, without actually destroying its vitality. Kidney Beans will grow pretty well with only one cotyledon, or even with neither; only in the latter case the young plant is very feeble. Oaks so treated have grown for several years, but were always remarkably small and delicate. Gourd seeds have had their radicle cut away as soon as it began to fruit, and it has been afterwards incessantly destroyed as it lengthened; the plumule also has been cut away, and yet in both cases germination has gone on as usual. Of course there must be a limit to these mutilations, but De Candolle exclaims, "Where, then, is life? Where is the seat of that mysterious principle which compels all the powers of decomposition to obey its call, to change their nature, and to become powers of recomposition?" This question is so difficult to answer, that we shall pass it by in silence.

Chapter XVI.

Of the Reproduction of Flowerless Plants.

The foregoing observations have carried us, somewhat superficially it must be confessed, but at the same time consecutively, through all the principal circumstances that occur in the life of a perfect plant.

All that relates to imperfect plants, or those which are increased by simple division of their own substance and not by seeds, is equally explicable upon the same rules, with the single exception of their reproduction. Upon this head it is necessary that we should offer a few special remarks.

It must be obvious upon consideration, that plants in which there exists neither stamens nor pistils, and in which there consequently cannot take place any of those phenomena we have lately been examining, must also be destitute of seeds; for a seed is nothing but a sac of mucous matter in a particular state of organization into which either the germ of a new individual has been conveyed, or wherein its existence has been produced by some unknown action of pollen. That Nature has not, however, neglected the means of propagating the lower tribes of plants, is plain from their great abundance in favourable situations; and, upon examination, we find that, if they have not reproductive organs like those of plants of a higher organization, they are furnished with matter of another kind which answers the purpose equally well. This matter consists of what are called *sporules* or *spores*, and is lodged in parts which may be considered analogous in their function to carpels,

although they have not only no resemblance in structure to those parts in flowering plants, but also very little among each other; the spore cases being sometimes elaborate pieces of organization, as in Ferns and Mosses, and sometimes mere simple tubes buried in the substance of the plant, as in Lichens, Fungi, &c.

In the more perfect of the tribes of flowerless plants, there can be no doubt that spores act precisely like seeds in reproducing the species; for if those from the back of the leaves of Ferns, or from the urn of a Moss are sown, as they have often been, they uniformly produce the same species as that from which they were derived. In regard to these plants, then, no difference exists between seeds and spores, except as to the origin, organization, and mode of development of the latter. Instead of having their centre divided into plumule and radicle, to which one or two cotyledons are attached, they are mere homogeneous masses of cellular substance; and instead of uniformly growing from two constant points of their surface, from one upwards, and from the other downwards, they are capable of sprouting into root or stem indifferently from any point of their surface; the nature of the part the spores produce depending not upon pre-existing organization, but upon accidental circumstances. When they begin to grow, that portion of the surface which is exposed to light extends into a stem, and that which is turned to darkness and humidity becomes root. Mirbel found in his experiments upon Marchantia, that it was possible, up to a particular period of the growth of the spores of that plant, to induce the parts they had developed to change their functions, the rudimentary stem taking on itself the office of a root, and the new-born root becoming stem when their situation was inverted.

It may be considered, then, an undoubted fact that the higher tribes of flowerless plants are multiplied by their spores, and reproduce their species each after its kind, just as much as flowering plants by their seeds. But with regard to the most simple forms of vegetation, such as Fungi, Lichens, and Sea-weeds, the subject is involved in so much greater mystery, that there are to this day Botanists of no mean reputation who believe such plants to be produced by means almost analogous to equivocal generation. In their opinion there is a common matter of vegetation, of which the green matter of Priestley may be taken as the purest form, consisting of simple globular cellules, and possessing the vital principle in each cellule. They suppose that such cellules have no specific power of reproduction, but that the various forms into which they eventually grow depend upon the atmospheric and other circumstances to which the cellules may be exposed, and not to any intrinsic property of their own. Thus such matter, which exists everywhere, if called into life upon a bare wall becomes a Lichen, in a dark cellar a Fungus, in the skin of a plant a Parasite, and in water a Conferva. It is thought that several circumstances tend to show the justice of such opinions; a Conferva, for instance, is never found in any other medium than water, and a Lichen only in air. Many forms of matter are said to be uniformly productive of the same species of plant, as, for example, decayed cheese, which has always the same kind of fungi—the Berberry, the Rose, and a host of other plants, whose parasites are always confined to particular species, and sometimes to particular organs, those of the bark not being always the same as those of the leaves. If a plant of these three tribes is examined microscopically, it will be found that it is often a mere mass of cellules, exactly like the spore or reproductive cellule, except in colour; and that, even in this respect, there is not always a difference; for in such species as the Red Snow-plant the cellules are all alike in colour as well as form. It is further asserted that the power of reproduction is not confined to the spores, but exists in all the cells of which these plants are composed; and we are told, by certain German writers, that if a Lichen be rubbed in pieces, its powder will produce a *Lichen-like* plant, although the spores are not allowed to mingle with the powder. It has been shown that one supposed species of merely cellular plants is transformed into another; and that even different genera might be seen to emanate from the very same original seed. Nees von Esenbeck watched the development of a cobwebby matter which is common in the hothouses at Bonn, and he found that when the weather was dark, as in the winter and autumn, it produced

the Sclerotium mycetospora; but that, upon the return of long, bright days, Agaricus volvaceus was born from it.

If we add to these considerations the singular fact that man holds, as it were, in his hands the power of creating these things at will, at least in the instance of the common Mushroom, which will always be produced by an artificial mixture of decayed and earthy matter, it cannot be denied that a strong *primâ facie* case is made out by those who doubt the specific power of reproduction in the spores of the lowest tribes of plants, and this without having recourse to the more questionable statements that spores become plants under one set of conditions, and animalcules under others.

It is, however, by no means clear that these arguments are well-founded. Many of them are answerable upon the ground of our imperfect powers of observation, which lead us to confound forms of matter which are essentially different. It by no means follows that spores are not differently organized from simple cells, because we cannot discover the difference in their organization. Let us remember that these parts can only be distinguished with the assistance of the finest microscopes, and we all of us know how little those instruments are capable of revealing, notwithstanding all their power. Neither have we a right to say that a cobwebby substance produces the genus Agaric in the summer, and the genus Sclerotium in the winter. We, in our blindness, may think fit to draw such distinctions; but our language ought rather to be that the Agaric and the Sclerotium are different states of the same species; for are they more different than the Pupa and the perfect Butterfly? That all sorts of errors as to the genera and species of imperfect plants do exist among Botanists is notorious. Unger has shown this to be the case in Lichens; no one can well doubt that it is so in Algæ. Unger has made it clear that not a few so-called parasitical plants are mere morbid conditions of the cuticle; and with regard to Fungi in general, what has just been said concerning their metamorphoses is quite sufficient to justify our doubts in regard to the distinctness in nature of what are called the genera and species of that tribe.

As to the conversion of living matter into either animal or vegetable forms, according to the external circumstances to which it is exposed, it must always be remembered that such supposed cases have only been found to occur when common water has been employed; and it is absurd in any observers to pretend to a knowledge of what kind of elementary matter impure water may contain. It is just as likely to contain the sperm of animalcules, invisible to our senses, as the spores of plants; and this is the more probable, when we consider that no one has ever procured either the one or the other from pure water. We have before us a jar of distilled water that has been standing freely exposed to light for eleven years, and it does not exhibit a trace of organic matter.

Surely it is more philosophical, more conformable to what we really know, to ascribe the phenomena that have lately been spoken of to myriads of microscopic spores floating in the atmosphere, and dispersed by currents of air wherever that air can penetrate; and those who are practically acquainted with the nature of spores will be the least likely to question the probability of this; for they best know how inconceivably minute, how infinitely numerous, such spores really are. Even the common observer may form some notion of the fact from the calculation that millions of millions must be contained in a single Mushroom; and that many hundreds of reproductive particles are emitted by every microscopic head of the common blue mould of cheese.

Let us not, then, be led astray by specious theories and imaginary facts concerning bodies so far beyond the cognizance of our senses; but, in the absence of demonstrative evidence to the contrary, let us believe the great Author of nature to be consistent with himself in all his works, and to have taken care to enable the most humble Sea-weed to be multiplied by some means as certain and unchangeable as is provided for the most stately lord of the forest. We may rest assured, for all philosophy, and all observation, and all reason prove it, that there is no such thing in nature as blind chance; but that all things have been carefully and wisely designed with reference to the particular circumstances under which they exist.

Chapter XVII.

Of Colours.

There certainly is no point of either animal or vegetable physiology now remaining to be explained of which so little is really known as the cause of the various and varying colours with which organic matter is adorned. We see in birds the plumage marked with the strongest contrasts of the most dissimilar colours, reproduced with an exactness which is most wonderful; we find the breeders of curious races able to preserve peculiar kinds of marking, and even to improve them, with the most admirable precision; we also know that in plants, without any visible constitutional change, without accident, and without any known predisposing cause, a yellow flower will become pink, and a pink one yellow; and we know that if the portion of the stem thus altered be multiplied by the division of itself, the change is fixed and may be multiplied for ever. A dingy brownish purple tulip will suddenly, and without warning, burst forth in the most radiant beauty, its dull disagreeable colours dispersed, a pure and spotless white taking its place in part, and the brightest and deepest streaks of crimson adding richness to its purity. If we look minutely to these circumstances, we shall find that each particular cell has its own colour,—that there is no intermixture of tints, but that whatever the hues may be, each has its own cluster of cells to represent it; and even in the midst of a large mass of uniform colouring, a few cells, or even a single one, will secrete a colouring matter which forms the strongest contrast with what surrounds it; as in the Blood Red Orange, and similar cases. To what causes all these extraordinary circumstances are to be ascribed no one knows. As yet our information concerning vegetable colours is of the vaguest nature. But as it is one of very great interest, and particularly deserving the notice of the philosophical botanist, we make no scruple of borrowing from De Candolle an abstract of what is at present known or conjectured of the subject.

We are so accustomed, he remarks, to see plants decorated with the most brilliant colours, or at least invested with the green hue which characterizes every scene, that it is not without difficulty that we accustom ourselves to the idea that such colours do not exist in their primitive state, but are communicated, as it were, to vegetation by its own act; and yet this is the exact truth. The tissue of plants is in itself completely colourless, of a silvery white, or of an exceedingly pale yellow; the matters contained in the cellules are, with a few exceptions, of the same hue; but all is changed when they are once exposed to solar light.

We are accustomed to say that green plants become white in total darkness, because the phenomenon, inaccurately observed, is usually presented to us under that form: but the truth is, that although the parts of plants which originally are white or black become more or less coloured when exposed to the action of light, yet that organs, once coloured, do not in reality lose their colour when kept in darkness; if they sometimes seem to do so it is owing to this,—that if half-developed leaves are placed in the dark, they grow larger, and the green matter which coloured them, being diluted by water and spread over a greater space, appears to be paler without being itself less coloured. That the action of solar light is, in reality, the grand cause of colour in plants is proved by leaves half covered from light and half exposed, of which the latter become green and the former remains colourless; all gradations of intensity being produced in proportion to the intensity of light to which the parts are exposed.

There are plants which, in those parts which are destined to become green, have spaces that preserve their original whiteness: such plants we call variegated, and find through almost all the divisions of the vegetable kingdom. In Exogens the blotches are for the most part irregular: in Endogens they are usually arranged in bands that follow the course of the principal veins. In these places it is clear that *chromule*, or colouring matter, is either not found at all or in very small quantity, but the cause of the deficiency is entirely unknown. It is, however, interesting to remark, that variegations of this kind are best preserved in sterile, and are soonest lost in fertile soil, as if they were in reality an unhealthy state of a plant,—a supposition, however, which there are no sufficient grounds otherwise for entertaining.

We have already seen that all parts which either are green or susceptible of becoming so, decompose the carbonic acid of the sap or of the atmosphere when they are exposed to solar light, that they part with the oxygen, and fix the carbon in their own tissue. Hence it was natural to conclude that this operation is connected with the formation of a green colour. In fact, when it takes place, greenness ensues; when it does not take place, the organ which developes in darkness, preserves the primitive white colour of the tissue; and when it has taken effect incompletely, the results are intermediate between the two preceding cases.

The deposition of carbon thus induced does not act upon the vegetable membrane; that is always of its original pearly lustre. But it forms a peculiar matter called green *chromule*; the abundance or scantiness of which is what causes the different tints of leafy surfaces. The action of the membrane produces some effect, no doubt, either by reason of its own pallid hue, or its transparency or density, or of the hairs with which it is often covered, or of the air which it contains, or, finally, of the waxy matter by which they are protected. But how does it happen that carbon, which is black, is capable of producing a green appearance in vegetation? The old physiologists supposed that it is in reality an intense blue, and not a black; and that, shining through the yellow sides of the cells, the combination of the two colours produced green. This notion, however, is disproved by the most casual inspection, for the colouring matter may be separated from the tissue with the greatest facility, and it still preserves its colour; and, besides, the yellow of tissue, if any, is so excessively feeble as to be wholly insufficient to overcome the blueness of the carbon if *it were blue*. The fact is, that the cause of carbon in the system of vegetation being green belongs to that numerous class of facts, of which no explanation can be given in the existing state of human knowledge.

Although we are justified by the mass of evidence in asserting that the green colour of plants is owing to the fixation of carbon in their tissue, in consequence of the power that light possesses of decomposing their carbonic acid, yet there are some exceptions that deserve attention. Humboldt found Poa annua and compressa, Plantago lanceolata, Trifolium arvense, Wallflower, and the Rhizomorpha verticillata green in the subterranean galleries of the mines of Freyberg, although born in total darkness, but in atmosphere highly charged either with hydrogen or nitrogen. Ferns and Mosses, again, will be green when other plants are blanched; and Humboldt found near the Canaries a Fucus which was bright grass-green, although it had grown at the depth of from 25 to 32 fathoms (190 feet.) Now, as light, according to the experiments of Bouguer, after traversing 180 feet is weakened in the proportion of 1 to 1477·8, this Fucus must have been illuminated when growing by a power 203 times less than that of a candle at a foot distance. Are we to suppose that this feeble degree of illumination was sufficient to decompose the carbonic acid of such a plant, or was not the decomposition rather owing to the operation of some unknown cause?

Leaves, which, as we very well know, are usually green, may assume different colours in special cases. It is common to see in the autumn this green change to yellow, as in the Lombardy Poplar, &c.; or to red, as in the Barberry, the Sumach, the Virginian creeper, and many kinds of Oaks. It has been ascertained by Macaire that in such cases the leaf, shortly before this change takes place, ceases to exhale oxygen in sun-light without ceasing to absorb it at night; whence he infers that the chromule is oxydized, which at first brings on a yellow and afterwards a red colour, for the most decided red always begins by a change to yellow. It is remarked that red colours are most common in leaves which contain some kind of acid, as the Vine, the Pear, the Viburnum, the Sorrel, &c. The red colouring matter obtained from leaves forms infusions which, like those from flowers, become more intense when acted upon by acids. Yellow leaves act in this manner like yellow flowers. It is supposed by some, that while red is owing to the development of acid, other colours may be ascribed to the presence of an alkali. This is however far from proved.

The same colours which mark leaves in the autumn may also be produced by certain accidents. Thus the puncture of an insect, the attacks of parasitical fungi, or injury from early frosts, produce partially or entirely yellow or red colours; and what is remarkable, the colours thus accidentally assumed are the same as the plant would have

taken of itself in the autumn: thus accidents turn the leaves of the Poplar and the Lilac yellow, of the Sumach or the Pear tree red, as they become in the autumn.

Certain leaves offer naturally on one or both their surfaces marks coloured in a particular manner, from the moment when they first unfold. Tradescantia discolor, and several Begonias have their under surface red; certain Arums are irregularly blotched with red; there are species of Amaranth which, in an apparently healthy and natural state, have leaves banded with both yellow and red. Macaire has determined that the red chromule of leaves which are thus discoloured is chemically the same as that produced in the autumn. It is worthy of note, that in regular and natural colourations red is very common, and yellow comparatively rare, although one would have thought that the latter, caused, as it seems to be, by a slighter kind of change than red, would have been the most common. Blue seems altogether excluded from changes of the leaves, except in the case of certain Eryngoes.

In many plants, the leaves which grow in the vicinity of flowers are accustomed to offer various tints, which are almost uniformly in unison with the colours of the flowers they accompany; such floral leaves or bracts are yellow in many Euphorbias, scarlet in Sages, violet in Clary, and blue in particular states of the Hydrangea. Macaire assures us that the chromule of the bracts of Salvia splendens presents the same chemical characters as that of leaves which turn red in autumn. Such bracts appear coloured because the chromule deposited in their cells varies in its degree of oxygenation, and such variations appear to be in distinct relation with the flowers. The same observations apply to many calyxes.

Why then should it be different with petals and the petal-like parts of a flower? These organs are in truth nothing but modified leaves; they are capable in particular cases, such as Hesperis Matronalis, of transforming themselves into genuine leaves, green and capable of exhaling oxygen. Can there be any the smallest reasonable doubt that these leafy petals contain in their cellules a chromule analogous to that of leaves, and consequently that when they are coloured they owe their colouring to a modification of chromule?

It is therefore probable that all the various colours of flowers, with the exception of certain special cases determined by the presence of some free alkali or acid, depend in general upon the various degrees of oxygenation of their chromule; and that this theory ought to extend to fruits and bracts where those organs participate in the same colours.

With regard to the exact relation that colours really bear to one another and to the causes that are supposed to influence them, a memoir upon the colours of flowers, published at Tubingen, in 1825, by Messrs. Schubler and Funk, is deserving of especial attention. From their account it appears that flowers may be divided into two great series—those having yellow for their type, and which are capable of passing into red or white, but never into blue; and those of which blue is the type, which can pass into red or white, but never yellow. The first of these series is called by these observers oxydized, and the second disoxydized, and they consider greenness as a state of equilibrium between the two series. De Candolle calls the first series *xanthic*, and the last *cyanic*. Upon this principle they admit the following scale, leaving white out of consideration:—

Red	
Orange red	Oxydized or Xanthic series.
Orange	
Orange yellow	
Yellow	
Yellow green	
Green	Colour of leaves.
Greenish blue	
Blue	Disoxydized or Cyanic series.
Violet blue	
Violet	
Violet red	
Red	

Which may be otherwise expressed thus—

	Green		
Cyanic or disoxydized series.	Greenish-blue	Yellow-green	Xanthic or oxydized series.
	Blue	Yellow	
	Violet-blue	Orange-yell.	
	Violet	Orange	
	Violet-red	Orange-red	
	Red		

It will be at once remarked, in considering these tables, that almost all flowers susceptible of changing colour only do it in general by rising or descending in the series to which they belong. Thus in the xanthic series, the flowers of Marvel of Peru may be yellow, orange-yellow, or red; those of the Austrian Rose, orange yellow or orange-red; those of the Nasturtium vary from yellow to orange and orange-red; those of the garden Ranunculus pass through every gradation in the series, from red to green. As to the cyanic series, the Anemone varies from blue to violet and red; the Hyacinth from green to red through all the gradations; the Lithospermum purpuro-cœruleum from blue to violet-red; and the China-aster from violet-blue to violet, violet-red, and red.

Although there are certain exceptions to these rules, particularly in the Hyacinths, some of whose varieties approach the xanthic series, yet they are so far conformable to nature as to help us either in searching for the causes of colours, or in predicting the possible varieties of colour in flowers of the same species and sometimes of the same genus.

To the xanthic series belong all, or nearly all, the species of Cactus, Fig-Marigold, Aloe, Cytisus, Wood sorrel, Rose, Mullein, Potentilla, Œnothera, Ranunculus, Adonis, Tulip, &c.; to the cyanic series those of Campanula, Phlox, Epilobium, Hyacinth, Geranium, Anagallis, Globularia, &c. Hence we may assume that there is in general a relation between the colours of flowers and generic classification—an hypothesis which may be the more readily admitted when it is considered that some apparent exceptions to the cases just quoted in reality confirm the rule: as for instance, in the Campanula aurea, whose flowers are deep yellow, in a series otherwise cyanic: it is now known that this plant constitutes in reality a genus essentially different from Campanula, and called Mussehia; and so with others.

It will have been remarked that white is omitted from these two series. It may be doubted, indeed, whether it really exists in a state of purity in flowers, and it seems to be rather some other colour reduced to an exceedingly light tint. Redouté, the French flower-painter, is said to have availed himself with great advantage of this fact. He always placed the flower he wished to represent before a sheet of paper like that on which he had made his drawing, and he uniformly found that the flower would differ from the paper in being more yellow, or more pink, or more blue, or in some other way. White Campanulas become blue when they are dried; infusions of white flowers in alcohol have always a perceptible tinge. Flowers which are white verging upon yellow, yield infusions which alkalies bring to a more decided yellow or a more positive brown; infusions of those which are white, tending to blue or red, become light red by the action of acids, and greenish by the action of alkalies.

It is probable that whiteness, or that kind of paleness which constitutes white, is owing to the chromule not being completely elaborated. This may be inferred, 1. from the analogy between this colour and blanched plants; 2. from the much greater number of white flowers in northern than in equatorial regions; and 3. from a considerable number of flowers which are born white, acquiring some other colour before they die, if exposed to solar light. Thus the Cheiranthus Chamæleo has a flower at first of a whitish colour, which afterwards becomes lemon-yellow, then red, slightly violet. Stylidium fruticosum has its young petals pale yellow, its old ones white tinged with red. The flowers of Œnothera tetraptera are at first whitish, afterwards pink, and finally red. The petals of the common Tamarind are said to be white the first day, and yellow the second. The corolla of Cobœa scandens is greenish-white the first day, and violet the next. Finally, Hibiscus mutabilis unfolds its blossoms in the morning white, by noon they are pink, and red at night. These changes are constant in the West Indies: but M. Ramon de la Sagra observed that on the 19th of October, 1828, the flowers of this plant remained white all day in the garden at the Havannah, and did not become pink till noon the next day. Now this 19th of October was remarkable for the centigrade thermometer not rising higher than 19°, while the ordinary temperature of the flowering season of the Hibiscus is 30° centigr.; so that it would seem that heat has some important connexion with the development of colour; and this notion is in accordance with the fact already mentioned, that white flowers are most common in cold countries.

Black is omitted in the two series of colours; it appears to be, in all cases, an excessively dark state of brown,

produced from a yellow base, or from a deep red; and is of too rare an occurrence to be deserving much consideration while so much remains to ascertain concerning commoner colours.

In red, there is this remarkable fact, that it belongs to both series; and if the theory of oxydation should be confirmed, it will appear to result from both the maximum and minimum of oxygenation. We may remark indeed that the various tints of red flowers differ much more from each other, than those of any other colour. Those which become red through the xanthic series have usually a more brilliant, richer, and more scarlet hue; while such as reach it through the cyanic series have a decidedly violet tinge. Rose, which is nothing but diffused red, may belong to both series; thus the rose colour of the Hydrangea evidently tends to blue, while that of the Rose itself appears to derive its origin from yellow. An infusion of red flowers in alcohol takes a tinge more or less red; add a little acid, and this colour immediately deepens; sometimes, as in the Pelargonium, it passes to orange. Alkalies produce the most variable results in different plants.

An examination of the two most irreconcileable colours, yellow and blue, points out some characters which are sufficiently well marked.

Infusions of yellow flowers in alcohol are of a clear yellow, without the flowers losing much colour. Acids produce no other effect in these infusions than to weaken their colour slightly. Alkalis make them more brilliant or browner.

Blue flowers produce, in alcohol, infusions either of a clear blue, as those of flax, or very dark, as in the case of the Aconite and the Larkspur. By the addition of acids they become red, and of alkalies green. Those which are coloured red by acids will not recover their blueness by the addition of alkalies, as sometimes happens to infusions of red flowers. Macaire having seen a red infusion of violets regain by degrees the natural blue of those flowers, by the addition of a vegetable alkali, such as quinine or strychnine, suspects that the colour of the violet depends upon the combination of their chromule with some alkali. Schubler and Funk assure us that the infusion of the Blue Day Lily (Funkia cœrulea), treated with an acid, will present in the same glass all the tints of the coloured spectrum. Blues are among the most changeable colours in vegetation, passing freely to white, and to different tints of violet and red.

From what has now been stated, it appears to result that modifications of chromule are the cause of the diversity of colours; and that these modifications depend principally upon the degree of oxygenation. In leaves fully developed the chromule is green; it gains a tendency to yellow or red when it is more oxydized, as one perceives by the changes of the colour of leaves in autumn by the effect of acids; and it appears to verge to blue when it is less oxydized, or, which comes to the same thing, more carbonated: thus we know that the flower of the Hydrangea becomes blue in a soil sufficiently impregnated with carbonate of iron.

All the brilliant spectacle of vegetable colours tends to disappear either in consequence of accidents or upon the approach of death; and what renders this subject the more curious is that, 1. discolouration is often determined by the same agents as, in other cases, produce colour; and 2. that certain organs which have no colour while alive gain when dead a very decided tint.

Solar light seems to be the most usual cause of those losses or changes of colours. While plants are alive, it acts, as we have so frequently seen, by colouring them; but in certain cases its too powerful action discolours them. Thus the cultivators of Tulips place their flowers under a tent, knowing very well that the direct action of the sun tends to alter their colours more promptly than would be the case in the shade. A great number of delicate flowers, particularly of those belonging to the cyanic series, exhibit this phenomenon.

Most aquatic plants gain in death a whitish hue; this is particularly remarked in Sea-weeds, which, from the most brilliant blue or green, pass to white when they die, an effect which seems to be augmented when they are exposed to air and light; but the exact mode of action of these several agents has not been appreciated. Fresh-water confervæ and several aquatic herbs present the same system of discoloration. Air evidently produces its effect by altering their chromule, probably by abstracting its carbon; for such is the ordinary effect of the air upon dead vegetable matter. Charas, in particular, when dried in the air become quite white; this tint is no doubt to be ascribed to the alteration of their chromule, but in all probability also to the enormous quantity of calcareous matter that those plants, while alive, fix in their tissue; other cases of a like nature may be easily named. The straw-coloured hue of the green parts in a great number of dead vegetables after death depends, on the one hand, upon the oxygenation of their chromule, and on the other on the decarbonization determined after death by the action of the oxygen of the air.

Most leaves when they die are invested with a uniform russet colour; it has some analogy with what happens in bletted fruits, such as the Medlar. Such a state of the leaf may very well be owing in leaves, as well as in fruits, to an alteration in their principles analogous to putrefaction or fermentation. It is always accompanied with a great loss of water; but we have no direct evidence as to the nature of this change.

Chapter XVIII.

Of Odours.

Not less curious nor less difficult to reduce to any intelligible laws is the subject of Vegetable Odours. Our senses are daily gratified by the sweet perfumes exhaled by the leaves and flowers that surround us; and art exhausts its skill to preserve them by means which enable us always to have them present for our use; but as to the reasons why one kind of flower is odoriferous, and another scentless, we are still more in the dark than in what relates to colour. Here, therefore, we shall confine ourselves very much to a mere statement of facts, introducing theory only in cases which may appear to be pretty well understood. For this purpose we again avail ourselves of many of the materials collected by De Candolle in his invaluable *Vegetable Physiology*.

All odours are owing to the disengagement of volatile matter, and as there are few organized bodies in which, in their natural state, there is not some volatile constituent part, so neither are there many organic bodies absolutely destitute of smell. But it is only to cases in which the scent is very perceptible to our senses that we apply the idea of odoriferous, and it is consequently to those that we here confine ourselves; dividing them into *permanent*, *fugitive*, and *intermittent*.

Those odours are the most *permanent* in which the volatile matter is so inclosed in cells and concentrated as to disperse slowly. Of this many instances are afforded by wood and bark, which being in truth the only permanent parts of vegetation, will of necessity be the receptacle of durable odours; such parts are not scented, because of their own proper nature, for all the tissue of plants is originally scentless, or nearly so, but they owe their property to the fragrant secretions imprisoned in their cavities, and the permanence of their odour will be proportioned to the difficulty the volatile parts of their secretions experience in escaping through the tissue which incloses them, as well as to the degree in which the volatile matter may be fixed. Thus resinous woods, such as Cedar and Cypress, are fragrant for an indefinite period, because the resinous matter in which their odour resides is parted with slowly. Parts, whose scent resides in essential oil, preserve their scent for a long time, where the essential oil is but slightly volatile, or the wood is thick and hard: thus the Rose-wood of Teneriffe (not the Rose-wood of the English cabinet-makers), produced by Convolvulus scoparius, preserves its odour a very long time; and in order to elicit it, it is necessary to rub the wood strongly, so as to produce heat enough to volatilize the matter which is locked up in the very compact tissue of which that plant consists. The necessity of producing a little heat, in order to produce an exhalation of the volatile matter, is further exemplified by the fragrance emitted by many woods, otherwise scentless, when exposed to the violent friction of a turner's lathe: Beech is said to acquire, under such circumstances, the smell of Roses. But when, on the other hand, the volatile matter is inclosed in wood of a loose texture, neither is heat required to elicit it, nor has the wood, if exposed to the air, the power of retaining it for any considerable time, for the oxygen of the atmosphere will seize upon it rapidly, and quickly leave nothing behind but the inodorous tissue: this happens to Cassia and Cinnamon.

Fugitive smells are those which, belonging to perishable organs, are either

extremely perishable in their very nature, or are placed in tissue of the laxest kind, or are situated on the surface of plants where their volatile parts are continually abstracted by the atmosphere, or finally are secreted in quantities so small that a short exposure to air suffices to dissipate them. All these odours are produced only during the life of a plant; they are dispersed as they are formed, and after death leave no trace of their existence behind them. Like permanent odours these are continually given off, and in some plants, as the Orange and the Violet, without any variation in intensity in different states of the atmosphere; but in the majority of cases the power of the smell will vary according to the elevation of temperature, and the dampness of the air. This fact must be familiar to all who are acquainted with gardens. In the hot, dry weather of a summer's noon, flowers either become scentless, or at least lose a large proportion of their usual fragrance; and in walking through a wilderness of the most sweet-smelling plants, we find little sign of their odour, unless they are bruised or trampled upon. But if a heavy shower should come on, all will be changed in an hour's time; every leaf, every flower, will emit its peculiar odour; the Musk plant (Mimulus moschatus) will fill the air with its singular scent, and it will be obvious that the addition of moisture to the air has produced a total change in the action of the odoriferous organs of plants.

The same phenomenon is daily repeated in the driest days of autumn. Those only who are accustomed to take their early walks abroad can have any idea of the difference between a richly-stored garden early in the morning and at noon. When the sun has dried the air, and has been beating for some time upon vegetation, ill able to bear his action in consequence of the dryness of the source from which they draw their means of compensating for evaporation, however beautiful a garden may still remain, it cannot be compared to the same place before the dew has dispersed—when every herb, tree, and flower is pouring forth a stream of the most varied and delicious fragrance—when the air is impregnated with the most delicate balsamic odours—and when all nature seems as if offering up incense in gratitude for the refreshing powers of darkness and of dew. Let any one, for example, visit a thicket of Cistuses at noon, and again the next morning, and the difference will be exceedingly apparent. To what cause this is owing is unknown; possibly the effect of dryness and excessive heat may be to close the stomates, and to contract the tissue of plants, thus rendering it difficult for volatile matter to pass through their cuticle: it may also act by depriving them of the necessary proportion of water required to enable them to perform their functions of secretion and assimilation, and thus arrest for a time the elaboration of the fugitive principles upon which fragrance depends. While, however, dew and showers, with intervals of bright light, are eminently favourable to the eliciting of vegetable perfumes, a continuance of wet and gloomy weather, without much sunshine, is as greatly unfavourable. This latter circumstance is explicable upon the general law of physiology, that secretions cannot be readily produced without the direct assistance of the sun's light.

With regard to what we call *intermittent* odours, no explanation seems possible in the present state of our knowledge. A few examples of them will therefore be all that we can give. All dingy-flowered plants, such as botanists call *tristes*, belong to this class; such as the Pelargonium triste, Hesperis tristis, Gladiolus tristis, which are almost entirely scentless during the day, but become deliciously fragrant at night.[m] Great numbers of Orchideous plants have flowers possessing the same property; the Catasetums have a fine aromatic odour at night, none in the day, except C. purum; Cymbidium Sinense is also chiefly fragrant at night; and so with a great many more. Cestrum nocturnum is another plant of the same nature; in the day it has no odour, at night its perfume is extremely powerful. One of the most singular instances of exceptions to all rules appears to be referable to this class: Cacalia septentrionalis exhales an aromatic odour if exposed to the direct rays of the sun, and if anything is interposed between it and the sun its odour disappears, but is renewed as soon as the interference is removed.

Agreeable as vegetable odours usually are to our senses, there are some striking exceptions. Many Stapelias, the Arum dracunculus, and several other species of the same genus, whose

flowers are of a deep livid colour, have a smell so completely that of putrid meat, that flies actually deposit their eggs in them by mistake; Arum trifidum has an abominable stercoraceous odour; and the pollen of the Sweet Chestnut and the Barberry has a peculiarly disagreeable smell. Even the most delicate kinds of fragrance when concentrated prove disagreeable, and in many cases, in their simple state, act powerfully upon the nerves; even oil of Roses highly concentrated can scarcely be supported, and every one knows that a perfumer's shop, although the receptacle of the sweetest essences, is by no means an agreeable place. The spasmodic affections produced by the odours of flowers are more common than is generally supposed, but vary in different individuals according to their respective powers of endurance. Some of the most remarkable cases are the following:—The Jonquil and the Tuberose are insupportable by persons of delicate nerves; few can bear the fragrance of the Lilac, especially in a room; even Violets, the last flowers to be suspected, have in many cases proved deleterious; De Candolle says he has witnessed many ladies faint from carrying too many of them on their persons, or from having placed them too near them when asleep. It is asserted that people have died from being shut up in a room in which the Oleander was in flower; hysterics have been brought on by the Musk Mallow; Saffron has been known to produce swooning; and the flowers of Lobelia longiflora have caused suffocation. The odours of other organs may also produce inconvenient consequences: the Elder, the Walnut, and the Anagyris bring on headache in persons who sleep beneath their shade; and the Manchineel tree is said to have proved fatal to travellers who have trusted to its shelter.

Vague and unsatisfactory as all these details must be admitted to be, they are so connected with one of the most curious inquiries in either the vegetable or animal kingdom, that we think we cannot have done otherwise than render good service to our readers by letting them form a part of this treatise, especially as they are scarcely to be found adverted to in our English elementary works; and we close what relates to the physiology of plants, by strongly recommending the investigation of the subject to all those whose tastes, leisure, and attainments may lead them to occupy themselves with one of the richest fields of inquiry which yet remain in Nature to be explored.

ELECTRICITY.

Chapter I.

General Facts and Principles.

(1.) The science of Electricity, which now ranks as one of the most important branches of Natural Philosophy, and which embraces so many subjects of inquiry, exceedingly curious in themselves, and highly interesting from their relations with every department of nature, is wholly of modern creation. The ancients were, indeed, acquainted with a few detached facts, depending on the agency of electricity; such as the attractive power which amber acquires by being rubbed, the benumbing shocks which are experienced on touching the *torpedo* (or electrical eel), and the appearance of those sparks or streams of light which, on some occasions, are seen to issue from the human body. But no suspicion was entertained that these phenomena had any connexion with one another; and far less was it imagined that they were the effects of a power pervading all material bodies, and extensively concerned in all the operations of nature.

(2.) It was only by slow degrees that this knowledge was acquired. The first step towards a generalization of the phenomena was made by Dr. Gilbert, an English physician, who, in the year 1600, published a very original and valuable treatise on the magnet. He remarked that several other bodies besides amber can, by friction, be made to attract light bodies; and he was thus led to the discovery of a property common to all of them. The Greek name for amber being ἤλεκτρον (*Electron*), the bodies possessed of this property were denominated *Electrics*; and the power they manifested was termed Electricity. The observations of Boyle, Otto Guericke, Newton, and a few other philosophers of the same period, contributed somewhat to the extension of our knowledge on this curious subject; but even the information collected during the whole of that century amounted to nothing that could be entitled to the name of science. The real science of Electricity can, properly speaking, be considered as taking its rise only in a later age; and it was the first fruit of that active spirit of investigation, which at the commencement of the eighteenth century was rapidly diffusing itself over Europe. The establishment of the Royal Society of London appears to have had considerable influence in promoting the cultivation of electricity: for we find that almost every discovery of importance in this science was made by the members, and is recorded in the Transactions of that Society. But it was not until the present century that the extensive relations which connect electricity with so many other branches of physical science, were discovered, and their importance appreciated. Already have we seen, in this short era, the rise of a new science, founded on that peculiar modification of Electricity, which is known by the name of Galvanism. Hence, have we derived new instruments of analysis, new paths of research, and new powers of extending the dominions of science; hence, have we been able to trace alliances between several of the great agents concerned in the phenomena of the material universe. Electro-Chemistry has thus arisen as one of the connecting branches between remote divisions of the Philosophy of Nature. Still more recently there has been opened to us, in the subject of Electro-Magnetism, another new province of science, which establishes a natural connexion between two powers hitherto regarded as distinct.

So rapid has been the march of scientific improvement, that it is difficult for those whose attention has not been steadily and exclusively devoted to these particular objects, to keep pace with the progress of discovery. The materials collected by the numerous labourers in these wide fields of inquiry have poured in upon us so fast, that there has scarcely yet been time for marshalling them in their proper places, and for

disposing them in the order best fitted for instruction. It is to be lamented that there exists as yet no general and comprehensive treatise embracing the whole of these extensive and complicated subjects of modern research; and that the student has still to gather the information he seeks from a multitude of journals and other miscellaneous sources, where they lie irregularly scattered, and are not to be arranged, or even found, without a great expenditure of time and labour. It is the aim of these treatises to supply, in some degree, this deficiency, in as far, at least, as relates to the instruction of those who have no previous acquaintance with the subject, and are desirous of being initiated in the principles of the science.

(3.) In order to convey the clearest and most philosophical views of the subject we are about to treat, we shall begin by stating, independently of all theory, the most general facts relating to Electricity; presenting them at first in their simplest form. We shall, in the second place, review the theories which have been framed for the purpose of connecting these facts in the mind. We shall thus be enabled, lastly, to study their combinations, to unravel their complicated results, and to follow them in their practical applications.

(4.) The general facts relating to Electricity may be reduced to the six following heads:—

1. Excitation.
2. Attraction.
3. Repulsion.
4. Distribution.
5. Induction.
6. Transference.

§ 1. *Of Excitation, Attraction, and Repulsion.*

(5.) If a piece of amber, or sealing-wax, or a smooth surface of glass, perfectly clean and dry, be briskly rubbed with a dry woollen cloth, and immediately afterwards held over small and light bodies, such as pieces of paper, thread, cork, straw, feathers, or fragments of gold leaf, strewed upon a table, these bodies will be seen to fly towards the surface that has been rubbed, and adhere to it for a certain time. The surfaces which have acquired by friction this attractive power are said to be *excited*; and the substances thus susceptible of excitation are termed *electrics*, in contradistinction to such as are not excitable by a similar process and which are, therefore, termed *non-electrics*.

(6.) The principal electric substances in nature are the following: viz. amber, gum-lac, resin, sulphur, glass, talc, the precious stones, silk, the fur of most quadrupeds, and almost all vegetable substances (excepting charcoal), which have been thoroughly deprived of moisture, as, for example, baked wood, and very dry paper.

(7.) After the bodies which had been attracted by the excited electric have remained in contact with it a certain time, the force which held them together ceases to operate: the bodies then recede from the electric, and if the latter be again presented to them, they will, provided they have touched no other body, be repelled, or driven off, instead of attracted. This change from attraction to repulsion takes place more slowly with some substances than with others: some bodies will adhere to the electric a considerable time before they recede; while others, and especially metallic bodies, are repelled the instant after contact:—the reason of this will afterwards be seen.

(8.) It is also to be noticed that two bodies which have both of them been in contact with the same electric, mutually repel each other.

(9.) The phenomena of electrical attraction and repulsion are best observed when electrics of considerable size are employed. For the experiments we are about to describe, it is convenient to have them of a cylindrical shape, which admits of their being more easily carried in the hand, and more readily transferred to wherever we may wish to place them. We may employ as our electric a thick cylinder of sealing wax, or one of sulphur. If glass be chosen, it should be in the form of a tube of considerable diameter, and should, previously to the experiment, be gently warmed before the fire, in order to expel all moisture from its surface. As a rubber we may use a silk handkerchief, a piece of clean flannel, or the fur of a quadruped; but the material which produces the greatest effect when rubbed with glass is an amalgam (or mixture) of mercury with tin or zinc. Whatever be the substance employed, it should be perfectly dry; to ensure which condition it should, previously to being used, be held for some time before the fire.

(10.) When, by attending to these precautions, a sufficiently powerful excitement of the cylinder has been obtained, we may observe several other remarkable phenomena, besides those of attraction. If the experiment be performed in a dark room, flashes of light, of a bluish colour, will be perceived during the friction, extending over every part of the surface rubbed; and sparks, attended with a sharp snapping sound, will be seen to dart around it in various directions. If a round body, as a metallic ball, be presented to it, and moved from one end to the other, a succession of sparks will be obtained as the ball passes along the surface; and if the knuckle be presented instead of the metallic ball, each spark will be accompanied by a pricking sensation. When the excited cylinder is brought near to the face, an unpleasant sensation of tickling is felt in the skin, as if it had been covered with a cobweb.

(11.) If a globe of metal be suspended in the air by silk threads, and if, while in this situation, it be rubbed by an electric, such as silk, fur, or the outside of the skin of a cat, it will also become electrical, and exhibit the same properties of attraction and of repulsion as if it had been itself an electric. The circumstance of its being thus insulated or cut off from the contact of any substance, except the air and the electric which sustains it, is essential to the success of this experiment.

(12.) Various modes have been devised for exhibiting distinctly the attractive and repulsive agencies of electricity; and for obtaining indications of its presence, when it exists only in a feeble degree. Instruments for this purpose are termed *Electroscopes*. One of the simplest of these is the Electroscope of Hauy, which is very similar to that formerly proposed by Dr. Gilbert. It consists of a light metallic needle, terminated at each end by a light pith ball, which is covered with gold leaf,

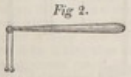
Fig. 1.



and supported horizontally by a cap at its centre, on a fine point. The attractive or repulsive power of any electrified body presented to one of the balls, will be indicated by the movements of the needle.

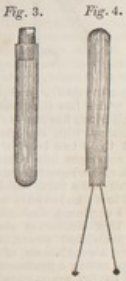
(13.) In some cases it is more convenient to employ a pair of similar balls, suspended from a brass ball fixed to the end of a glass handle, by very fine silver wires, or by hempen threads, previously steeped in a solution of salt, and afterwards dried. See *fig.* 2.

Fig 2.



(14.) Cavallo has contrived an electroscope of the same kind, which has the advantage of being more portable than that of Hauy, while it is, perhaps, equally sensible. It is formed by two fine silver wires, each carrying at one of their ends a little ball made of cork, or of the pith of the elder tree; the other ends of the wires being suspended from a cork, which is rather long, and tapering at both ends, so as to fit either way into the mouth of a varnished glass tube, serving both as a handle to the instrument when in use, and as a case for it when carried in the pocket. When it is to be employed as an electroscope, the wires with pith balls are placed so as to hang out from the end of the tube, and will indicate by their divergence any electricity which may be communicated to them. (*Fig.* 4.) When

Fig. 3. *Fig.* 4.



the instrument is not in use, the wires are put into the tube, by inverting it, and closing it with the other end of the cork. (*Fig.* 3.)

(15.) For studying the circumstances

attending electrical attraction, we should be provided with stands, from the ends of which are suspended by their respec-

Fig 5.



tive threads one or two pith balls, about the size of a small pea, as shown in *fig.* 5.

§ 2. *Distribution and Transference.*

(16.) If an excited electric be brought near a pith ball suspended by silk, the ball will, in the first place, approach the electric (*fig.* 6.), indicating an attraction towards it, and if the position of the electric will allow, the ball will come into contact with it and adhere to it for a short time; but it will presently afterwards recede from the electric, showing that it is now repelled. (*fig.* 7.) If we

Fig. 6. *Fig. 7.*



now remove the electric, and present to the ball which has thus touched it, a second ball which has had no previous communication with any electric, we find that these two balls attract one another, and come into contact. The same actions are repeated between this second ball and a third, which may be presented to it; and so on in succession, but with a continued diminution of intensity. This diminution plainly indicates a diminished power, in consequence, as it would seem, of its being distributed among a number of bodies.

(17.) In the prosecution of these experiments, therefore, the effects will be more distinct, if, instead of small pith balls, we employ a globe of metal of larger size, which will allow of the reception of a considerable quantity of this electric influence by contact with the excited electric. A globe, suspended by silk threads, as the pith balls are, and which has extensively touched the electric, will act upon these balls precisely in the same way as the original electric would have acted upon them, and may accordingly be substituted for it in all these experiments. It is, indeed, exactly in the same condition as the globe rubbed by an electric, already mentioned. (§ 11.)

(18.) From the whole of these facts we necessarily infer that the electric has imparted to the ball or globe which came in contact with it, properties exactly similar to those which had been excited in itself by friction. By repeated contact with a number of bodies, an excited electric is found to lose its electrical powers in the same degree as these powers have been acquired by the bodies themselves; and fresh excitation alone can renew them. It is evident, then, that the unknown agent, which we have termed *Electricity*, is capable of transference, in the same sense in which we speak of heat being communicated or transferred from one body to another, and that, like heat, it is weakened by diffusion among a number of bodies.

(19.) If the electrified ball be touched with the finger, it will be deprived of the whole of its electricity, which will pass into the body of the person who touches it. It is now reduced to its original or natural state, and is again susceptible of being attracted, either by an excited electric, or by another body to which electricity has previously been communicated.

If the electrified body, instead of being touched with the finger, had been touched by a rod of metal held in the hand, the effect would have been the same in both cases: hence we may infer that the metallic rod is capable of conveying away from the body the whole of its electricity. But if a glass rod be substituted, the result is very different; the body touched is found to retain the whole of its electricity, notwithstanding the contact of the glass rod. We are thus led to the conclusion that some substances, such as glass, are incapable of conducting electricity; while others, such as the metals and the human body, readily convey that influence.

(20.) It is invariably found that all *electrics* are, at the same time, *non-conductors*. Conductors, on the other hand, are *non-electrics*. The two qualities of a capability of excitation, and a power of conducting electricity, appear to be incompatible with each other—for the one is always found to diminish in proportion as the other increases. The permanence of electricity in metallic bodies, which are suspended in the air by silk threads, shows that the air as well as the silk is a non-conductor. Bodies which are in this way surrounded on all sides by non-conductors are said to be *insulated*. When this condition is not observed, that is, when the body is in contact with conducting bodies which communicate with the earth, its electricity will escape by the channel which is thus opened for it, and will be lost by diffusion in the mass of the earth, which is formed of conducting materials, and which may be regarded as the great reservoir both for the absorption and supply of electricity. Hence we see why it is not possible to accumulate electricity in a conducting body while it is held in the hand, and why electrics alone are capable of permanent excitation.

(21.) The insulating power of atmospheric air depends principally upon two circumstances, its density and its dryness. Air with the density which it has under the ordinary pressure of the atmosphere, if perfectly dry, is a remarkably good insulator, even although it be rapidly renewed on the surface of the electrified body. This is shown by an experiment of Franklin's, in which he whirled an electrified ball round his head, by means of a silk line, with great rapidity, so as to make it perform many hundred revolutions, without being able to perceive that it had thereby lost any sensible portion of its electricity. Neither an increase, nor a diminution of temperature, appears to lessen its insulating power. But in proportion as the air is rarefied by the removal of the superincumbent pressure, its power of confining electricity diminishes, till, at last, when the rarefaction is very great, it opposes scarcely any resistance to the passage even of very feeble electricity; and it may be then classed among conductors. This is the case with the imperfect vacuum produced by the air-pump, from which it is almost impossible to exclude minute quantities of air. Even in the space left in the upper part of the tube of a barometer by the descent of the mercury, or the Torricellian vacuum, as it is called, there is in general present a minute portion of air, as well as of mercurial vapour, which are sufficient to conduct electricity. Small globules of air usually adhere to the mercury, and to the sides of the tube; and these, upon the removal of pressure, expand into an atmosphere. It has been asserted by Mr. Morgan that if great care be taken to remove every source of error, by the employment of very pure mercury, and by boiling it for a long time in the tube, a perfect vacuum may be obtained, which does not conduct electricity. His experiment, however, was made long ago, and requires careful repetition, before the result can be confided in.

(22.) The circumstance which chiefly determines the conducting power of common air is that of its containing a greater or less quantity of moisture. Water is a very good conductor of electricity; and that portion which is suspended in the air tends powerfully to carry off electricity from the bodies which are charged with it, and which are surrounded by air. Moisture also easily attaches itself to glass and other electrics, and deprives them of the power of insulation. Hence, the same experiments which succeed in a clear dry day, will often fail when tried in damp weather: and hence we see the utility of previously drying every part of the apparatus, in order to exclude as much as possible the interference of moisture.

(23.) The conducting powers of most bodies are influenced by changes of temperature, and also of form. Thus, although water in its liquid state is a good conductor, yet, when congealed, in the form of ice, its conducting powers are much impaired; and at a very low temperature, namely, at −13° of Fahrenheit's scale, ceases altogether. Mr. Achard, who observed this fact, formed ice of this temperature into a spheroid, and mounting it upon an axis, was able to excite it by friction as any other electric. On the other hand, by raising the temperature of water, its conducting powers are increased. Charcoal is also found to transmit electricity with more facility when hot, than when cold. Glass, which is a non-conductor when cold, becomes a tolerably good conductor when heated to redness; and a similar change takes place in sulphur and in resinous bodies when melted; and also in baked wood when heated. Reducing substances to

powder has often an effect upon their powers of conducting electricity. Snow conducts less readily than ice of the same temperature. The same is the case with powdered charcoal, when compared with the same substance in its entire state. But glass, on the contrary, acquires some conducting power by being pulverized, as was ascertained by Van Swinden, who extended the same observation to sulphur.

Many bodies, which, in their usual state, are good conductors of electricity, lose this power when they are made very dry. This is the case with recent vegetable and animal substances, their conducting power appearing to be derived solely from the fluids they contain.

(24.) Strictly speaking, there is no substance hitherto known that is perfectly impervious to electricity; for the intensity of that agent may be so increased as to force it, for a certain small distance, through all bodies: neither is there any body in which the conducting power is infinitely great; that is, which opposes no resistance to the transmission of electricity. If the degree of conducting power which bodies possess could be ascertained with sufficient precision, they might be arranged in progressive order; but the present state of our knowledge affords only an approximation to such a series. As a table of this kind, however, with all its imperfections, may be of great use, we subjoin the following, in which the different bodies are arranged in one series, beginning with those which have the greatest conducting power, and terminating with those that have the least. The order in which they possess the power of insulating is, of course, the reverse of this.

Catalogue of Bodies in the Order of their conducting Power.

The perfect, or least oxidable metals.
The more oxidable metals.
Charcoal prepared from the harder woods, and well burned.
Plumbago.
The concentrated mineral acids.
Powdered charcoal.
Dilute acids.
Solutions of metallic and neutral salts.
Metallic ores.
Animal fluids.
Pure water.
Snow.
Living vegetables.
Living animals.
Flame.
Smoke
Steam.
Metallic salts
Salts with alkaline or earthy bases.
Rarefied air.
Vapour of alcohol.
Vapour of ether.
Earths and stones in their ordinary state.
Pulverized glass.
Flowers of sulphur.

Dry metallic oxides.
Oils.
Vegetable ashes.
Animal ashes.
Dry transparent crystals.
Ice below —13° Fahrenheit.
Phosphorus.
Lime.
Dry chalk.
Native carbonate of barytes.
Lycopodium.
Caoutchouc, or Indian rubber.
Camphor.
Siliceous and argillaceous stones in proportion to their hardness.
Dry marble.
Porcelain.
Baked wood.
Dry atmospheric air, and other gases.
White sugar, and sugar crystallized.
Leather.
Dry parchment.
Dry paper.
Cotton.
Feathers.
Hair, especially that of a living cat.
Wool.
Dyed silk.
Bleached silk.
Raw silk.
Transparent gems.
Diamond.
Talc.
Metallic vitrifications.
Glass, and other vitrifications.
Fat.
Wax.
Sulphur.
Resins, and bituminous substances.
Amber.
Gum-lac.

Although the precise point in the scale which forms the separation between conducting and insulating bodies must, or course, be somewhat indefinite, we have endeavoured to mark it by the division in the above table.

(25.) It appears, from the experiments of Mr. Coulomb, that a thread of gum-lac is the most perfect of all insulators, and is ten times more effectual than a silk thread as dry as it can be made; for the former, when only one inch and a half in length, insulated as well as a fine silk thread of fifteen inches. When the thread of silk was dipped in fine sealing-wax, it was equal in power to a thread of pure lac of four times its length. Professor Robison found that the conducting power of silk thread depends greatly on its colour; or, in other words, on the nature of the drug with which it is dyed. When of a brilliant white, or a black, its conducting power is the greatest; and a high golden yellow, or a nut brown, renders it the best insulator. Glass, even in its dryest state, and in situations where it was impossible that moisture could have access to it, is stated by the same author to insulate considerably better than silk; and when drawn into a slender thread, and coated with gum-lac, it acted as well as a thread of lac of one-third of the length. It was found, however, at the same time, that extreme fineness was requisite; for it dissipated in proportion to the square of its diameter. The insulating power of glass is remarkably injured by having a bore, however fine, unless that bore admits of being also coated with lac. Human hair, when completely freed from every thing that water could wash out of it, and then dried by lime, and coated with lac, was equal to silk. Fir, cedar, larch, and the rose-tree, when split into filaments, and first dried by lime, and afterwards baked in an oven, which just made paper become faintly brown, seemed scarcely inferior to gum-lac. The white woods, as they are called, and mahogany, were much inferior. Fir, baked and coated with melted lac, seems, therefore, the best support when strength is required. The lac may be rendered less brittle by a minute portion of pure turpentine, which has been cleared of water by a little boiling, without sensibly increasing its conducting power. Lac, or sealing-wax, dissolved in spirits, is far inferior, for these purposes, to what it is when melted by heat.

(26.) The laws which regulate the gradual dissipation of electricity from bodies in a state of imperfect insulation have been investigated with great ability by Coulomb. Three causes chiefly operate in depriving a body under these circumstances of its electricity:—First, the imperfection of the insulating property in the solids by which it is supported. Secondly, the contact of successive portions of air, every particle of which carries off a certain quantity of electricity. Thirdly, the deposition of moisture upon the surface of the insulating body, which establishes communications with its remote ends, and may be considered as virtually increasing its conducting power.

(27.) With regard to the first cause, Mr. Coulomb has completely ascertained that for all fine cylindrical fibres, such as hair, silk, filaments of gum-lac, &c. if the nature of the substance, the diameter of the fibre, and the dispersive state of the air are supposed constant, the length of the fibre requisite for the complete insulation of a given intensity of electricity, varies as the square of that intensity. Theory, therefore, leads to the conclusion that, however great may be the intensity, there is always a certain length beyond which a filament of any of these bodies becomes a perfect insulator; and we find, in practice, that by diminishing the intensity of the electricity, or increasing the length of the substance it has to traverse, a sufficiently accurate degree of insulation may be obtained. With respect to the second source of dissipation, it was found that in a given state of the atmosphere, as far as it could be determined by the indications of the barometer, thermometer, and hygrometer, the dissipation at each instant of time, varied directly as the intensity of the electricity.

(28.) There is one very material circumstance relating to the dissipation of electricity that should here be mentioned, although its explanation must be deferred till the principles on which it depends have been developed; and it is, that the power of retaining electricity in any body is much influenced by its shape. The form most favourable to its retention is that of a sphere; next to which is a spheroid, and a cylinder terminated at both ends by a hemisphere. On the other hand, electricity escapes most readily from bodies of a pointed figure, especially if the point projects to a distance from the surface. In such bodies it is scarcely possible, indeed, to accumulate any sensible degree of electricity, on account of its rapid dissipation from the point. In like manner pointed bodies receive electricity more readily than those of any other form.

§ 3. *Of the two species of Electricity.*

(29.) We have hitherto viewed electrical phenomena as arising from the operation of a single agent, which could be called into action, and transferred from one body to another. We have seen that bodies, which have received their electricity from excited glass, repel one another, and are likewise repelled by the excited glass. The same thing happens with respect to those bodies which have received their electricity from excited sealing-wax. But upon examining the action of any of the bodies belonging to the one set, upon any of those belonging to the other, we find, that instead of repelling, they attract each other. Thus, the ball which has received its electricity from the glass, attracts that which has been electrified by the sealing-wax, and is attracted by it; but, what is still more remarkable, the moment these balls have come into contact, provided they have both been electrified in the same degree, they cease at once to exhibit any signs of electricity, as if the electricities of both were suddenly annihilated by their mutual communication. Thus there appears to be two different, and, in some respects, opposite kinds of electricities; the one obtained from glass, the other from sealing-wax. Du Fay, by whom this distinction was first noticed, denominated the former the *vitreous*, and the latter the *resinous* electricity.

(30.) The mode of action which these two electricities exert on matter, may be expressed by the following law: namely, that *bodies charged with either species of electricity, repel bodies charged with the same species, but attract bodies charged with the other species; and that, at equal distances, the attractive power in the one case is exactly equal to the repulsive power in the other.*

Accordingly, if we wish to ascertain what is the species of electricity with which a given body is charged, we have only to approach it to a small insulated pith ball, which has previously been touched either with excited glass or with excited sealing-wax. If the body in question repel it in the former case, or attract it in the latter, its electricity is vitreous; if the contrary happens, it is resinous.

(31.) Although each of these two electricities, when taken separately, acts in a manner precisely similar to the other, they nevertheless exhibit in all their relations to each other a marked contrariety of nature. Hence they are naturally viewed as agents having opposite qualities, which completely neutralize one another by combination.

(32.) Another remarkable circumstance which characterizes these agents, is, that the excitation of one species of electricity is always accompanied by the excitation of the other; and both are produced in equal degrees. Thus, when glass is rubbed by silk, or flannel, just as much resinous electricity is produced in the silk, or flannel, as there is vitreous electricity produced in the glass; and whatever electrified bodies are repelled by the one are attracted in the same degree by the other. If one of the substances happen to be a conductor, and be held in the hand, the whole of the electricity which the friction excites in it will disappear as soon as it is produced, from its escaping through the body of the person holding it, and being lost in the earth. But if the precaution be taken of insulating the rubber, its electricity will become manifest, and is always found to be of the opposite species to that which is excited in the body which is rubbed.

(33.) Since the two surfaces rubbed acquire opposite electricities, it follows as a consequence of the law above stated, that they must attract one another; and this is found invariably to be the case. If a white and a black ribbon of two or three feet long, and perfectly dry, be applied to each other by their flat surfaces, and are then drawn repeatedly between the finger and thumb, so as to rub against each other, they will be found to adhere together, and if pulled asunder at one end, will rush together with great quickness. While united they exhibit no sign of electricity, because the operation of the one is just the reverse of that of the other, and their power is neutralized and inoperative. If completely separated, however, each will manifest a strong electrical power, the one attracting those bodies which the other repels.

(34.) The very act of separation is accompanied by appearances which indicate that considerable portions of the electricities excited on each of the surfaces fly back to the opposite surface, and by their union become as it were extinguished or inoperative; and it is only the remaining quantities which have adhered more tenaciously to the surfaces, that retain their activity. When the experiment is made in the dark, flashes of light attend these sudden exchanges of electricity, passing between the two surfaces, and accompanied with a rustling noise.

(35.) Numberless experiments have been made with a view of ascertaining the conditions that determine the species of electricity excited in the respective bodies of which the surfaces are made to rub against each other, but they have led to no satisfactory conclusion. The mechanical configuration of the surface appears to have a greater influence in the result than the peculiar nature of the substance itself. If a plate of glass with a polished surface be rubbed against one which is roughened, the former always acquires the vitreous, and the latter the resinous electricity. No approach to an explanation of this peculiarity has ever been made. Smooth glass acquires vitreous electricity by friction with almost every substance, except the back of a cat, which gives it the resinous electricity; but roughened glass, if rubbed with the same substances, becomes charged with resinous electricity, while the rubbing bodies acquire the vitreous. Sealing-wax, rubbed with an iron chain, acquires, if polished, the resinous electricity; but if its surface is previously rough with scratches, the vitreous. Silk, rubbed by resin, takes the vitreous, but with polished glass, the resinous electricity. The following is a list of several substances which acquire vitreous electricity when rubbed with any of those which follow it in the order in which they are set down; and resinous electricity if rubbed with any of those which precede:—

The back of a cat.
Polished glass.
Woollen cloth.
Feathers.
Wood.
Paper.
Silk.
Gum-lac.
Roughened glass.

In the experiment just mentioned, in which a black and a white ribbon are rubbed together, the former is found to be resinously and the latter vitreously electrified. But if two pieces of the same ribbon of the same length be rubbed, the one being drawn lengthwise and at right angles over a part of the other, the one which has suffered friction in its whole length acquires vitreous, and the other resinous electricity. In like manner, when the whole length of the bow of a violin is drawn over a limited part of the string, the hairs of the bow exhibit a vitreous, and the string a resinous electricity, the body whose excited portion is of the least extent being generally found to be resinously electrified. But in truth, the slightest difference in the conditions of these and similar experiments on the species of electricity arising from friction, will be often sufficient to produce opposite results.

(36.) Electrical excitation may also be produced by the friction of liquids or of gases against solid bodies. This is the case when mercury is made to fall, in a fine shower, under the exhausted receiver of an air-pump, against the glass. If a current of atmospheric air be directed against a pane of glass, by means of a pair of bellows, the glass becomes vitreously electrified.

§ 4. *Induction.*

(37.) Another class of electrical phenomena must here be noticed. Whenever a body is charged with electricity, although it be perfectly insulated, and of course all escape of that electricity prevented, it tends to produce an electrical state of the opposite kind in all the bodies in its vicinity. Thus the vitreous electricity tends to induce the resinous electricity in a body that is situated near it; and this with greater energy, as the distance is smaller. This effect is termed the *induction* of electricity, and may be ranked among the general facts, or laws of the science. The further development of the consequences it leads to, must, for the present, be postponed, as we shall hereafter be better prepared to understand them. But there is one of its results which we shall now point out, as it refers immediately to the phenomena that have already occupied our attention.

(38.) If an electrified body, charged with either species of electricity, be presented to an unelectrified or neutral body, its tendency, in consequence of the law of induction, is to disturb the electrical condition of the different parts of the neutral body. The electrified body induces a state of electricity contrary to its own in that part of the neutral body which is nearest to it; and consequently a state of electricity similar to its

own in the remote part. Hence the neutrality of the second body is destroyed by the action of the first; and the adjacent parts of the two bodies, having now opposite electricities, will attract each other. It thus appears, that the attraction which is observed to take place between electrified bodies and those that are unelectrified, is merely a consequence of the altered state of those bodies, resulting directly from the law of induction; and that it is by no means itself an original law, or primary fact in the science.

(39.) The effects of induction will be in proportion to the facility with which changes in the distribution of electricity among the different parts of a body can be effected, a facility which corresponds with the conducting power of the body. Hence the attraction exerted by an electrified body upon another body previously neutral, will be much more energetic if the latter be a conductor, than if it be an electric, in which these changes can take place only to a very small extent. This is confirmed by the following experiment: suspend by fine silk threads of equal length, two small balls of equal dimensions, both made of gum-lac, but one having its surface covered with gold leaf. Place these two pendulums, as they may be called, at a little distance from one another, so as to admit of a comparison of their motions; and then present to them an excited electric, which may be either a tube of glass, or a cylinder of sealing-wax. It will at once be seen that the ball, with a metallic covering, which readily admits of the transfer of electricity from one side to the other, will be much more readily and powerfully attracted, than the other ball which allows of no motion in its electricity. The latter ball will, by slow degrees, however, assume electrical states of the same kind as the gilt ball, and will be feebly attracted. As this change is very slowly effected, so it is more permanent when once produced; and the plain ball adheres for a considerable time to the electric which has attracted it. The gilt ball, on the contrary, is sooner repelled, by its readily receiving the charge of electricity imparted to it by the electric. A degree of permanent electricity, however, is also induced on this ball, in consequence of its gradual penetration into the substance of the gum-lac.

Chapter II.

Theories of Electricity.

(40.) It is impossible to arrive at the full comprehension of the multifarious facts relating to any of the physical sciences without the aid of some leading principles, or modes of viewing them, by which their connexions can be represented to the mind, so as to combine them into an intelligible system. We begin by classing the different agents in nature, designating them by specific names; we next endeavour to conceive these agents as possessed of certain powers or qualities adapted to the production of the observed effects. In the case of light, for example, we may conceive the phenomena to result from the action of material particles, emanating in all directions from the luminous body, and obeying certain laws in their course; or we may adopt another hypothesis, namely, that they proceed from the undulations of an elastic medium pervading space. By employing either the one or the other of these hypotheses, we acquire great facility in tracing the connexions of the phenomena of optics, and retaining them in our minds. This advantage is not immediately dependent on the truth of the particular hypothesis we employ for that purpose: for, in the example before us, it is evident they cannot both be true, and yet they both answer this end. But, of course, the utility of an hypothesis will be proportionate to the degree of exactness with which it accords with the phenomena. No inconvenience can arise from its adoption, as long as we bear in mind that our reasonings are founded on a mere hypothesis, and as long as we hold ourselves in readiness to abandon it, the moment we meet with facts with which it is decidedly inconsistent.

(41.) The hypothesis which naturally suggests itself for the explanation of electrical phenomena is that of a very subtile and highly elastic fluid, pervading the earth and all other material bodies, but itself devoid of any sensible gravity. We must suppose this fluid to be capable of moving, with various degrees of facility, through the pores or actual substance of different kinds of matter. In some, as in those we call *conductors*, or *non-electrics*, such as the metals, it moves without any perceivable obstruction: but, in glass, resin, and, in general, in all bodies

called *electrics*, or *non-conductors*, it moves with great difficulty. Moreover, as the phenomena appear to point out the existence of two distinct kinds of agencies, we may further assume that there are two distinct species of electric fluid, which we shall, for the present, name the *vitreous* and the *resinous electricities*. They must each have, when separate, the same general properties as have already been enumerated; but, in relation to each other, there must be a complete contrariety in their natures, so that when combined together, their actions on the bodies in their vicinity, or on the particles of electric fluid contained in those bodies, are exactly balanced; and all visible action ceases. It is in this state of union, in which they perfectly neutralize one another, that they exist in bodies which may be said to be in their *natural state* with regard to electricity.

(42). Thus, then, may the problem be solved, in which it is required to conceive an agent, analogous, in many respects, to other known agents, and to assign to it such properties as will, in their results, correspond to all the observed phenomena. In order to apply to it this latter test, we must trace all the consequences which flow from the suppositions we have made, and strictly compare them with the facts both as presented to us by nature, and as resulting from experiment. These facts, it will be recollected, are reducible to those of excitation, attraction, and repulsion, distribution, induction, and transference.

(43.) *Excitation.* From various causes, of which the friction of surfaces is one, the state of union in which the two electricities naturally exist in bodies, is disturbed; their latent powers are called forth by their separation; the vitreous electricity is impelled in one direction, while the resinous is transferred to the opposite side; and each can now manifest its peculiar energies. When accumulated in any body, or part of a body, each fluid acts in proportion to its relative quantity, that is, to the quantity which is in excess above that which is still retained in a state of inactivity by its union with electricity of the opposite kind. Thus when glass is rubbed with a metallic amalgam, a portion only of the electricities at the two surfaces is decomposed; the vitreous electricity resulting from this decomposition attaches itself to the glass; the resinous, to the amalgam. What remains in each surface undecomposed continues to be quite inert, and has no other influence on the phenomena, than being ready, on the continuance of the decomposing action, to furnish a fresh supply of both fluids to the bodies in the vicinity.

(44.) *Distribution.* Each of these fluids, being highly elastic, their particles repel one another with a force which increases in proportion as their distance is less: and this force acts at all distances, and is not impeded by the interposition of bodies of any kind, provided they are not themselves in an active electrical state. From the most careful analysis of the phenomena, it has been deduced that the exact law of this force is the same as that of gravitation, namely, that its intensity is inversely as the square of the distance.

The mode in which the electricity imparted to a conducting body, or to a system of conductors, is distributed among its different parts, is in exact conformity to the results of this law, as deduced by mathematical investigation. But we reserve the examination of this subject for a future chapter.

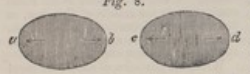
While the particles of each fluid repel those of the same kind, they exert an equally strong attraction for the particles of the other species of electric fluid. This attraction, in like manner, increases with a diminution of distance, and follows the same law as to its intensity, namely, that of the inverse ratio of the square of the distance. This force, also, is not affected by the presence of any intervening body.

(45.) *Transference.* Since the two electricities have this powerful attraction for each other, they would always flow towards each other and coalesce, were it not for the obstacles that are opposed to their motion by the non-conducting properties of electrics. When these obstacles are overcome, and a free channel is open for the passage of the electricities, they rush into union with great force and velocity, producing, in their transit and confluence, several remarkable effects. After their coalescence, their power seems to be at once annihilated, or, more properly speaking, it remains dormant, until called into play by the renewed separation of the fluids.

(46.) *Attraction and Repulsion.* The repulsion which is observed to take place between bodies that are insulated

and charged with any one species of electricity, for other bodies similarly charged, is derived from the repulsive power which the particles of this fluid exert towards those of their own species. Let us suppose a body charged with electricity to be suspended in the air, or otherwise surrounded by a non-conducting medium, which allows it to move freely. As long as this body remains alone, the outward pressure which the electric fluid exerts against the insulating medium that confines it, will, by the laws of hydrostatics, be equal on all sides; and the body, thus balanced by equal and opposite pressures, will have no tendency to move. But if another body, similarly circumstanced, be brought near it, the repulsive action between the similar electricities contained in these bodies, will diminish the outward pressures of each fluid against the sides of the bodies, (*b*, *c*, *fig.* 8.) which are adjacent to each

Fig. 8.



other; and it will, at the same time, increase the outward pressure on the opposite or remoter sides (*a*, *d*.) Both these causes conspire to destroy the equilibrium; each body is impelled in the direction of the preponderating force, that is, in a direction from the other body; and an effect, which may be called repulsion, takes place. The very same explanation, it is evident, applies to both kinds of electricity, their properties being in this respect exactly alike.

If, on the other hand, a body charged with vitreous electricity be presented to one that is charged with resinous electricity, the attraction of these two fluids will diminish the outward pressure on the remote sides of the bodies, and increase it on the adjacent sides; hence, the bodies will be urged towards each other, and motions indicative of attraction will result. Thus, in all cases, do the movements of the bodies represent the forces themselves which actuate the particles of the developed electricities they contain.

(47.) *Induction.* The law of induction is a direct consequence of the hypothesis we are considering. Wherever one of the electricities exists in an active state, it must repel the particles of the same electricity in all surrounding bodies, and attract those of the opposite species: or, in other words, it tends to decompose their united electricities, accumulating the electricity of the opposite species towards the nearest side, and impelling that of the same species towards the remote side. The body thus acted upon is no longer neutral, although it contains, on the whole, its natural quantities of both electricities; but, in consequence of their partial distribution, electrical appearances will be exhibited in its different parts. The further prosecution of this branch of the subject must also be postponed to a subsequent chapter, our present object being merely to point out, in a general way, the coincidence of the fundamental facts with the proposed theory.

(48.) Thus far we have proceeded upon the hypothesis of there being two distinct electric fluids, having certain properties in common, but each being characterized by a certain modification of these properties. It is, however, equally possible to account for all the phenomena with the same exactness, on the supposition of their resulting from the agency of a single electric fluid. This simplification of the theory may be considered as the discovery of the immortal Franklin, although it had occurred at the same period to Dr. Watson; for it was Franklin who first pointed out the mode in which it might be successfully applied to explain some of the most remarkable phenomena of the science. Several particular points in his theory, as he originally proposed it, were defective, and were found on strict examination to be at variance with ascertained facts. It is to Æpinus and to Cavendish that we owe the rectification of these errors: and the theory of Franklin, as thus amended, whatever alterations the future progress of discovery may oblige us to make in it, will ever remain one of the most beautiful specimens of this kind of reasoning which philosophy has produced. Of this hypothesis we shall now present a brief outline; and point out the mode in which it explains the phenomena.

(49.) We set out, then, with supposing that there exists in all bodies a subtile fluid, which we shall call the *electric fluid*;—that its particles repel one another with a force varying inversely as the square of the distance;—that they attract the particles of all

other matter, or some specific ingredient in that matter, with a force following the same law of the inverse square of the distance;—that this fluid is dispersed through the pores of bodies, and from some unknown peculiarity, can move through them with various degrees of facility, according as they are conductors or non-conductors. Bodies are said to be in their natural state with regard to electricity, when the repulsion of the fluid they contain for a particle of fluid at a distance is exactly balanced by the attraction of the matter in the body for the same particle. In this state they may be considered as *saturated* with the electric fluid. Whenever they contain a quantity of fluid greater than this, they are said to be *positively electrified*, or to have *positive electricity*. When, on the other hand, there is a quantity less than that required for saturation, the body is said to be *negatively electrified*, or to have *negative electricity*. In the former case, it is the fluid that is redundant, or in excess; in the latter, it is the matter which is left unsaturated that should be considered as the redundant principle. The state of positive electricity, then, consists in a redundance of fluid, or in matter that is *over-saturated*, as it has been termed; that of negative electricity, in a deficiency of fluid, or in matter *under-saturated*, or, what is an equivalent expression, in *redundant matter*. In mathematical language, the former condition may be expressed by the sign *plus*; the latter by that of *minus*. In considering the mutual electrical actions of bodies, the portions in which the matter and the fluid mutually saturate each other, need not be taken into account, since their actions, as we have seen, are perfectly neutralized: and we need only attend to those of the redundant fluid and the redundant matter.

(50.) When a body contains more than its natural proportion of electric fluid, the surplus will, by the repulsive tendency of its particles, overflow and escape, if such escape be allowed, until the body is reduced to its neutral state. When under-saturated, the redundant matter will attract fluid from all quarters from which it can receive it, until it is again brought to its neutral state. This efflux, or influx, is prevented either when the body is surrounded on all sides by substances, through the pores of which the fluid cannot pass, or when the body itself is of that nature.

(51.) The mutual recession of two positively electrified bodies is a direct consequence of the repulsion of the redundant fluids contained in each, which, being attached to the matter by their attraction for it, impel it in the direction of their own repulsion. In the same way the mutual approximation of two bodies in opposite electrical states is the immediate effect of the attraction of the redundant fluid in the one, for the redundant matter in the other; and *vice versâ*, for this attraction is mutual.

(52.) A difficulty does, indeed, occur when we attempt to apply the theory to the case of two bodies which are both in a state of negative electricity, that is, in which there exists in both certain quantities of matter unsaturated with electric fluid. What action does the theory, as hitherto stated, point out as the result in this particular case? Plainly none. All those portions of the matter of each body which are still saturated, together with the fluid which saturates them, can have, as we have already seen, no effect either of attraction or repulsion. The only active element is the unsaturated matter; but the hypothesis does not assign any action of this matter upon other matter at a distance. Yet we learn from experience that the bodies, under these circumstances, actually repel one another. In order, therefore, to render the hypothesis conformable to fact, we are obliged to annex to it another condition; namely, that the particles of simple matter, that is, of matter uncombined with the electric fluid, exert a repulsive action on one another. It is singular that so acute a mind as that of Franklin should not have discerned this defect in his own theory, or perceived that this further condition was absolutely requisite for the explanation of the phenomena. Without it, indeed, we should be unable to explain the want of action between two neutral bodies; for the repulsion of the fluids in both bodies being balanced by the attraction of the fluid in the one for the matter in the other, the remaining attraction of the fluid in the second body for the matter in the first would be uncompensated by any repulsion, and the forces would not be held in equilibrium, as we find they really are.

(53.) The law of electrical induction is an immediate consequence of the Franklinian theory. When a body charged with electricity is presented to a neutral body, the redundant fluid of

the former exerts a repulsive action on the fluid in the latter body; and if this happens to be a conductor, it impels a certain portion of that fluid to the remote end of this body, which becomes at that part positively electrified; while its nearer end, which the same fluid has quitted, is consequently in the state of negative electricity. If the first body had been negatively electrified, its unsaturated matter would have exerted an attractive force on the fluid in the second body, and would have drawn it nearer to itself, producing an accumulation or redundance of fluid at the adjacent end, and a corresponding deficiency at the remote end: that is, the former would have been rendered positive, and the latter negative. All this is exactly conformable to observation.

(54.) The phenomena of transference are easily explicable on this hypothesis; and they arise from the destruction of the equilibrium of forces, which confined the fluid to a particular situation or mode of distribution.

(55.) There is, indeed, no fact explicable by the hypothesis of a double fluid, which is not explained with equal facility by that of a single fluid, with the condition already stated. The explanation by the first is easily converted into an explanation by the second, by substituting the expressions of *positive* and *negative* for those of *vitreous* and *resinous electricities*; and considering the action of the latter as arising from the influence of redundant or unsaturated matter, to which is ascribed in the Franklinian hypothesis a similar operation to that of the resinous electricity in the hypothesis of Du Fay. The hypothesis of a single fluid has, it must be allowed, the advantage of greater simplicity: but, on the other hand, it lies open to the objection of its involving a condition which appears, at first view, to be at variance with our preconceived notions of the primary laws of matter, and more especially with that of gravitation; namely, that which implies the mutual repulsion of its particles when void of electricity.

When viewed as a mere hypothesis calculated to facilitate our comprehension of the phenomena and of their connexions, it is a matter of indifference which we employ, for they will either of them answer the purpose. In our future explanations we shall, in general, adhere to the language of the Franklinian theory, as being the simplest, and generally the most convenient; and because a conversion of terms the reverse of that just now pointed out will in all cases enable us to supply the explanation of the same phenomenon according to the theory of Du Fay. As to the question which of these two hypotheses approaches the nearest to the real state of things, we are not yet prepared to discuss the arguments that could enable us to decide it; and we must, therefore, wait till we can resume the subject in the sequel.

The further development of these theories, and of the law of induction, in particular, must, for the present, be postponed, since they require us to be acquainted with many practical details relating to the accumulation of electricity, and its management when applied to various objects of experimental research.

Chapter III.

Electrical Machines.

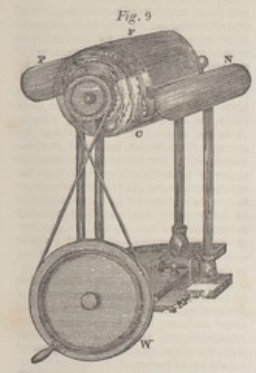
(56.) The essential parts of an instrument for procuring large supplies of electricity for the purposes of experiment, or an *electrical machine*, as it is called, are the electric, the rubber, the prime conductor, the insulator, and the machinery for setting the electric in motion.

(57.) The electric, by the excitation of which the electricity is to be developed, may be made of various materials. Globes of sulphur were employed by the earlier electricians for that purpose; but polished glass is found, on the whole, to be the most convenient substance. The original form given to it by Hauksbee, who was the inventor of the electrical machine, was that of a globe, which he caused to revolve upon a vertical axis. The most convenient forms, however, are those of a hollow cylinder, or of a flat circular plate, revolving upon a horizontal axis. When used in the form of a globe or cylinder, it has sometimes been found advantageous to line the inside of it with a thin layer of a resinous composition, consisting of four parts of Venice turpentine, one of resin, and one of bees' wax. This must be introduced in sufficient quantity into the inside of the globe or cylinder, and, when the glass is brought gradually to an equal degree of heat throughout the melted substances, is allowed to spread itself over the interior surface, by turning the globe or cylinder about its axis. The principal use of such a coating is to improve bad machines, for it is not required in good ones.

The earlier electricians contented themselves with using the hand as a rubber, till a cushion was introduced for that purpose by Professor Winkler, of Leipsic. The cushion is usually made of soft leather, generally basil skin, stuffed with hair or wool, so as to be as hard as the bottom of a chair, but yet sufficiently yielding to accommodate itself, without much pressure, to the surface of the glass to which it is applied.

(58.) Of cylindric machines, the simplest and most perfect construction is that invented by Nairne, and which is represented in *fig.* 9. The glass cylinder C is from 8 to 16 inches in diameter, and

Fig. 9



from one to two feet long, supported, for the purpose of insulation, on two upright pillars of glass, which are fixed to a firm wooden stand. Two hollow metallic conductors P, N, equal in length to the cylinders, are placed parallel to it, one on each side, upon two insulating pillars of glass, which are cemented into two separate pieces of wood that slide across the base so as to allow of their being brought within different distances from the cylinder. To one of these conductors N, the cushion is attached, being fastened to it by the intervention of a bent spring, the purpose of which is to keep it equally pressed against the cylinder in every part of its revolution. The pressure of the cushion is also further regulated by an adjusting screw adapted to the wooden base, on which the glass pillar that supports the conductor is fixed. From the upper edge of the cushion there proceeds a flap F of thin oiled silk, which is sewed on the face of the cushion about a quarter of an inch from its upper edge. It extends over the upper surface of the glass cylinder to within an inch of a row of metallic points, proceeding like the teeth of a rake from a horizontal rod, which is fixed to the adjacent side of the opposite conductor P. The motion of the cylinder must always be given in the direction of the silk flap; and it may be communicated either by a single handle, or by a multiplying wheel W, as in the figure: the latter produces more electricity in the same time, but the labour of turning is increased nearly in the same proportion. On some accounts it is more convenient to place the conductor to which the rubber is not attached, at right angles to the cylinder; and this is the plan adopted in the common electrical machines.

(59.) The conductor P, to which the rubber is not attached, is generally called the *prime conductor*, or the *positive conductor*, as the electricity with which it becomes charged is positive. It is a cylindrical tube, each end terminating in a hemisphere. There is no advantage in its being made of solid materials, for the electricity is contained only at the surfaces. It may be made of thin sheet brass, or copper, or tin, or of pasteboard, covered with gold leaf or tin foil. Care must be taken that its surface be free from all points and asperities; and the perforations which are made in it, and which should be about the size of a quill, for the purpose of attaching wires, and other kinds of apparatus, should have their edges well rounded and smoothed off. For the more perfect insulation of the conductor, it is advisable to apply upon the glass pillar which supports it, a varnish of gum-lac, or of sealing wax.

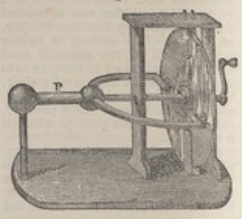
(60.) The degree of excitation produced in the glass depends much upon the substance employed as a rubber. Mr. Singer observes that dry silk is very efficacious, but that the most powerful effects are obtained by the use

of an amalgam of tin, zinc, and mercury, applied by means of hog's lard, to the surface of leather or oiled silk. That part of the cushion which comes in contact with the glass cylinder, should be coated with an amalgam of this kind, spread evenly over its surface, until level with the line formed by the seam which joins the silk flap to the face of the cushion. No amalgam should be placed over this seam, nor on the silk flap; which last should be wiped clean whenever the continued motion of the machine shall have soiled it, by depositing dust or amalgam on its surface. The same attention is requisite to the surface of the glass, which often becomes covered with black spots and lines, more particularly when the amalgam has been recently applied. It is essential to remove these as often as they are formed in any quantity, since they tend to lessen the power of the machine. The surface of the amalgamated cushion is also soon soiled; for the excited glass constantly attracts dust from surrounding bodies, and this dust is collected by the rubber as the glass passes it. If the dust is removed after every course of experiments, by separating the cushion from the negative conductor, and gently rubbing its surface, and the surface of the silk flap, with a dry linen cloth, the machine may be kept in good order without a frequent renewal of the amalgam; such renewal being only necessary when that which has been applied becomes irregularly distributed over the cushion, or impregnated with dust.

(61.) The amalgam recommended by Mr. Singer, is made by melting together one ounce of tin and two ounces of zinc, which are to be mixed, while fluid, with six ounces of mercury, and agitated in an iron, or thick wooden box, till cold. It is then to be reduced to very fine powder in a mortar, and mixed with a sufficient quantity of hog's lard to form it into a paste. When amalgams have a large proportion of mercury, their action is variable and transient. The best cement for attaching the cylinder to its pivots, is made by mixing five pounds of resin, one pound of bees' wax, one pound of red ochre, and two table-spoonfuls of plaster of Paris. The ochre and plaster of Paris should be well dried, and then added to, and alternately mixed with the other ingredients, when they are in a state of fusion.

The plate machine, *fig.* 10, was originally proposed by Dr. Ingenhouz, and has been since much improved by Cuthbertson. This machine, in its most perfect form, consists of a circular plate of glass, turning on an axis that passes at right angles through its centre: it is rubbed by two pair of cushions, fixed at opposite parts of the circumference by elastic frames of thin mahogany, which are constructed so as to press the glass plate between them with the requisite force, by means of regulating screws. A brass conductor P, supported by glass, is fixed to the frame of the machine, with its branched extremities opposite to each other, and near the extreme diameter of the plate, in a direction at right angles to the vertical line of the opposite cushions. The branched extremities of the conductor are furnished with pointed wires, that serve to collect the electricity from the surface of the excited plate.

Fig. 10.



(62.) It is not quite determined which of these two arrangements affords the greatest quantity of electricity from the same surface; but the cylinder is less expensive, and less liable to accidents than the plate, and it appears to possess nearly equal power.

(63.) From what has already been explained of the general laws of electricity, the mode in which these machines act will readily be understood. The friction of the cushion against the glass cylinder produces a transfer of electric fluid from the former to the latter; that is, the cushion becomes negatively, and the glass positively, electrified. The fluid which thus adheres to the glass, is carried round by the revolution of the cylinder; and its escape is at first prevented by the silk flap which covers the cylinder, until it comes to the immediate vicinity of the metallic points, which being placed at a small distance from the cylinder, absorb nearly the whole of the electricity as it passes near them, and transfer it to the prime conductor. Positive electricity is thus accumulated in the prime conductor, while the conductor connected with the cushion, being deprived of this electricity, is negatively electrified.

But if both these conductors are insulated, this action will soon have reached its limit: for when the cushion and its conductor have been exhausted of their fluid to a certain degree, they cannot by the same force of excitation supply any further quantity to the glass. In order to enable it to do so, we must replenish it, as it were, that is, restore to it a quantity equal to what it has lost. This purpose will be answered by placing it in communication with a conducting body of large dimensions; or, what is still more effectual, by making it communicate with the earth, which is an inexhaustible source of electric fluid. In order, therefore, to supply the prime conductor with a constant stream of electricity, we must destroy the insulation of the cushion, by placing on the conductor to which it is fixed, a metallic chain, or wire, extending to the ground. If, on the other hand, we wish to obtain negative electricity, by means of the same machine, we must keep the negative conductor insulated, and connect the prime conductor with the ground, in order to allow the fluid to escape from it as soon as it is collected from the cylinder. The fluid will thus continue to be drawn without interruption from the negative conductor, as it now meets with no impediment to its discharge on the opposite side of the machine.

That the quantity of positive electricity produced in one conductor is exactly equal to that of the negative electricity in the other, is proved by the fact that, if the two conductors are connected by a wire, no signs of electricity are obtained in any of the conductors on turning the machine: but if the wire be not continuous, but interrupted by short intervals, a succession of sparks appear at each interval, indicating the passage of a stream of fluid from the one side to the other of the apparatus.

(64.) A person standing on a stool with glass legs is thereby insulated; and if, in this situation, he touch the prime conductor, either with his hand, or through the intermedium of a metallic rod, or chain, he may be considered as forming part of the same system of conductors. When the machine is worked, therefore, he will partake with the conductor of its charge of electricity, and sparks may be drawn from any part of his body by the knuckle of any other person who is in communication with the ground.

Chapter IV.

Effects of Electrical Attraction and Repulsion.

(65.) Having obtained, by the electrical machine, the means of accumulating considerable quantities of electricity, we are enabled to multiply and extend our observations of the phenomena, and to examine with more precision their correspondence with the results of theory. The effects of electrical attractions and repulsions may be exhibited much more distinctly, and on a larger scale than with the simpler instruments we had previously employed. The experiments formerly mentioned on the alternate approach and recession of light bodies, may be repeated with either conductor of the machine, when charged with electricity, and we may note with more accuracy the differences which occur in the rapidity with which the changes from one electrical state to another take place according as the bodies are more or less good conductors of electricity. A pith ball, or a fragment of gold leaf, is very strongly and immediately attracted by the electrified conductor, and the instant after it has come into contact with it, is repelled; but it is now attracted by the other bodies in its neighbourhood, to which it communicates its own electricity, and then is again in a state to be influenced by the conductor, and to be again attracted: and this alternation of effects will continue as long as the conductor remains charged.

(66.) These alternate and rapid movements are best seen by placing these small bodies between two metallic plates, placed as in fig. 11, the one over the other, at a certain distance; the upper one communicating with the prime conductor, the lower one with the ground. If figures of men and women are cut out of paper and placed between

the two plates, they will exhibit a rapid dance, while they fetch and carry the electricity from the upper to the lower plate; or contrariwise, if the conductor be in the negative state.

Fig. 11.



(67.) This alternation of attractions and repulsions accompanying the transferring electricity by moveable conductors, is also illustrated by the motions of a ball (*fig.* 12.), suspended by a silk

Fig. 12.



thread, and placed between two bells, of which the one is electrified, and the other communicates with the ground. The alternate motion of the ball between the two bells will produce a continued ringing. As thus described, it is a mere toy, but the same arrangement has been applied to the philosophical purpose of giving notice of changes taking place in the electrical state of the atmosphere.

(68.) The mutual repulsion of bodies that are similarly electrified gives rise to many amusing appearances. The filaments of a feather will separate from each other and diverge, when electrified, presenting a singular and unnatural appearance. A small figure in the shape of a human head, covered with hair, when placed upon the conductor and electrified, will exhibit the appearance of terror from the general bristling up and divergence of the hair. A lock of wool highly charged with electricity will, in like manner, swell out to a large size, in consequence of the mutual repulsion of the filaments which compose it. On approaching a needle to it, held in the hand, whereby its electricity is quickly drawn off, the cotton will suddenly shrink into its original dimensions.

(69.) We have already adverted to the effects of fusion in rendering some bodies conductors, which in their solid state had the contrary property. This is the case with sealing-wax; and accordingly, if melted sealing-wax be electrified, its particles will tend to separate by their mutual repulsion, and to draw out into filaments. Let a piece of sealing-wax be fixed on the end of a wire, and be set fire to, but the flame immediately afterwards blown out. While the surface of the wax is still melted, present it, at the distance of some inches, to the electrified conductor, a number of extremely fine filaments will immediately dart out from the sealing-wax to the conductor, on which they will be condensed into a kind of net-work resembling wool. If the wire with the sealing-wax be stuck into one of the holes of the conductor, and a piece of paper be presented at a moderate distance to the wax, just after it has been ignited, on setting the machine in motion, a net-work of wax will be formed on the paper. The same effect, but in a slighter degree, will be produced, if the paper be briskly rubbed with a piece of Indian rubber, and the melting sealing-wax be held pretty near the paper immediately after it has been rubbed. If the paper, thus covered with filaments of sealing-wax, be gently warmed before the fire, the wax will adhere to it, and exhibit permanently the result of the experiment. Still more beautiful are the appearances produced by camphor subjected to a similar process. For the purpose of obtaining them, a spoon, holding a piece of lighted camphor, must be kept electrified by working the machine, while it communicates with the conductor; the camphor will then throw out curious ramifications, which appear to shoot like those of a vegetable.

(70.) It is on the same principle that

the escape of a conducting fluid, such as water, through a narrow aperture, is promoted by electrifying it. If a small metallic vessel filled with water be suspended from the prime conductor, and there be placed in the water one end of a glass syphon, with a capillary bore of such a diameter as that the water will scarcely drop from it; upon turning the cylinder of the machine so as to convey electricity to the vessel and its contents, the water immediately flows in a stream, and, if the electrical charge be very powerful, the descending current will be seen to separate into several branches.

(71.) If a sponge, saturated with water, be suspended from the prime conductor, the water will at first only drop gradually from the sponge; but when the conductor has become strongly electrified, the drops will fall plentifully, and, in the dark, will produce the appearance of a luminous shower of rain.

(72.) Advantage is taken of the repulsive property of electrified bodies for the construction of an *Electrometer*, or instrument adapted to measure the intensity of the electricity they may contain. Henley's electrometer (*fig.* 13.)

Fig. 13.



consists of a slender rod of very light wood, *r*, serving as an index, terminated by a small pith ball, and suspended from the upper part of a stem of wood, *s*, which is fitted to a hole in the upper surface of the conductor. An ivory semicircle, or quadrant, *q*, is affixed to the stem, having its centre coinciding with the axis of motion of the rod, for the purpose of measuring the angle of deviation from the perpendicular, which the repulsion of the ball from the stem produces in the moveable rod. The number of degrees which is described by the index, affords some evidence of the quantity of electricity with which the apparatus is charged; though the instrument has obviously no pretensions to being an exact measure of its intensity.

(73.) One of the most delicate instruments for detecting the presence of electricity is that which was invented by Mr. Bennet, and is usually called the *gold-leaf electrometer*; although it is, properly speaking, only an electroscope. It consists (*fig.* 14.) of two

Fig. 14.

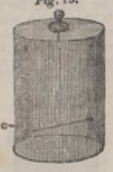


narrow slips of gold leaf, *g*, suspended parallel to each other, in a glass cylinder, which secures it from disturbance by accidental currents of air, and attached to the end of a small metallic tube, which terminates above either in a flat surface, S, of metal, or in a metallic ball. Two slips of tin-foil *t t*, are pasted to the inside of the cylinder, on opposite sides, in a vertical position, and so placed as that the gold leaves may come in contact with them, when their mutual repulsion is sufficiently powerful to make them diverge to that extent. These slips of tin-foil terminate in the foot of the instrument, and thus are in communication with the earth. A very minute charge of electricity communicated to the upper end of the tube, is immediately transmitted to the gold leaves, which are thus made to repel each other; but if the repulsion is such as to make them strike against the tin-foil, their insulation ceases, and their electricity is carried off; and being now rendered neutral, they cease to repel one another, and, collapsing, resume their original position.

(74.) The most perfect electrometer for measuring very small quantities of electricity, is the apparatus contrived by Coulomb, and to which he has given the name of the *torsion balance*. It is represented in its simplest form in *fig.* 15, and consists of a cylindrical glass jar, covered at the top by a circular glass plate, with a hole in its centre. Through this hole a single fibre of

the web of the silk-worm descends nearly to the bottom of the jar, and

Fig. 15.



carries at its lower extremity a transverse needle. This needle consists of either a filament of gum-lac, or a silk thread or piece of straw coated with sealing-wax. At one end it is terminated by a small pith-ball, and at the other by a disc of varnished paper, acting merely as a counterpoise to the ball. The upper end of the silk fibre is affixed to a kind of button having a small index, and capable of being turned round upon a circular plate divided into degrees. One side of the jar is perforated to allow of the insertion of a short horizontal bar, having a small metallic sphere at each of its ends, the one being in the inside and the other on the outside of the jar; and the former being so situated as just to allow the ball of the suspended needle to come in contact with it in the course of its revolution. By turning the button, or the index, the needle may be brought into this, or any other required position with regard to the ball. It is found by experiment that the angle of torsion of the silk fibre is, within a certain range of distance, very nearly in the direct ratio of the force which acts in producing the torsion; and therefore, if the two balls be placed in contact by turning the button, and then similarly electrified, the distance to which they are repelled by the angular motion of the suspended ball, affords a measure of the repulsive force exerted. In like manner, the distance which the suspended ball is made to move when it is attracted by the fixed ball, when the two have opposite electricities, gives accurate measures of the attractive forces. It was by the employment of this apparatus, in a very elaborate series of experiments, that Coulomb was enabled to establish very satisfactorily the exact law of variation, both of the attractive and repulsive forces, arising from electricity, with relation to the distance, which we have already stated.

Chapter V.

Distribution of Electricity.

(75.) It had long been observed, that the quantity of electricity which bodies are capable of receiving, does not follow the proportion of their bulk, but depends principally upon the extent of their surface. It was found, for instance, that a metallic conductor in the form of a globe, or cylinder, contains just as much electricity when hollow, as it does when solid. Hence it was evident that the electricity resides altogether at the surface, or at least does not extend equally throughout the whole mass of the body. But it was only by applying to the theory all the refinements of mathematical investigation, that precise notions could be formed of the exact distribution of the electric fluid in bodies of different shapes. The labours of Cavendish, Coulomb, Poisson, and Ivory, have furnished the means of determining this problem in every case, however complicated; and whenever a comparison has been instituted between the results of experiment and of theory, the most perfect agreement has been found between them. Thus all the phenomena of electricity are found to be in exact conformity with the mechanical consequences of the theory: they can be anticipated with rigorous precision, and can even be reduced to numerical calculation in their minutest details, as well as in their most intricate combinations.

(76.) For the purpose of measuring the proportional quantities of electricity with which different parts of the same, or of different bodies are charged, no instrument is so well fitted as the balance of Coulomb, of which an account has just been given. What peculiarly adapts it for these experiments, is its extreme sensibility, by which the slightest variation in the intensity of the attractive or repulsive force produces a very considerable effect in the movement of the horizontal needle. In some of the experiments related by Coulomb, a force only equal to the 279th of a grain was sufficient to make the needle perform an entire revolution round the

circle: the 360th part of this force, therefore, or less than the 100,000th of a grain, might be estimated by each degree of its angular motion.

In order to apply to the instrument only such forces as it is capable of measuring, and of collecting at the same time from the different parts of bodies such minute quantities of electricity as are exactly proportional to those with which they are themselves charged, Coulomb employed what he calls a *proof plane*, which is simply a small circular disc of gilt paper, *d*, (*fig.* 15,) fixed to the extremity of a very slender cylinder of gum-lac, and thus completely insulated. If we wish, then, to ascertain the proportions in which electricity is distributed on the surfaces or interior of any particular body, we first insulate that body as completely as possible, and impart to it a small quantity of electricity by a spark from the prime conductor. We next touch any of the points on its surface, the electricity of which we may wish to measure, with the little gilt disc, holding it by the other end of its insulating handle; then carrying the plane to the torsion balance, of which the moveable ball has been previously charged with an electricity of the same kind, we bring it for an instant in contact with the fixed ball. We then withdraw it, and the fixed ball being now electrified in the same manner as the moveable one, repels the latter with a force measured by the angle of torsion, at which the moveable ball stops. While the little plane and the balls of the balance remain the same, the division of the electricity between the little plane and the moveable ball preserves the same uniform proportion; and thus the repulsive force which results, and which drives off the moveable ball, is proportional to the quantity of electricity with which the little plane is charged. It has been proved, by a series of well-contrived experiments, that this quantity is exactly proportional to the quantity of electricity which really exists at the point of the body with which it has been placed in contact. By applying the same test and method of admeasurement to various other points of the body we are studying, we may determine the manner in which the electricity is distributed in all its parts; for the method is applicable even to the interior of the body, if we pierce it with a small hole terminating at the part whose electricity we wish to examine, and pass the proof plane into it till it is applied to the bottom of the aperture. Care must be taken, however, in conducting these last experiments, that the proof plane be not suffered to touch any other part of the body except that of which the electricity is to be determined, and not even the sides of the aperture through which it is introduced, as such contact would entirely falsify the result.

The following are among the principal results of these investigations:—

(77.) In a solid body having the form of a perfect sphere, and charged with positive electricity, the whole of the fluid is, in consequence of the repulsion of its own particles, which is everywhere directed from the centre outwards, accumulated in a thin stratum at the very surface of the sphere. If the body be charged with negative electricity, the deficiency of fluid will take place only in the superficial stratum of matter.

(78.) If, instead of being spherical, the body have any other form, the electricity will still be chiefly confined to the surface; and if it have an elongated form, there will be a greater charge in the remoter parts than in those nearer to the middle.

(79.) This result of theory, respecting the limitation of electricity to the mere surface, is confirmed in the most decisive manner by the experiments of Coulomb. A conducting body of the form represented by the section, *fig.* 16,

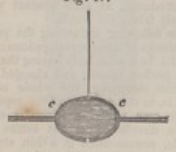
Fig. 16.



had small pits made in various parts of its surface. They were half an inch in diameter, and some of the most shallow were not depressed more than one-tenth of an inch below the surface. When the body was electrified, and the small proof plane applied in accurate contact to the bottom of these pits and depressions, care being taken that it should not touch their margin, and then applied to the electrometer, no indication of its having received any electricity could be perceived; whereas the contact of the same proof plane with any part of the even surface showed the latter to be strongly electrified.

(80.) The following experiment of Biot's contains also a striking practical illustration of the same truth. Let *a* (*fig.* 17.) represent a section of any spheroid of conducting matter, suspended by a thread which perfectly insulates it. Let *c c* be two caps formed of gilt-

Fig. 17.

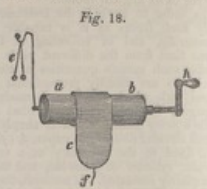


paper, tin-foil, or any conductor, and such that, when united, they accurately fit the surface of the spheroid; and let them be also furnished with insulating handles of gum-lac. Let there be communicated to the ball, *a*, any degree of electricity; and then let the two caps, held by their insulating handles, be carefully applied to its surface. Upon the removal of these caps, it will be found that the whole of the electricity has been abstracted from the spheroid, so that it will no longer affect the most delicate electrometer; whilst the two caps will be found, upon accurate trial, to have acquired precisely the same quantity of electricity which had at first resided in the body *a*.

We may conclude, both from theory and experiment, therefore, that although, strictly speaking, the electricity must reside within the substance of conducting bodies, it extends, in fact, to a depth so small as to be inappreciable by any known methods of observation.

(81.) The effect of an expansion of surface in lessening the intensity of electricity, while its absolute quantity remains the same, is well illustrated by the following experiment mentioned by Biot. *Fig.* 18 represents an insulated cylinder, *a b*, moveable round a horizontal axis, and capable of being turned by an insulating handle *h*. Around the cylinder is coiled a thin lamina of any metal, *c*, the end of which is semicircular, and has attached to it a silk thread *f*. The whole apparatus communicates with an electroscope *e*, formed of two linen threads, each terminating in a pith ball. On communicating a charge of electricity to the cylinder, the threads and balls of the electroscope diverge. Upon taking hold of the silk

Fig. 18.



thread, and unrolling the metallic lamina from the cylinder, the balls gradually collapse; thus indicating a diminution in the intensity of electrical repulsion. If the lamina be sufficiently long, the electrical charge may be spread over so great an extent of surface, as to allow the balls to hang perpendicularly and come in contact. But on winding up the lamina, the intensity of the electricity is restored, and the balls diverge to the same extent as before, allowance being made for the small dissipation of electricity which may have occurred from the contact of the air during the experiment.

(82.) In the case of a long and slender lamina of conducting matter, charged with electricity, Coulomb found that its intensity continued nearly uniform from the middle of the lamina to within a short distance from the ends; at that part it rapidly increased; and at the very extremity it became twice as much as at the middle part. In a circular plate, the electricity is accumulated in much greater quantities at the circumference than about the centre; the intensities being in the proportion of 2.9 to 1: that is, the intensity at the centre is nearly one-third of that at the circumference.

(83.) If the body be an oblong spheroid, arising from the revolution of an ellipse on its greater axis, the thickness of the strata of electricity, or, in other words, its intensity, at the extremities of the two axes, is exactly in the proportion of the respective axes themselves. It thus appears, that if the ellipsoid be much elongated, the intensity must be very feeble at the equator, but very great at the poles. A still more rapid augmentation of the relative

intensity at the extremities takes place in bodies of a cylindric or prismatic form; and the more so as their length bears a greater proportion to their breadth. Coulomb found by experiment that, in a cylinder thirty inches long and two inches in diameter, the intensity of the electricity at the ends was to its intensity at the middle, or at any part more than two inches from the extremity, as 2.3 to 1. Pursuing this train of reasoning, it will lead us to a conclusion of some importance, namely, that if the conducting substance be drawn out into a point, the intensity of the electricity at that point will be exceedingly great; and that the point will accordingly absorb and draw into itself nearly the whole of the electricity that is contained in the body. This vast concentration of electricity is found actually to take place in all points that project beyond the general surface.

Chapter VI.

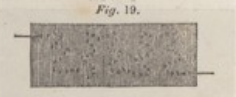
Transference of Electricity.

(84.) We are next to consider the condition of bodies during the prevalence of those forces which tend to overset the electric equilibrium, over those which tend to preserve it. The pressure exerted by the electric fluid against the non-conducting medium, such as the air, which opposes an obstacle to its escape, is in a ratio compounded of the repulsive force of its own particles at the surface of the stratum of fluid, and of the thickness of that stratum; but as one of these elements is always proportional to the other, the total pressure must, in every point, be proportional to the square of the thickness. If this pressure be less than the resistance, or coercive force, as it has been called, of the air, the electricity is retained; but the moment it exceeds that force, in any one point, the electricity suddenly escapes, just as a fluid confined in a vessel would rush out if it were to burst open a hole in the side of the vessel.

(85.) It is only a certain proportion of the whole quantity of electricity in the conducting body that thus suddenly escapes; but the irruption of it is marked by many very striking phenomena, all indicative of the abruptness and violence with which the change is effected. A sharp snap is heard, accompanied by a vivid spark, and there are evidences of an intense heat being evolved in the line which the electricity takes.

(86.) The passage of the electric fluid through a perfect conductor is unattended with light. Light appears only where there are obstacles in its path by the interposition of imperfect conductors; and such is the velocity with which it is transmitted, that the sparks appear to take place at the very same instant along the whole line of its course. Thus, if a row of small fragments of tin-foil be pasted on a piece of glass, *fig.* 19 and electricity be sent through

Fig. 19.



them by connecting one of its ends with the conductor of an electrical machine, while the other end communicates with the ground, it will not be possible to detect any difference of time in the occurrence of the light in the different parts, so that the whole series of luminous points, if sufficiently near, appear, in the dark, like a vivid and continuous line of light. By varying the arrangement of the tin-foil, we may distribute the light in any manner we please, so as to exhibit a brilliant delineation of the figure they represent. Even when conducting bodies appear to be in contact, if the experiment be made in the dark, a spark is generally seen to pass between them, unless the bodies be pressed together with considerable force. Hence, a chain appears luminous at each link, while conveying a charge of electricity.

(87.) The longest and most vivid sparks are obtained between two conductors having a rounded form, and the more so in proportion as they are both portions of spheres of large diameter. This may be exemplified in a common electrical machine, by presenting a metallic ball of large size to that side of the prime conductor which is furthest from the cylinder of the machine. In such cases, however, the electricity being of weaker intensity, the distance between the conducting bodies requisite for the transfer of electricity through the air, or what is termed *the striking distance*, is necessarily small. If the ball is of smaller diameter, or the conductor of a more elongated shape, the electricity at its surface is of higher

intensity, and will therefore pass through a greater extent of air; the spark is in this case of considerable length, appearing as a long streak of fire extending from the conductor to the ball, and instead of being directed towards one point, being distributed to various points throughout a certain extent of the surface of the ball.

Often, when very long, the spark is seen to have an angular or zig-zag course, (see *fig.* 20.) exactly like that of a flash of lightning.—This irregularity

Fig. 20.



is probably occasioned by the fluid darting obliquely in its course to minute conducting particles that are floating in the air, a little removed from the direct line of passage. Even particles of moisture suspended in the air would be sufficient to occasion these deviations. The presence of such particles will account also for the appearance of lateral scintillations, which frequently seem to diverge from the principal stream of electricity. The greater the number of such intermediate conductors, or stepping-stones, as it were, for the electricity, the more readily will the balance between the forces be overset, and the irruption of electric fluid determined.

When the air is either sufficiently moistened, or sufficiently rarefied, the electric fluid passes through it with comparative facility, and its track is indicated by streams of light, probably occasioned by many parallel series of minute sparks passing from particle to particle.

(88.) Electrical light differs in no respect from the light obtained from other sources. Dr. Wollaston found that, when observed through a prism, the ordinary colours arising from the decomposition of light are obtained; but the prevailing tint of colour will vary according to the different substances through which the sparks pass, or to the nature of the surface from which they emanate, or by which they are received. Dr. Brewster found that it is capable of undergoing polarization, either by transmission through a doubly refracting crystal, by reflection at the proper polarizing angle from a polished plane surface, or by oblique refraction through a series of glass plates.

(89.) The brilliancy of the electrical spark is proportional to the conducting power of the bodies between which it passes. When an imperfect conductor, such as wood, is employed, the electric light appears in the form of faint red streams; but metals afford them of great brilliancy. Its colour is subject to variation, from a great number of different circumstances. Sparks passing through balls of wood or ivory, are of a crimson colour; but this depends also upon their position with regard to the surface. If two pointed wires be inserted obliquely and in opposite directions into a piece of soft deal, having their points an inch and a half distant, but penetrating to different depths below the surface, and so that the line joining them is in the direction of the fibres, the sparks passing from the one to the other, will exhibit different colours at different depths; and if one of the points be inserted deeper than the other, all these colours will appear at once, according as the electric light is transmitted at various depths. Electric sparks passing from one polished metallic surface to another are white; but if the finger be presented to an electrified conductor, the sparks obtained are violet. They are green when taken from the surface of silvered leather; yellow when taken from finely powdered charcoal; and of a purple colour when taken from the greater number of imperfect conductors. If one of the bodies between which the spark takes place is a green plant, the light is red; and the same is the case with water or ice. In the vapour of ether green sparks are seen when the eye is placed close to the tube: but they appear reddish when viewed at a considerable distance. Even between the same two metallic conductors the colour may vary from the most brilliant white to the most delicate violet, according to the distance through which the electricity is transmitted, and according to the resistance of the medium which it is compelled to traverse. In exceedingly rarefied air, the colour of the spark is green; in denser air, it acquires a blue tint, and passes to a violet and purple, in proportion as the condensation of the air is increased. Transmitted through other gases, the colour varies according to their density.

In carbonic acid gas, the spark is white and vivid; in hydrogen gas, it is faint and red.

(90.) It should be recollected, in making these experiments, that in proportion as the medium is more rare, its conducting power increases, and a smaller intensity of electricity is required for the production of light. In the ordinary vacuum produced by the air-pump, the passage of electricity is rendered sensible by streams or columns of diffused light occasionally varying in their breadth and intensity, and exhibiting movements which give them a marked resemblance to the coruscations of the Aurora Borealis. After rarefying the air contained in a glass jar, about one foot long and eight inches in diameter, to the 500th part, Mr. Smeaton placed the jar upon a lathe, and caused it to revolve rapidly, whilst at the same time he rubbed it with his hand. A considerable quantity of lambent flame appeared under his hand, variegated with all the colours of the rainbow. The light was steady; but every part of it was constantly changing colours. When a very perfect vacuum is made in a glass cylinder covered with a brass plate, the electric stream will pass between it and the plate of the receiver of the air-pump, in a continued stream of the same size throughout its whole length. If a Torricellian vacuum be formed in the upper portion of a long bent glass tube filled with mercury, and inverted, by placing the legs of the bent tube in separate basins of mercury, when electricity is transmitted through the tube, light is seen to pervade the vacuum in a continued arch of lambent flame, without the least divergency.

(91.) It was natural to suppose, before sufficient consideration had been bestowed upon the subject, that the light which appears during the passage of electricity, was actually the electric fluid itself, which, at some certain degree of accumulation, was in itself luminous; and such was the notion entertained by the early electricians. But since we know that common atmospheric air becomes luminous by violent compression, and we must also presume that electricity exerts a very sudden and powerful pressure upon the air by its passage through that resisting medium, we are certainly justified in drawing the inference that the same phenomena proceed in both cases from the same cause. Biot has adopted this opinion, which appears to be more consonant with philosophical views of the subject than any other: for it is certain that the whole of the electrical light that appears is not more than what may proceed from the mechanical compression of the air, the vapours, and other constituents of the medium through which the passage of the electricity is effected.

(92.) The sound which accompanies these various modes of transference is subject to corresponding modifications, dependent likewise, no doubt, upon the degree and the suddenness of the impulses given to the air. The full, short, and undivided spark is attended with a loud explosion; the more lengthened spark, with a sharper snap, which becomes more broken and rattling in proportion to the distance it has to traverse. The luminous streams produced by a succession of minute sparks are scarcely productive of noise, but are accompanied only by a faint rustling sound, like that of a stream of wind through a narrow chink.

(93.) A peculiar odour has sometimes been perceived in the neighbourhood of an electrical machine which has been briskly worked, so as to emit for some time a great number of sparks; and it has been thought to resemble that of phosphorus. This is also probably owing to some unknown chemical decomposition effected by the electricity during its passage through the air.

(94.) We have already had occasion to remark the great increase of intensity which the electric fluid acquires at the extremity of all elongated parts of conducting bodies; and the indefinite augmentation of this intensity which takes place at the apex of all projecting points. This high intensity will necessarily be accompanied with a powerful tendency in the fluid to escape; a circumstance which furnishes a natural and exact explanation of the rapid dissipation of electricity which takes place from all bodies of a slender and pointed form.

The following experiments illustrate these positions. Let the insulated conductor of a machine be furnished with a pair of pith-balls, suspended by a fine wire, and charged with either species of electricity; the divergence of the balls will indicate the presence and degree of this electricity. If a metallic rod with a ball at one end be held in the hand,

and the ball presented to the conductor, taking care not to bring it sufficiently near to draw a spark, the balls will be but little affected, and their divergence will continue for a considerable time. But if the rod terminate in a sharp point, instead of a ball, and the point be presented to the conductor at the same distance as the ball was in the former case, the electroscope will immediately collapse, showing that the electrical charge has entirely disappeared: it has, in fact, been rapidly drawn off by the pointed rod. It is quite immaterial to the success of the experiment whether we affix a point to the conductor itself, or whether we present to it a point held in the hand; the escape and dispersion of the electricity being equally promoted by the presence of a point, whether the fluid be given out or absorbed; for it is scarcely necessary to remark that the very same kind of reasoning applies equally to both the positive and negative conditions of electricity.

(95.) Currents of air always accompany the discharge of electricity, whether positive or negative, from pointed bodies; for each particle of air, as soon as it has received its electricity from the point, is immediately repelled by the body. These currents tend powerfully to increase the dissipation of the electricity, by bringing in contact with the point a continued succession of particles of air, that are not yet electrified, and are, therefore, ready to receive a charge. Many amusing experiments are founded on this principle. Let two cross wires, (*fig.* 21.) the ends of which terminate in

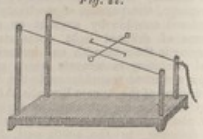
Fig. 21.



points, bent in a similar direction with respect to the axis, be supported by means of a cap upon a fine point, and electrified by being placed upon the prime conductor of a machine. Each of the points will give off a stream of electricity: this will remove a part of the pressure which the fluid would have exerted on that side if no efflux had taken place; but as the pressure of the fluid on the opposite side of the wire, in the opposite direction, still operates in full force, the wire will be impelled in the direction of that force, that is, in a direction opposite to that of the stream; and this taking place at all the four points, the whole system will revolve backwards with considerable rapidity.

The following is another form in which this experiment may be made. Two wires, (*fig.* 22.) are stretched in

Fig. 22.



the direction of a plane, slightly inclined to the horizon, between four insulating pillars. Across these wires, another wire is made to rest, terminating by small balls at each end, and having a cross wire fixed to it at right angles, with two bent points, as in the former experiment. When this system is electrified, the dispersion of the electricity from the points produces a revolution of the bars, which makes the transverse bar roll up the inclined plane.

An apparatus consisting of wires terminating in points, and having balls annexed to them to represent the planets, may be constructed so as to revolve when electrified; and thus to imitate the planetary motions. Such an apparatus has been called an electrical orrery.

(96.) It should be observed, however, that a point loses its power of concentrating and dispersing electricity when it is surrounded by other parts of the conducting body which are equally prominent; as when it is placed between two balls, or inclosed in a tube, or when it does not rise above the general surface of the body. The effect of one point is much diminished even by the vicinity of another point; so that if several points placed near each other be presented to the conductor, the electricity is drawn off much less rapidly, and will be transferred by sparks instead of forming a continued stream.

(97.) When the transfer of electricity takes place between smooth surfaces of a certain extent, no difference can be perceived in the nature and appearance of the spark, whichever be the position of the negative surface. But in the passage of electricity through points,

the effect is considerably modified by the species of electricity with which the bodies are charged; or, in other words, by the direction in which the fluid moves. When the electric fluid is escaping out of a pointed conductor, the luminous appearance is that of diverging streams, as represented in *fig.* 23; forming what is termed a *pencil of light*, and

Fig. 23.



resembling the filaments of a brush. When, on the contrary, the electric fluid is entering into the pointed body, the light is much more concentrated at the point itself, having a resemblance to a *star*, in which, if any streams appear, they are disposed like radii, and equally so in all directions. An approach to these different modifications may be remarked when sparks pass between balls of small diameter, especially if the charge is high. Thus the direction of the lateral ramifications sent out from the principal line, in the branched spark, *fig.* 20, is from the positive to the negative surface.

(98.) In describing the above appearances, we have, as usual, referred to the hypothesis of Franklin: but if we adopt that of the two electricities, we have only to consider the appearance of the pencil of light as arising from the double current of the vitreous electricity issuing from the point, and of the resinous electricity passing into it: while the star will be the effect of the irruption of the resinous, and the absorption of the vitreous electricities. But this remarkable difference in the phenomena produced, according to the particular species of electricity with which the point is charged, has always been urged as a convincing argument in favour of the Franklinian theory. They appear very strongly to indicate the emanation of some material fluid from the positive, and its reception by the negative point. The diverging lines on the one side, and their inflections on the other, represent exactly the paths of particles flowing out as from a pipe, and urged forwards by a force which gives them such a projectile velocity as to prevent their spreading out beyond a certain distance from the direct line of projection. But this very velocity will carry the particles that happen to have deviated most, somewhat beyond the point to which they are attracted: while the attraction to this latter point will tend to deflect them from the line of their path, and gradually turn them back, so that they will arrive at the point of attraction by very different paths, and some even by a retrograde motion. Hence, while in the first case they form a diverging cone of rays, in the latter they must be distributed on all sides of the point like the rays of a star. The annexed diagram, *fig.* 24, will sufficiently illustrate this explanation by

Fig. 24.



representing the supposed course of the particles of electric fluid, passing through the air from the positive to the negative point. What weight the argument derived from this phenomenon may be allowed in deciding the question, will be discussed in the sequel.

(99.) The difference which we have now described in these two appearances, may be employed, on many occasions, as a useful criterion of the species of electricity, at least, which is passing from one conductor to another, if not of the absolute direction of its motion. For, if a needle be presented to an electrified body, the appearance of a star on the needle will show that the electricity of that body is positive; while, on the contrary, a luminous brush on the needle will indicate that the body is negative.

(100.) The influence of a point projecting a short distance from the surface of a body, is greater when that body is negative than when it is positive. Hence, a spark is more readily obtained in the latter case than in the former.

On this principle an instrument has been invented by Mr. Nicholson for distinguishing the negative from the positive electricity. It consists simply of two metallic balls fixed at the ends of two curved rods of glass, and moveable like branches on a joint, so as to admit of the balls being placed at different

distances from each other, when held by a handle proceeding from the joint. A short point projects from one of the balls on the side adjacent to the other ball; and this point affords a spark at a shorter distance when positively, than when negatively electrified.

Chapter VII.

Development of the Law of Induction.

(101.) We have next to trace the consequences of that important law of electricity which has been called the Law of Induction.

Active electricity existing in any substance tends always to induce the opposite electrical state in the bodies that are near it. Now it is impossible, as we have already seen, to induce one electrical state in any body without at the same time producing the opposite state in the same body, or in the one which is immediately contiguous. According to the simpler theory, the accumulation of electricity in any one part can be effected in no other way than by withdrawing it from another part, nor can it be abstracted from the one without being received by another; so that there is always an equal degree of negative as of positive electricity, and *vice versâ*, in every case. According to the more complex theory, if we decompose the natural electricities residing in any body, we must at the same moment obtain equal quantities of both the vitreous and resinous electricities. It follows, therefore, that if the bodies subjected to the inductive influence are non-conductors, although the tendency to produce the opposite electricity still exists, yet in consequence of the immobility of the fluid, it can produce no visible change. In proportion as the body opposes less resistance to the passage of electricity, the operation of the disturbing force becomes sensible; and in order to fix our ideas, let us first take the case of a positively charged electric, acting by induction on an insulated conducting body. The redundant fluid in the former will tend to repel all the fluid contained in the latter: a portion of this fluid will, therefore, be driven from the side adjacent to the first body, towards the remoter side. The adjacent side will thus be rendered negative; the remote side, positive. But this will take place to a certain extent only: for there is a limit at which the repulsion of the fluid accumulated at the remote end, will just balance the repulsion of the fluid in the electric, added to the attraction of the under-saturated matter, in the near end; and when this limit has been attained, the flow of electric fluid from the near to the remote end of the body will cease, and an equilibrium will be established.

(102.) Experiment shows the perfect coincidence of theory with the actual fact. Let a cylinder of metal, NP, (see *fig.* 23,) of some length, with rounded ends, and furnished in different parts

Fig. 25.



with pairs of suspended pith-balls, to serve as electroscopes, being previously insulated, be placed in the vicinity of an electrified globe of glass, E, taking care that it be not sufficiently near to receive any quantity of electricity by transference.

We shall find that every pair of balls, except those situated in a particular plane M*m*, about the middle of the cylinder, will immediately diverge, indicating the electrical states of the parts from which they are suspended. Those at either extremity of the body, *n*, *p*, diverge the most; and the divergence diminishes as we approach the middle plane before mentioned, at which the body is in the natural or neutral state. The position of this plane of neutrality, M*m*, varies according to the distance of the electric, and the relation which that distance bears to the length of the body itself. If we further examine the species of electricity residing in the different parts, we shall find it to be negative in all the parts nearer to the electric than the neutral plane, and positive in all those more remote. We may ascertain with much greater accuracy these electrical states by the employment of the proof plane and electrometer of Coulomb, than by the pith-balls; and the results are then found to correspond, with the most rigorous precision, with the deductions from the theory of electrical action.

(103.) These effects, it should be remarked, are simply the result of the action of electricity at a distance; for they depend upon no other circumstance.

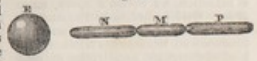
They take place in an equal degree whatever substance be interposed between the bodies which are exerting this action on one another, provided the interposed substance undergoes no change in its own electrical state; a condition which is fulfilled in electrics only. Thus, induction will take place just as effectually through a plate of glass, as if no such substance had intervened.

(104.) Let us now suppose that the acting body, E, is, instead of an electric, a conducting body, a globe of metal, for example, charged with positive electricity. The primary effects of this globe on the cylinder will be the same as in the former case; but the electrical state which the globe has induced on the cylinder will re-act upon its own electricity. The negative electricity, that is, the under-saturated matter at the nearer end of the cylinder N, exerts a tendency to induce positive electricity in the globe, and more especially upon the adjacent side, F: that is, it will tend, by its attraction for the fluid, to draw it to that side, and thus render it still more highly positive than it was before. This can only be done at the expense of the other side, O, from which the fluid must be taken, and which is, therefore, rendered less charged with fluid, that is, less positive than before. But this new distribution of the electric fluid in the globe, by increasing the positive state of the side, F, next to the cylinder, tends to augment its inductive influence on the fluid in the cylinder; that is, to drive an additional quantity of fluid from the negative to the positive end. This is followed, in its turn, by a corresponding reaction on the globe, and so on, constituting a series of smaller adjustments, until a perfect equilibrium is established in every part. When this has been attained, the electrical states will, it is evident, be of the same kind as those consequent upon the immediate actions, though somewhat increased in intensity by the series of reactions.

The following experiment is a practical illustration of the preceding reasoning. Furnish the metallic globe with electroscopes on its opposite surfaces; when the globe is insulated and alone, any electricity communicated to it will diffuse itself equally over the surface, and both the electroscopes will diverge equally. But no sooner do we bring near to it a conducting body, than the balls of the electroscope at the side most distant from that body begin to collapse, while those at the nearer side diverge to a greater degree than before; thus showing the nature of the reflex operation of the induced electricity of the conductor upon the body from which the induction originated.

(105.) It should be recollected that in all the changes we have thus traced as the effects of induction, there has been no transfer of electricity from either of the bodies to the other; as was sufficiently proved, indeed, by their taking place equally in a plate of glass be interposed. Another proof is afforded by the circumstance that the mere removal of the bodies to a distance from one another, is sufficient to restore each of them to their original state. The globe remains as positively electrified as before; the cylinder returns to its condition of perfect neutrality; nothing has been lost, and nothing gained on either side. The experiment may be repeated as often as we please, without any variation in the phenomena. But this would not be the case if the cylinder were divided in the middle, and one or both of the parts were removed separately, while they still remained under the influence of the globe. The return of the electric fluid from the positive to the negative end being thus prevented, each part will retain, after its separation, the electricity which had been induced upon it. The nearer portion will remain negative; the remoter portion, positive. If the division had been in three parts, the middle part only would have been neutral. The experiment may be made by joining two or more conductors endwise, as shown in *fig.* 26, so that they

Fig. 26.



may act as a single conductor when placed near to the electrified globe, and after induction has thus been produced, removing them separately, and examining their electrical states. If E be positive, N will be found negative, P positive, and M neutral.

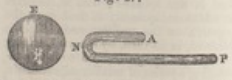
(106.) Another modification of effect will take place when an insulated conductor, rendered electrical at both ends by induction, is made to communicate with another conductor. Let us first suppose that a long metallic conductor

is brought into contact with the remote end of the first cylinder P, (*fig.* 25), which has been rendered positive by induction. The fluid accumulated at this end will now pass into the conductor, and will remove to the most distant part of the conductor. The transit will now take place before actual contact, and will be manifested by the appearance of a spark when the bodies are brought within the striking distance. The removal of this fluid to a greater distance will occasion a disturbance in the equilibrium that had before been established. The repulsion which that fluid had excited, and which had contributed to prevent any more fluid from being propelled from the negative end N, is now considerably weakened by the greater distance at which it acts; and more fluid will leave the negative end, which end will consequently become more highly negative. This change of distribution will again occasion a further effect, by its reaction on the fluid in the globe whence the action originally proceeded; and another series of changes and adjustments will follow, until a new condition of equilibrium takes place, and then the fluid will be at rest.

(107.) Thus we learn that the effects of induction on a conductor are augmented by increasing its length; they would, therefore, be greatest of all, if we could give it infinite length: but the same condition is attainable by placing the conductor in communication with the earth, which will accordingly carry off all the fluid which the electrified body is capable of expelling from the nearest end. Accordingly, if we touch with the finger, or with a metallic rod held in the hand, the remote end of an insulated conductor under the influence of induction, we obtain a spark, more or less vivid according to the intensity of the electricity so induced; and the conductor so touched has now only one kind of electricity, namely, the one opposite to that of the electrified body which is acting upon it. The part touched is brought into a state, in which it appears to be neutral as long as it remains in the vicinity of the electrified body; because the actions of the redundant fluid, and unsaturated matter in the two bodies, exactly balance one another. But it all the while really contains less fluid than its natural share, in consequence of the repulsive tendency of the fluid in the body which produces the induction; and this negative state will readily become active, if the conductor that has been touched be again insulated, and then removed from the influence of the former. This peculiar condition of a body, in which its parts are really undercharged or overcharged with fluid, although, from the action of electrical forces derived from bodies in its vicinity, a state of equilibrium is established, and no visible effect results, has been denominated by Biot, *disguised electricity*.

(108.) It is also worthy of remark, that if the communication between the insulated conductor and another longer conductor, or the earth itself, be made at either end of the former, the same effect will result, and the electric fluid accumulated at its remote end will be carried off by the longer conductor, although, it will have, in one case, to pass round through the end nearest to the body which repels it. The operation which here takes place may be illustrated by the motion of a fluid in a syphon. A repulsive force is acting upon the fluid, both in the shorter and the longer column; but with regard to the motion of the fluid in the bent channel the one force is in opposition to the other, and the tendency of the fluid in the longer column prevailing over that in the shorter, will draw off the latter, round the bend of the supposed syphon. Thus in the bent conductor A N P (*fig.* 27,), the repulsion exerted by the fluid in E for that in the longer column N P,

Fig. 27.



being greater than its repulsion for that in the shorter column N A, the fluid in A will be carried over the bend N, notwithstanding its tendency to move from N towards A.

(109.) We have hitherto supposed the acting body to be positively electrified; but precisely the same effects would happen with regard to degree, although opposite as to the species of electricity, if it had been negatively electrified: and the same explanations will in every respect apply, with the requisite substitution of the terms negative for positive, and of attraction for repulsion, and *vice versâ*. A little reflection will also easily show the application of the

theory of the double electricities to explain the same phenomena.

(110.) Another consequence of the induction of electricity must not be overlooked, namely, that the bodies between which it takes place, necessarily attract one another: for the action of the adjacent sides F and N (*fig.* 25), which are brought into opposite electrical states, is greater than the action of those sides which are in the same electrical states, F and P, and which are more distant: hence the attractive force always exceeds the repulsive. We have already seen that this circumstance sufficiently explains the fact that conducting bodies, previously neutral, are attracted by electrified bodies. Another fact, which appears more singular, and which cannot be accounted for on any other principle, is also a direct consequence of the law of induction. If a small body weakly electrified, be placed at a distance from another and a larger body, more highly charged with the same species of electricity, it will, as usual, be repelled; but there is a certain distance within which if it be brought, attraction will take place, instead of repulsion. This happens in consequence of the inductive influence producing so great a change in the distribution of electricity, as to give a preponderance to the attractive forces of the adjacent parts of the two bodies, over the repulsive forces that take place in the other parts, and which would have alone acted if the fluid had been immoveable.

(111.) From the principles now laid down, it will be easy to understand how induction may operate through a succession of conductors, which are all of them insulated, except the last; and which are separated from each other by distances greater than that at which a transfer of electricity would take place. If, under such circumstances, the first be electrified, alternate states of opposite electricities will be produced in the two ends of each conductor in succession. In all the ends nearest to the first body, the electricity will be of the opposite kind to that with which the first has been charged; in the other ends it will be of the same kind as that of the first body. The vicinity of these opposite electricities will tend powerfully to retain them in that condition, and will diminish their electric action on surrounding bodies. A large portion of the electricities so arranged and retained, is, therefore, in the condition designated by the term *disguised electricity*.

(112.) In proportion as the interruptions to the continuity of the line of conductors are more numerous, the more nearly will such a system approach to the condition of an imperfectly conducting body. The same principle admits of being extended, with some modifications indeed, to the constitution of electrics themselves, as we shall have occasion to notice in the sequel.

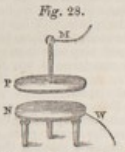
Chapter VIII.

Accumulation of Electricity by Induction.

(113.) The most important application of the principle of induction is that by which a vast accumulation of electricity is obtained in a small space, while its intensity, or tendency to escape, is at the same time rendered exceedingly small. This condition exactly corresponds to that which has been termed *disguised electricity*.

(114.) Let two circular metallic plates P and N (*fig.* 28), be placed the one immediately over the other, but separated by a non-conducting medium, such as the air, or, what is still better, a plate of glass. Let the upper one P, commu-

Fig. 28.



nicate, by a wire M, with the prime conductor of the electrical machine; and let the lower one N, be insulated by resting upon three glass supporters. Let P be charged with a certain quantity of electric fluid. The fluid naturally contained in N, will be repelled by the fluid in P, and will quit the upper surface of N in order to occupy its lower surface. When this change has taken place, let N be touched by a wire W, establishing a communication between it and the ground. All the fluid which was accumulated in the lower surface of N, will be carried off by the wire, and the whole plate will thus be negative, or undercharged with fluid. The

redundant matter in N will, by its attraction for the fluid, draw more of it into the upper plate, which will be supplied from the conductor of the machine through the wire M; and such an additional quantity will be accumulated in P, as will balance the increased attraction of the matter in N, and maintain it at the same intensity as the fluid in the prime conductor. That this is what really happens will be rendered evident by placing an electroscope upon the prime conductor; for the moment the plate N communicates with the ground, the balls of the electroscope collapse, showing that the intensity of the fluid in the prime conductor is suddenly reduced by the great quantity that has been absorbed by the plate P. The machine must now again be set in motion, in order to supply the electricity which has been thus abstracted from the conductor. The operation of each plate on the other may be considered as that of increasing its electrical capacity, or of rendering a large proportion of its electricity latent or disguised.

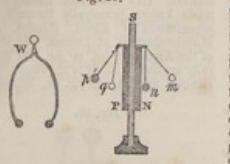
(115.) It is evident that the quantity of electric fluid driven out of the lower plate by the action of the fluid in the upper one, can never be quite equal to that of the fluid with which the upper one is itself charged, and the difference will be greater in proportion to the distance of the plates. When they are very close to each other, these two quantities approach very near to an equality; and this circumstance it was that misled Franklin into the belief that they were actually equal.

(116.) The capacity for accumulating electricity corresponding to a given intensity in the upper plate depends upon the distance between the plates, provided always that the intervening electric opposes a sufficient obstacle to the direct transfer of the electricity from the one to the other; and is in some inverse ratio to that distance. The lower plate, N, which communicates with the ground by the wire W, although strongly negative, is rendered, by the vicinity of the fluid in the upper plate P, neutral with respect to fluid in the wire W: that is, the attraction of its unsaturated matter, although nearer, is exactly balanced by the repulsion of the redundant fluid in the upper plate, which, although really stronger, is, from the greater distance at which it acts, only equal to the former. With reference to fluid in the wire M, however, the action of the redundant fluid in P, is not balanced by that of the unsaturated matter in N, which latter is both weaker in itself and more distant. Thus, while N is neutral with respect to the conductors which touch it, P is in a slight degree active, in consequence of this small preponderance of force, and a portion of its fluid tends to escape. Hence, if N be again insulated, by removing the wire W, and the wire M be now made to communicate with the ground, this portion of the fluid in P will pass off by it; but not any larger quantity, for the remaining portion is retained by the attraction of the unsaturated matter in N. P is, by this loss, rendered neutral, as N had before been, and it now no longer acts on the fluid beyond it in M. The influence of P on that fluid is greater than that of N in respect to its greater vicinity, but less in as far as regards the intensity of action, and the compensation is exact. But under these circumstances, N, which was before neutral, becomes in its turn active, and now that the repulsion of the fluid in P is diminished, will absorb a certain quantity of the fluid as soon as it is touched by W, after P has been again insulated. By this contact, N is again restored to the neutral state, a fresh portion of fluid in P is released from the attraction of N, and P is again active. By repeating these alternate contacts a sufficient number of times, we gradually deprive the plates of their whole charge of electricity; alternately imparting small portions to the negative plate, and taking away the like portions from the positive one, until they are both brought to their natural unelectrified state. The quantities of fluid which are thus successively added and abstracted were found, by the calculations of Laplace, to be in geometrical progression.

(117.) The most convenient mode of obtaining the accumulated electricity arising from induction is by the employment of *coated glass*, that is, of a plate of glass, on each side of which is pasted a sheet or coating of tin-foil. Care must be taken to leave a sufficient margin of glass uncovered by the metal, for preventing the transfer of electricity from the one coating to the other round the edge of the glass; and all sharp angles, or ragged edges in the coatings, should be avoided, as they have a great tendency to dissipate the charge.

(118.) The following experiment of Professor Richman, (the philosopher who fell a sacrifice to his zeal for electrical science by a stroke of lightning from his apparatus,) is very instructive. Let a pane of glass placed vertically, and seen edgewise in *fig.* 29, be coated on both sides, and furnished with two

Fig. 29.



small electroscopes, *p*, *n*, consisting of two pith-balls, one attached to each of the coatings. Let the coating P be charged positively, while the coating N is made to communicate with the ground. The electroscope *p* will stand out from the plate, and *n* will hang down close to its coating, as long as N communicates with the ground. But in proportion as P loses electricity by gradual dissipation in the air, the ball *p* will gradually, but very slowly descend. If we now insulate N, *p* will fall down at first very speedily, and then more slowly, till it reaches *q*, about half its first elevation. The ball *n* will at the same time rise to nearly the same height; the angle between the two electroscopes continuing nearly the same as at first. When *n* has ceased to rise, both balls will very slowly descend, till the charge is lost by dissipation. If we touch N during this descent, *n* will immediately fall down, and *p* will as suddenly rise nearly as much; the angle between the electroscopes continuing nearly the same. Remove the finger from N, and *p* will fall, and *n* rise, to nearly their former places; and the slow descent of both will again recommence. The same thing will happen if we touch P, *p* will fall down close to the plate, and *n* will rise to *m*, and so on; and this alternate touching of the coatings may be repeated some hundreds of times before the plate is entirely discharged. If we suspend a crooked wire, bent, as shewn at W, (*fig.* 29,) having two pith-balls, from an insulated point, *s*, above the plates, it will vibrate with great rapidity, the balls striking the coatings alternately, and thus restoring the equilibrium by steps; each contact being attended by a spark.

(119.) If, instead of this gradual discharge, a direct communication is made between the two coatings by a metallic wire extending from the one to the other, the whole of the electric fluid which was accumulated in the positive coating rushes with a sudden and violent impetus along the conductor, and passes into the negative coating, thus at once restoring an almost complete equilibrium, and rendering every part very nearly, though not absolutely, neutral; for as there must always be some slight difference in the quantity of electrical charge in the two coatings, where one of them is in communication with the ground, there must always be a certain excess, however minute, of electricity, after the balance has been struck.

(120.) This sudden transfer of a large quantity of accumulated electricity is a real explosion; it gives rise to a vivid flash of light, corresponding in intensity to the magnitude of the charge. The effect of its transmission is much greater than that of the simple charge of the prime conductor of the machine; for while the latter gives a spark only, the former imparts what is called *an electric shock*, and the sensation it produces when passing through any part of the body is of a peculiar kind. We shall describe their effects in a future chapter; at present we must confine our attention to the purely electrical conditions of the phenomenon.

(121.) The presence of the coating is not absolutely essential to the charge and discharge for the two surfaces of the glass plate; for if the glass be furnished with moveable coatings, and charged in the usual manner, upon removing the coatings (taking care that they be touched only by electrics,) the greater part of the electricity will be found to have attached itself to the surfaces of the glass plate, where they are retained by their mutual inductive influence. In this state the charged plate of glass may be gradually discharged by making a communication between its several parts in succession. It cannot be discharged at once, for want of a common intermedium for the simultaneous transference of the electricity of the different parts of the surface. But if this be supplied by replacing the former coatings, or adding new ones

the complete discharge may be effected as before.

(122.) By peculiar management a charge may be given to a plate of glass independently of any coating whatever. For this purpose, it must be held by one corner, and passed before a ball, connected with the prime conductor of a machine, so that it may successively come in contact with every part of the middle of the plate of glass, while the finger, or any conducting body communicating with the ground, is held opposite to it on the other side. Thus the glass will be charged, and will be in the same state as the glass from which the coatings had been removed.

(123.) We often find, a short time after the discharge of coated glass, that it has acquired spontaneously a small charge, producing a faint spark when a second communication is made between the coatings by the discharging wire. This, which is called the *residual* charge, arises from two causes: first, a portion of the electricity adheres to the uncoated surface of the glass: and secondly, another part has penetrated from the coating for some little depth below its surface. Both these portions slowly return to the coatings after they have been deprived of their original charge, and give it a fresh charge. When a very large extent of coated glass is employed, this residual charge may even amount to a considerable quantity, and the experimenter should be cautious not to expose himself to the shock which he might thus receive, if he inadvertently touched the apparatus before he had properly discharged it. That charges are capable of penetrating even through the entire thickness of the glass is proved by the curious fact, that a coated, cylindrical jar may be discharged merely by keeping up for a sufficient time a continuance of the minute vibrations excited by rubbing it with the finger, or by making it ring. A discharge may also be effected by heating the glass, which renders it a conductor of electricity.

(124.) The most convenient form for coated glass for experimental purposes, is that of a cylinder or jar. In the earlier periods of electrical research, jars were filled with water, mercury, or iron filings, which furnished the interior coating, while the exterior coating was supplied either by water, in which the jar was immersed, or by the hand of the operator, who for that purpose grasped the outside of the jar: a rod of metal was employed to communicate the charge from the prime conductor of the machine to the inner coating. On making a communication between the exterior and interior coatings, by means of a circuit of conducting substances, the discharge took place, and the shock made to pass through the circuit thus formed. This instrument having been made known principally through the experiments of Kleist, Cuneus, and Muschenbroeck, at Leyden, the name of the *Leyden phial*, or *jar*, was generally applied to it. It is at present constructed as shewn in *fig.* 30, by applying coatings of tin-foil on both sides of the jar or bottle, leaving a sufficient space uncovered at its upper part to secure it from the risk of a spontaneous discharge, which might take place if the coatings were not separated by a sufficient interval. A metallic rod, rising two or three inches above the jar, and terminating at the top in a brass ball, which is often called the *knob* of the jar, is made to descend through the cover, till it touches the interior coating. It is through this rod that the charge of electricity is conveyed to the inner coating, while the outer coating is made to communicate with the ground. We have already seen, that if this last condition be not observed, the inner coating can receive no charge, and only a feeble spark will pass from the conductor to the knob.

Fig. 30.



(125.) The outer coating may be made to communicate with the ground by holding it in the hand; and on presenting the knob of the jar to the prime conductor when the machine is in motion, a succession of sparks will pass between them, while at the same time nearly an equal quantity of electricity will be passing out from the exterior coating, through the body of the person who holds it, to the ground. If, instead of this, the jar be placed on an insulating stand, and a ball of metal, or the knuckle of the finger, be held near the outside of the jar, we have evidence of the escape of the electricity from the latter by a succession of sparks simultaneous with those that occur between the prime conductor and the knob of the jar.

(126.) If, instead of touching the outer coating of a jar supported on an insulating stand, we bring into contact with it the knob of a second jar, of which the outer coating communicates with the ground, as shewn in *fig.* 31,

Fig. 31.



the electricity which is expelled from the outer coating of the first jar passes into the inner coating of the second jar, and thus both jars are charged. Thus may charges be given to a succession of jars, so placed as that the inner coating of each shall communicate with the outer coating of the one that precedes it in the series; taking care that the outer coating of the last jar communicates with the ground. All the jars will be found to be charged in a similar manner. It is evident, however, that the charge must diminish in intensity as it is conveyed from each jar to the next, because the quantity of electricity which is expelled from the exterior is never quite equal to that which passes into the interior.

(127.) For the sake of greater distinctness we have all along supposed the interior of the jar to be charged with positive electricity, but the very same effect would take place if the knob of the jar were charged negatively by communication with the negative conductor. A similar change in the electrical state of the coatings would result from placing the jar on an insulating stand, and then forming a communication between the outer coating and the prime conductor, while the knob is made to communicate with the ground. The only difference is, that the outer coating would then be active and the inner one neutral; but these conditions would again be reversed as soon as the knob was disconnected with the ground, and the outer coating touched with the hand.

(128.) If two jars, the one charged positively, the other negatively, be placed on two separate insulating stands, and their knobs then connected by a conductor, which is itself insulated, no explosion will take place, although the two coatings, which are thus brought into communication, are in opposite electrical states. But if the two outer coatings be at the same time connected, an explosion will take place, and both jars will be discharged.

(129.) Since the susceptibility of receiving a charge depends upon the proximity of the metallic surfaces, while the passage of the electricity from the one to the other is interrupted by the interposition of a non-conducting substance, it is evident that, in the construction of the Leyden jar, the thickness of the glass is an important consideration. The thinner the glass, the greater will be the power of taking a charge; but the power of retaining the charge will be less, on account of the diminished resistance which the glass will afford to the passage of the electricity through it. If the charge be higher than what the jar will bear, the glass will be broken by the violence with which the electricity forces a passage through its substance. Muscovy talc, even in very thin laminæ, resists much better than glass, and is, therefore, capable of receiving and of retaining a much higher charge. Another limit to the charge which a jar is capable of retaining, arises from the liability of the electricity to pass from one coating to the other, round the edges of the glass.

(130.) These spontaneous discharges, as they are called, are facilitated by the deposition of moisture on the glass, forming a chain of conducting particles in the very line which the electricity has a strong tendency to take. Hence, it is a requisite precaution to keep the apparatus in as dry a state as possible; and the deposition of moisture may be guarded against most effectually by covering the uncoated part of the glass with a layer of sealing-wax, or other

resinous varnish. The liquid should be applied with a flat, camel-hair pencil, the glass being previously warmed.

On the other hand, it is a curious circumstance, that there is a degree of humidity in the inside of the jar, not only compatible with a high charge, but which even contributes to retain it. This effect was accidentally observed by Mr. Brooke, and afterwards by Mr. Cuthbertson, who states that a jar will take a much greater charge, namely, one-third more, if its inside be considerably damped by blowing into it with the mouth through a tube reaching to the bottom. The explanation of this remarkable fact has been given by Professor Robison on the principles formerly explained, namely, that there is no electric intensity so great, but that it may be insulated by the least imperfect conductor, provided the latter be long enough, and so constituted as that the intensity of the electricity it contains shall diminish by sufficiently gentle gradations. An uniform dampness, indeed, will not do this; but it will diminish the abruptness of the variations of intensity, and thus give security against a spontaneous discharge. A similar protection against the breaking of the glass is afforded by placing a layer of paper between the glass and the tin-foil, and making it extend also an inch beyond the coating.

(131.) Glass balloons of a spherical shape, being of more uniform thickness than jars, would be much preferable for the construction of an apparatus of this kind, were it possible to apply an uniform coating to the inside. Professor Robison recommends the following construction for a portable jar, which he found to answer exceedingly well. A long-necked phial was made of sheet tin, and then coated entirely on the outside with fine sealing-wax, one thirtieth of an inch thick. The sealing-wax was then coated with tin-foil, all but the neck. It is evident, that the wax here acts the part of the glass in the common jar, the tin plate corresponding to the inner coating and wire, and the tin-foil to the outer coating. The dissipation is almost nothing if the neck be very small; and it only requires a little caution to avoid bursting by too high a charge. Even this may be prevented by coating the sealing-wax so near to the end of the neck, that a spontaneous discharge must happen before the accumulation is too great. Alternate layers of tin-foil and hard varnish form also a very compendious battery. It admits of a surprising accumulation, without shewing any vivid electricity; but it must be used with more caution, lest it should be spoiled by a spontaneous discharge, in which case we cannot discover where the flaw has happened, and the whole is rendered useless.

(132.) By combining together a sufficient number of jars we are able to accumulate an enormous quantity of electricity: for this purpose all the interior coatings of the jars must be made to communicate by metallic rods, and a similar union must be established among the exterior coatings. When thus arranged, the whole series may be charged, as if they formed but one jar; and the whole of the accumulated electricity may be transferred from one system of coatings to the other, by a general and simultaneous discharge. Such a combination of jars is called an *Electrical Battery*.

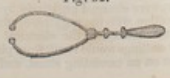
(133.) It is evident, that an apparatus of this kind, consisting of a great number of parts, must be more liable to derangement than a single jar: for if any one of the jars should happen to break by a spontaneous explosion, the whole battery would be rendered useless, until the broken jar be removed. It is prudent, therefore, to secure the adjacent jars from actual contact, by fixing them in a box having thin partitions; the coated bottoms of the jars resting on a trellis of wire, or on a sheet of tin-foil, which may establish a general communication between them; while the rods from the interior coatings are connected above by cross wires, having balls at their extremities in order to obviate the dissipation of the electricity. On the other hand, by limiting the communications to a certain number of jars, we have it in our power to charge only a part of the battery, without employing the whole.

Chapter IX.

Management of Electrical Jars and Batteries.

(134.) For the purpose of making the direct communication between the inner and outer coating of a jar or battery, by which a discharge is effected, the instrument shown in *fig.* 32, and which is

Fig. 32.



called the *Discharging Rod* or *Jointed Discharger*, may be conveniently employed. It consists of two bent metallic rods, terminated at one end by brass balls, and connected at the other by a joint, which is fixed to the end of a glass handle, and which, acting like a pair of compasses, allows of the balls being separated at different distances. When opened to the proper degree, one of the balls is made to touch the exterior coating, and the other ball is then quickly brought into contact with the knob of the jar, as represented in *fig.* 33, or with

Fig. 33.

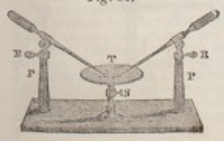


any part of the system of the interior coatings, and thus a discharge is effected; while the glass handle secures the person holding it from the effects of the shock.

(135.) If we wish to send the whole charge of electricity through any particular substance which may be the subject of experiment, we must so arrange the connecting conductors, as that the substance shall form a necessary part of the *circuit of the electricity*, as it is termed. With this view, we must place it between two good conductors, one of which is in communication with the outer coating; and the circuit may then be completed by connecting the other conductor with the inner coating by means of a discharging rod, to one branch of which, if necessary, a flexible chain may be added.

(136.) In order to direct the charge with more certainty and precision, an apparatus, called the *Universal Discharger*, was contrived by Mr. Henley, and is represented in *fig.* 34. It con-

Fig. 34.



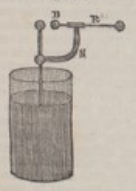
sists of a wooden stand with a socket fixed in its centre, to which may be occasionally adapted a small table T, having a piece of ivory (which is a non-conductor) inlaid on its surface. This table may be raised and kept at the proper height by means of a screw S. Two glass pillars P, P are cemented into the wooden stand. On the top of each of these pillars is fitted a brass cap, having a ring R attached to it, and containing a joint, moving both vertically and horizontally, and carrying on its upper part a spring tube, admitting a brass rod to slide through it. Each of these rods is terminated, at one end, either by a ball, a point, or a pair of forceps, and is furnished at the other extremity with a handle of solid glass. The body through which the charge is intended to be sent, is placed on the table, and the sliding rods, which are moveable in every direction, are then, by means of their insulating handles, brought in contact with the opposite sides, and one of the brass caps being first connected with the outside of the jar or battery, the other may be brought in communication with the inner coatings, by means of the discharging rod above described. For some experiments it is more convenient to fix the substance, on which the experiment is to be made, in a mahogany frame, consisting of two boards, which can be pressed together by screws, and which may then be substituted for the table T. In either of these ways the charge can be directed through any part of the substance with the greatest accuracy.

(137.) The quantities of electricity which can be accumulated in any given extent of coated glass, are in the inverse proportion to the thickness of the glass. Different jars or batteries, therefore, will, according to the thinness of their sides, and the quantity of coated surface they contain, have different capacities of holding charges of electricity. But in any given instrument of this kind, the quantity of the charge communicated to it by a machine may be measured by the intensity of the electricity in the prime conductor, which communicates with the interior coating. Some estimate of the intensity may be obtained by the employment of Henley's quadrant electrometer already described, (§ 72.) the index of which rises very slowly while the battery is charging, till it reaches a certain elevation, corresponding to the capacity of the battery. If

the electricity be accumulated beyond this limit, a spontaneous discharge takes place, and the process must then be renewed in order to obtain a full charge. It is more prudent, however, to stop before this degree of accumulation is attained: and one great advantage of Henley's electrometer is, that it shows us the progress of the charge, and how far we may proceed with safety.

(138.) But the most effectual security against fracture from a spontaneous discharge, is to form an interrupted circuit, of which the parts, where the interruption occurs, terminate by metallic balls, placed at a certain distance from each other. By varying the interval between them, we may regulate the quantity of electricity which we shall allow to accumulate in the battery; for the moment it exceeds the quantity of which that interval is the *striking distance* (§ 87,) an explosion happens, by the electricity forcing its way through the air from one ball to the other. If the balls be brought very near each other, a discharge will take place with a comparatively small accumulation: when farther separated, a greater charge will be retained, because a higher intensity of electricity is required in order to pass through the larger intervening space. It is on this principle that the instrument, called *Lane's Discharging Electrometer*, is constructed. It consists of a brass ball, B, *fig.* 35, placed at the end

Fig. 35.

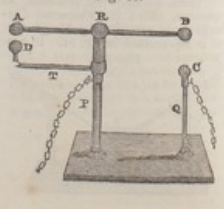


of a short metallic rod R, which moves through a tubular piece, supported by a bent glass stand S. This stand is made so as to be capable of being fixed, by its other extremity, to the rod passing up from the interior coating, and adjusted so that the ball B is immediately opposite to the knob of the jar, and may be brought to the exact *striking distance* from it which may be required: the other end of the moveable rod must be connected, by means of a chain or wire, with the outer coating.

The chief use of this instrument is to allow a jar to discharge itself spontaneously through any previously arranged circuit, without employing a discharging rod, or moving any part of the apparatus; and also to produce successive explosions nearly of the same strength. The magnitude of the charge is measured by the distance at which the balls are placed; and the power of the machine may be estimated by the number of explosions, which, at any given distance, take place in equal times. In Mr. Lane's experiment the shocks were twice as frequent when the interval between the balls was 1-24th of an inch, as when twice as much: hence he concluded that the quantity of electricity required for a discharge is in exact proportion to the distance between the surfaces of the balls. But the indications of this instrument are in reality subject to great fallacy, on account of the variable state of the atmosphere, which affects its conducting power; the quantity of dust which, even during the course of an experiment, is liable to be attracted, and to collect upon the balls; and also from the roughening and tarnishing of the metallic surfaces produced by frequent electric explosions. This last imperfection is one to which brass balls are particularly exposed; and might, if it were worth while, be remedied by having the balls made of fine silver.

(139.) Another contrivance for regulating the amount of the charge which we may wish to send through any substance, is that invented by Cuthbertson, and termed the *Balance Electrometer*. It consists of a metallic rod, R, *fig.* 36, terminated by two equal balls A, B, and balanced, like a scale-

Fig. 36.



beam, upon knife-edged centres. One of the arms of this beam is graduated, and carries a slider, which, when set at different distances from the centre of motion, acts on the lever with a proportionate weight from one grain to sixty. The ball A, at the extremity of this loaded arm, rests on a similar ball D, below it, which is supported by a bent metallic tube T, proceeding from the same stand as that which supports the rods; the whole being insulated by a glass pillar P. At a little distance below the ball B, at the other extremity of the beam, another ball C, insulated by the glass pillar Q, is placed; this last ball is to be connected by a chain with the outer coatings of the battery, while the metallic support of the balance is connected with the inner coatings. When a charge is communicated to the battery, the two balls A and D, which are in contact, become repulsive of each other; and when the force of this repulsion is sufficient to raise the weight on the loaded arm of the beam, the other arm will be forced down, and the ball B coming in contact with the ball C, the circuit will be completed and a discharge take place. As the force of the repulsion depends upon the intensity of the charge, the weight it has to overcome affords a measure of this intensity, and enables us to regulate its amount.

The practical application of accumulated electricity to various purposes of experiment, involves considerations which relate to the laws observed by electricity in its movements, and which more properly belong to the subject of the ensuing chapter.

Chapter X.

Of the Motion of accumulated Electricity.

(140.) In forming arrangements for directing the passage of accumulated electricity, it should be borne in mind that the electric fluid will, on these occasions, always pass through the best conductors, although they may be more circuitous, in preference to those which are more direct, but have inferior conducting power: and it must also be recollected, that when different paths are open for its passage, along conductors of equal power, the electricity will always take that which is the shortest. Thus if a person, holding a wire between his hands, discharges a jar by means of it, the whole of the fluid will pass though the wire, without affecting him: but if a piece of dry wood be substituted for the wire, he will feel a shock; for the wood, being a worse conductor than his own body, the charge will pass through the latter, as being the easiest, although the longest circuit. During its transit through the human body, in like manner, the shock is felt only in the parts situated in the direct line of communication; and if the charge be made to pass through a number of persons who take one another by the hand, and form part of the circuit between the inner and outer coatings of the jar, each will feel the electric shock in the same manner and at the same instant; the sensation reaching from hand to hand, directly across the breast. By varying the points of contact, however, the shock may be made to pass in other directions, and may either be confined to a small part of a limb, or be made to traverse the whole length of the body from head to foot.

(141.) By accurate experiments it appears that the force of the electric shock is weakened, that is, its effects are diminished, by employing a conductor of great length for making the discharge. But it is difficult to assign a limit to the number of persons through which even a small charge of electricity may be sent, so that all shall experience the shock; or to the distance along which it may be conveyed by good conductors. At an early period of electrical inquiries, much interest was attached to the determination of these points. The Abbé Nollet passed an electrical shock from a small phial through a hundred and eighty of the French guards in the presence of the king; and at the Carthusian convent in Paris, the monks were formed into a line of above a mile in length, by means of iron wires held between them: on the discharge of the phial, the sensation was felt at the same moment by all the persons composing this extensive circuit. Many experiments were made both by the English and French electricians with a view to ascertain the space which a discharge can be made to traverse, and the velocity with which it is transmitted. Of these the most ingenious and satisfactory were the experiments planned and executed by Dr. Watson, with the assistance of the leading members of the Royal Society. A circuit was formed by a wire which ex-

tended the whole length of Westminster bridge, at a considerable height above the river: one end of this wire communicated with the outer coating of a charged phial, the other being held by a person on the opposite side of the river, who formed a communication with the water by dipping into it an iron rod held by the other hand. The circuit was completed by another person, who stood near the phial, and who likewise dipped an iron rod into the river with one hand, and was enabled, by means of a wire held in the other, to effect a contact with the knob of the phial. Whenever the discharges took place, the shocks were felt by both persons; thus proving that the electric fluid must have been in motion along the whole line of the circuit, including both the wire above and the river below.

In another experiment, made on Shooters'-hill, at a time when the ground was remarkably dry, the electricity was made to perform a circuit of four miles; being conducted for two miles along wires supported upon baked sticks, and for the remaining distance, also of two miles, through the dry ground. As far as could be ascertained, by the most careful observation, the time in which the discharge was transmitted along that immense circuit was perfectly instantaneous: nor has any other trial that has yet been made afforded the least approach to a measurement of the velocity with which electricity moves.

(142.) On this subject, however, an important distinction should be made between the actual movement of each individual particle of electric fluid, and the transmission of an impulse along a series of such particles, for the one may bear hardly any proportion to the other; just as we find that sound proceeds with a velocity incomparably greater than that of the particles of air which are concerned in its propagation. In like manner the portion of blood, which raises the artery at the wrist, where the pulse is felt, is not the identical portion of blood which is thrown out from the heart by the contraction of that organ producing that pulsation: the impulse, in all these cases, being propagated like a wave, from one particle to another. There is, therefore, no reason to suppose that the same particles of electric fluid, which enter at one part, have traversed from one end to the other the whole line of conducting substances which form the circuit.

(143.) If we conceive the conducting bodies which compose the circuit to be divided into an indefinite number of filaments, every one of which is capable, in an equal degree, of conveying the electric fluid, it is evident that the united power of these filaments, or what is the same thing, the capability of the body itself to convey a charge of electricity, is in proportion to the number of these elementary filaments which it contains, that is, to the magnitude of its transverse section, without any relation to its form. Thus, the same metallic rod will conduct a charge equally well, whether it be flattened, or divided into several smaller wires, or whether it consist of a single cylinder of the same area.

(144.) If the size of the conductor be sufficiently great, the whole charge may be conveyed without any sensible obstruction or retardation, and therefore without any tendency to deviate from the direct line of its course. But it is otherwise when the conductor is too slender to afford a ready passage to the fluid which is pressing onwards: and it is important to inquire into the consequences to which these obstructions may give rise.

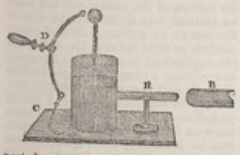
(145.) The first effect of an impediment to the free passage of accumulated electricity must be a retardation of its motion. It is reasonable, therefore, to expect that with a circuit composed either of bad conductors, or of conductors of inadequate size, although good, the discharge will not be effected so instantaneously, nor so completely; and that the shock which accompanies it will be diminished in its violence. This principle may find its application on occasions where it is desirable to soften the intensity of the shock, as in the medical employment of electricity, where imperfect conductors are on this account sometimes preferable, both for taking sparks and shocks.

(146.) A second effect resulting from an obstruction to the flow of electricity, is a tendency in the fluid to diverge from the direct line of its course, and to fly off to different objects in the vicinity. This is frequently exemplified in the case of lightning, which, on striking a building, is apt to take a very irregular and seemingly capricious route, darting towards conducting bodies which may happen to attract it, although at some distance from the immediate direction it was pursuing. The position of such

conducting bodies would appear to have a material influence in determining the striking distance. It was remarked by Dr. Priestley, that the explosion from a large battery extends to a greater distance over the surface of water than in air alone.

(147.) An effect which seems to depend upon this tendency in the fluid to divergence in consequence of obstruction, although it has by some been referred to a different principle, is that which has been termed *the lateral explosion*. When a large jar or battery is discharged by a metallic wire which is held in the hand without the protection of any glass or other insulating handle, it often happens that a slight shock is felt in the hand that grasps the wire, especially if the charge of electricity be very considerable. This apparent divergence or overflow of electric fluid, when rushing in large quantities through a narrow space barely sufficient to contain it, may also be rendered visible in other ways. If one end of a chain be connected with the outer coating of a charged jar, while the remainder of the chain is lying loosely upon a table, on discharging the jar in a darkened room, by a discharging rod, in the usual way, it will be found that the chain, although it makes no part of the circuit, is rendered luminous by the passage of sparks from one link to another. The following experiment, made by Dr. Priestley, may also be regarded as a case of lateral explosion. Let a thick metallic rod R, *fig.* 37, be supported on an insulating stand, and placed with one of its ends in contact with the outer coating of a Leyden jar; and at a distance of half an inch from its other extremity place a long conducting body B, of at least six or seven feet in length, and only a few inches in breadth. Let a chain C, be now placed upon the table, so that one of its ends may be about an inch and a half distant from the outer coating of the jar, and apply one end of the discharging rod D, to the other extremity of the chain. As soon as the other ball of the discharging rod is made to touch the knob of the jar, so as to effect a discharge, a brilliant spark is seen to extend between the insulated rod R, and the adjacent conductor B. This lateral spark has the same length and brilliancy whether it be received on flat or smooth surfaces, or on sharp points.

Fig. 37.



It is stated by Dr. Priestley, that the effect we have been describing takes place without any apparent change in the electrical state of the conductor B; and hence Cavallo conceived that the lateral spark was sent out from the jar, and returned to it almost at the same instant, allowing of no perceptible time for an electrometer to be affected. Dr. Robison, however, always observed, on repeating the experiment, that a very delicate electrometer was affected under these circumstances: and the same observation is confirmed by Biot.

The phenomena of the lateral explosion have been attempted to be explained by the electricity exerting, during its passage, an inductive influence, of which the effects may be expected to cease the moment the cause is removed. But this explanation appears to be less satisfactory than the one which attributes the phenomena to an expansive propulsion, followed by an immediate recession of electric fluid, produced by obstructions to its free passage in the circuit of conductors.

Chapter XI.

Effects of Electricity upon Bodies.

(148.) Having considered the circumstances attending the motion of electricity with reference chiefly to the fluid itself, we next proceed to give an account of the effects which it produces upon bodies by its passage through them.

(149.) Independently of electrical attraction and repulsion, it does not appear that the simple accumulation of electricity in any quantity in bodies, as long as it remains quiescent, produces the least sensible change in their properties. A person standing upon an insulating stool may be charged with any quantity of electricity from a machine, without being perceptibly affected, until the equilibrium of the fluid is disturbed, by drawing sparks from his body, or from the prime

conductor with which he may be in communication.

We have already seen, indeed, (§ 78, 79, 80,) that it is only a very small part of an electrified body, namely, the mere surface, that is in an active state, either of positive or negative electricity, and that the rest of the substance of the body is in a state of perfect neutrality.

(150.) It also appears that the uninterrupted passage of any quantity of electricity through a perfect conductor, such as a rod of metal which is of sufficient thickness to convey it, occasions no perceptible alteration in the mechanical properties of the conducting body.

(151.) On the contrary, very considerable effects are produced when a powerful charge is sent through a wire, which from the smallness of its size will not admit of the whole quantity to pass with perfect freedom; or through a substance which, although large, is deficient in conducting power; or, in other words, which opposes a degree of resistance to the passage of electricity. Thus, an iron conductor will carry off the whole electricity of a thunder-cloud in safety and in silence, while a beam of wood, or a tree, struck by lightning, is shivered into a thousand fragments.

(152.) When electricity thus changes the physical properties of bodies, its operation may, in general, be referred to that of separating their particles in the line of its course. This separation is effected with more or less violence, according to the intensity and quantity of the charge, and is frequently attended by the evolution of heat and light. The mechanical effects of electricity resemble those which would be produced by a material agent driven with great velocity and force through the substance of the body. Some of these effects, on the other hand, seem to be the consequences of the expansion produced by heat; but many of the changes induced by electricity are of a chemical nature, and such as mechanical agencies alone are insufficient to explain. We proceed to describe these several effects more particularly.

§ 1. *Mechanical Effects of Electricity.*

(153.) The cohesion of the particles of solid bodies may be conceived to oppose some resistance to the tendency of electricity to separate these particles from one another; for we find that fluids are more violently acted upon than solids, by the passage of the electric discharge. If the stem of a capillary tube, such as is employed for making thermometers, be filled with mercury, and placed so that the filament of this metal forms part of the circuit; on the discharge being made, the glass tube will be burst, and its fragments, together with the mercury, will be completely dispersed. If a fluid of inferior conducting power, such as water, be contained in a tube of larger diameter than in the preceding experiment, the passage, even of a moderate charge, will be sufficient to break the tube, and scatter its contents. Oil, alcohol, and ether, oppose still greater resistance than water to the passage of electricity, and they are expanded and scattered with still greater violence by a discharge being made to pass through them.

(154.) Beccaria introduced two wires through holes in the opposite sides of a perforated ball of solid glass of two inches diameter, the ends of the wires being separated by a drop of water, which occupied the centre of the perforation. On passing a shock through the wires and intervening drop, the ball was shattered with great violence. By a similar arrangement, Mr. Morgan succeeded in breaking green glass bottles filled with water, when the distance of the wires between which the explosion passed exceeded two inches. In this way, also, glass tubes, half an inch thick, with a bore of the same diameter, were burst with a very moderate charge, in Mr. Singer's experiments. If a cup-like cavity be turned in a piece of ivory, capable of receiving the half of a light wooden ball, with a small conical cell at the bottom of the cavity, and two wires be inserted into it through the sides of the ivory; on putting a drop of water, alcohol, or ether between the wires, and placing the ball over them in its cavity, and sending a charge through the drop of fluid, part of it will be suddenly converted into vapour, and the ball will be propelled with great violence. Even a common drinking glass, filled with water, may be broken by the explosive force with which vapour is formed at the point where the electricity passes. Beccaria constructed a small mortar with a ball, behind which a drop of water was placed, so as to be between the two wires that passed through the sides of the mortar. The charge being sent through the two wires, the drop of water was expanded with such force, as to drive out the ball with great velocity. Mr. Lullin, of Geneva, found that, by

using oil instead of water in this experiment, the ball was projected with still greater force.

(155.) If two wires be introduced into a soft piece of tobacco-pipe clay, so that their ends be near each other, and a shock passed through them, the clay will be curiously expanded in the interval between the wires. The experiment will not succeed if the clay be either too dry or too moist. If the clay be too dry, or the shock too powerful, the mass will be shivered into innumerable fragments. If the clay be placed in the tube of a tobacco-pipe, or in a glass tube, the expansion of the clay will be so considerable as to shatter the tube which contains it.

(156.) The expansion of air by the passage of the electrical fluid, either in the form of sparks or shocks, is shown in the following experiment of Kinnersley, the apparatus for which has been called the *Electrical Air Thermometer*. It consists of a glass tube closed at both ends by air-tight brass caps, through which two wires slide in the direction of the axis of the tube. These wires are terminated by brass balls, which are made to approach within the striking distance. To an aperture in the bottom of the lower cap is fitted a bent tube of glass which turns upwards, and is open at both ends; the bent part is filled with mercury, or with a coloured fluid, which may indicate by its rising or falling in the tube any dilatation or contraction that may take place in the air within the vessel. It is found that every time a spark passes between the brass balls, the fluid suddenly rises, but descends again to its former level immediately after each explosion; thus showing that the dilatation of the air, produced by the abrupt passage of electricity, is but of momentary duration.

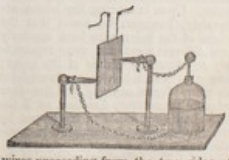
(157.) When a strong electrical charge is sent through a very confined portion of air, the explosive effects produced by it are as considerable as those we have seen exhibited by denser fluids. Thus if a piece of plate glass of the size of a square inch, and half an inch in thickness, be laid flat upon the small table of Henley's universal discharger, (§ 136,) and pressed down by a weight, and the points of the sliding wires be set opposite to each other and against the under edge of the glass, so that the electricity may pass beneath it, the charge of a large jar transmitted in this way will break the glass into innumerable fragments, and even reduce a portion into an impalpable powder. If the mouth of a small mortar made of ivory, with a cavity of half an inch diameter and an inch deep, be stopped by a cork, fitted so as to close the aperture accurately, yet without much friction, and if two wires be inserted through the sides of the mortar so that their points within the cavity be separated by an interval of about a quarter of an inch, a strong charge being sent through the wires will expand the air within the cavity so suddenly as to project the cork to some distance.

(158.) Solid bodies of a porous texture, such as wood, are easily torn asunder by an electric charge. If two holes be drilled in the opposite ends of a piece of wood, about half an inch long, and a quarter of an inch thick, and the ends of two wires inserted in the holes, so that their points may be at the distance of a quarter of an inch; on passing a strong charge through them, the wood will be split in pieces. Stones, loaf-sugar, and other brittle and imperfectly conducting substances, may be broken in a similar way.

Place a piece of dry writing paper upon the table of the universal discharger, and having removed the balls from the ends of the sliding wires, press the points of the wires against the paper at the distance of two inches from each other; if a powerful shock be now sent through the wires, the paper will be torn in pieces. If a number of wafers be placed on the table, instead of paper, they will be dispersed in a curious manner, and many of them broken into small fragments.

(159.) A singular result is obtained by the following variation in the circumstances of the last experiment, which was made by Mr. Lullin. Suspend a varnished card by silk threads, (see *fig.* 38,) in such a manner that two blunt

Fig. 38.



wires proceeding from the two sides of a jar or battery, may be in contact with

the opposite sides of the card, but at the same time half an inch distant from each other; when the discharge is made between the wires, and along the surface of the card, the latter is found to be perforated, but always at the point where the wire communicating with the negative side of the battery had touched it. The same perforation takes place at this point, even when a hole has been previously made at the point, where it is touched by the positive wire.

The course of the electric fluid may be traced with more precision, by having both sides of the card coloured, previously to the experiment, with vermilion, for it will then leave on the card a well defined black line extending from the point of the positive wire to the perforation; and a diffused black mark on the opposite side of the card, around the perforation, and next to the negative wire.

(160.) When the electrical discharge is made to pass in a perpendicular direction through the thickness of a card, which may be effected by placing it against the outer coating of a Leyden jar, and setting the lower ball of the discharging rod against the other side of the card, so that its thickness may be interposed between it and the tin-foil, and making the explosion in the usual way, as represented in *fig.* 33, (§ 134,) the card will be perforated. At the edge of the perforation, on each side of the card, there will be a small bur or protrusion, which is always larger on the side next to the jar, than on that next to the discharging rod; the former being the negative, and the latter the positive side. By passing the shock through a quire of paper, instead of a single card, the progress of this effect at different depths from the surface may be accurately analysed. Mr. Symmer, who devised this experiment, observed that the ragged edges were for the most part directed outwards from the body of the quire. Upon examining the leaves separately, however, he found that the edges of the holes were bent regularly two different ways, and more remarkably so about the middle of the quire; one edge of each hole being throughout its course forced one way, and the other edge in the contrary direction, as if the hole had been made in the paper by drawing two threads through it in opposite directions.

(161.) The following variation of the experiment illustrates the nature of the mechanical impressions made by electricity. Let a sheet of tin-foil be placed in the middle of a quire of paper; on making the discharge through it, the tin-foil is found to have received two indentations in opposite directions, and the leaves of paper are rent in such a manner, that on both sides of the tin-foil the burs point towards the outsides of the quire; but the indentations upon the tin-foil, and the burs on the paper, are in opposite directions. If another quire of paper be taken, and two sheets of tin-foil be placed within it, so that they are separated by the two middle leaves of the quire, the result will be that all the leaves will be perforated, excepting the two within the tin-foil, and in these two leaves there will be two impressions or indentations in opposite directions.

(162.) The mechanical effects we have just described have been often adduced, not only as proofs of the materiality of the electric fluid, but also as positive indications of the direction of its motions, according as either the one or the other of the two theories of electricity is adopted. But this is a subject which we reserve for future discussion.

(163.) The fracture of glass by the electrical explosion has already been adverted to, (§ 129;) but there are still a few circumstances attending it which deserve to be noticed. The edges of the fractured portion appear well defined on the positive side; while on the negative side they are splintered, as might be expected from the passage of a material agent from the former to the latter. It is remarkable also, that a perforation may be made in glass by a very moderate discharge, when the glass is in contact with oil or sealing-wax. Thus if a small phial, or glass tube, closed at one end, be filled with olive oil, and a pointed wire, bent at right angles, and passing through a cork fitted to the mouth of the phial or tube, be introduced into it, so that the point may touch any part of its inside beneath the surface of the oil; on suspending the vessel by its wire to the prime conductor of an electrical machine, and applying to the outside, either the knuckle, or a brass ball, exactly opposite to the point of the wire within, so that a spark may pass between them, it will be found to have made a small perforation through the glass; by bringing the wire in contact with different parts of the glass, a great number of holes may thus be made in it. The effect of the oil appears

to be that of controlling the tendency of the electric fluid to diverge, and of concentrating the whole power of the charge into a single point.

(164.) This repulsive tendency is also well illustrated by the following experiments made by Dr. Priestley. If a clean brass chain, previously dipped in melted resin, be laid upon paper, and the charge of a battery of at least 32 square feet be sent through it, the resinous coating will be thrown off from every part of the chain, which will be left perfectly clean, and free from resin. If a brass chain be laid upon a piece of glass, and a similar charge passed through it, the glass will be marked in a beautiful manner on every part of its surface, where it had been touched with the chain, every spot having the width and colour of the link. The metal may be scraped off the glass at the outside of the marks, but in the middle part it is forced within the pores of the glass. Dr. Priestley communicated a similar tinge to glass, by means of a silver chain, and small pieces of other metals; but he could not succeed with large pieces.

(165.) The effects of accumulated electricity upon metallic bodies, are referable, for the most part, to the agency of the heat produced by its passage through them; yet the phenomena, in many cases, indicate also the operation of other forces. By the transmission, through a piece of metal, of repeated shocks, which are not powerful enough to effect its fusion, or even ignition, a permanent alteration may be produced in its form, such as would not have resulted from heat alone. Dr. Priestley and Mr. Nairne found by experiment, that a chain through which an electrical charge had passed, undergoes a diminution in its length. A piece of hard drawn iron wire, ten inches long and one hundredth of an inch in diameter, was found, after fifteen discharges, to have lost one inch and one tenth of its length; and the increase of thickness seemed to be in proportion to this longitudinal contraction, for the wire had not perceptibly lost any of its weight during the experiment. A copper wire plated with silver, of the same dimensions as the former, underwent, by the same treatment, a diminution of length two thirds as great as that of the iron wire.

On the other hand, if the shocks be transmitted through a wire which has a weight suspended by it, so as to give it considerable tension, the length of the wire becomes increased instead of diminished, as in the above experiment. This is evidently owing to the influence of the heat which accompanies the passage of the electricity, and which diminishes the cohesion of the particles of the metal, and disposes them to yield to the extending force which the weight supplies.

§ 2. Evolution of Heat by Electricity.

(166.) The ignition and fusion of metals by the electric discharge, are phenomena which have been long observed. Thus by passing a strong charge through slender iron wires, they are ignited, and partly melted into globules. It was formerly believed that very large batteries were necessary for obtaining this effect; but if the wire be sufficiently fine, the electricity accumulated in a single jar of moderate size will suffice for its production. The best material for exhibiting this effect, is the finest flatted steel sold at the watchmakers' tool shops, under the name of watch pendulum wire. Van Marum has given a statement of the lengths of wires of different diameters, and of different metals, which his powerful machine enabled him to melt; when they were drawn to the thirty-second part of an inch in diameter, he found that he could fuse 120 inches of lead wire, and the same quantity of tin wire; five inches of iron wire; three inches and a half of gold wire; and only one quarter of an inch of wires of silver, copper, or brass.

(167.) From the experiments of Brooke and of Cuthbertson, it has been inferred that the length of wire which is thus melted by the electric discharge, varies as the square of the quantity of accumulated electricity which is sent through it; thus a combination of two jars, charged to an equal degree, will melt four times the length of wire which one jar will melt.

(168.) While the electric battery thus effects the fusion, and even in some cases the volatilization of metals, the phenomena appear also to indicate the action of propelling or dispersive forces, as if the agent concerned in their production was endowed with great mechanical momentum. Thus the densest metals are rent and dispersed with violence by the passage of accumulated electricity. If a slip of gold or silver leaf be placed on white paper, and a

strong shock passed through it, the metal will disappear with a bright flash, and the impulse with which its particles are driven against the paper will produce a permanent stain of a purple or grey colour. Franklin found that if the metallic leaf be placed between two panes of glass firmly tied together, the explosion, provided the glass withstands the concussion, will leave on each of its surfaces an indelible stain, in consequence of some of the metallic particles being actually forced into the substance of the glass, and being then inaccessible to the action of chemical solvents applied to the surface of the glass. Sometimes it is found that these metallic stains extend to a greater distance than the breadth of the piece of metal. It often happens, however, that the pieces of glass themselves are shattered to pieces by the discharge.

(169.) The colours produced by the electric explosion of metals have been applied to impress letters or ornamental devices on silk and on paper. For this purpose Mr. Singer directs that the outline of the required figure should be first traced on thick drawing paper, and afterwards cut out in the manner of stencil plates. The drawing paper is then placed on the silk or paper intended to be marked; a leaf of gold is laid upon it, and a card over that; the whole is then placed in a press or under a weight, and a charge from a battery sent through the gold leaf. The stain is confined by the interposition of the drawing paper to the limit of the design, and in this way a profile, a flower, or any other outline figure may be very neatly impressed.

(170.) The heat evolved by electricity, like most other of its effects, is in proportion to the resistances opposed to its passage. The less the conducting power of a metal, the greater is the portion of it which the same shock can ignite or destroy. A rod of wood of considerable thickness being made part of the circuit, has its temperature sensibly raised by a very few discharges. Most combustible bodies are capable of being inflamed by electricity, but more especially if it be made to strike against them in the form of a spark or shock obtained by an interrupted circuit, as by the interposition of a stratum of air. In this way may alcohol, ether, camphor, powdered resin, phosphorus, or gunpowder be set fire to. The inflammation of oil of turpentine will be promoted by strewing upon it fine particles of brass filings. If the spirit of wine be not highly rectified, it will generally be necessary previously to warm it, and the same precaution must be taken with other fluids, as oil and pitch; but it is not required with ether, which usually inflames very readily. But, on the other hand, it is to be remarked that the temperature of the body which communicates the spark appears to have no sensible influence on the heat produced by it. Thus the sparks taken from a piece of ice are as capable of inflaming bodies as those from a piece of red-hot iron. Nor is the heating power of electricity in the smallest degree diminished by its being conducted through any number of freezing mixtures which are rapidly absorbing heat from surrounding bodies.

(171.) Light, as well as heat, is emitted during the electric discharge at every point where the circuit is either interrupted, or is occupied by bodies of inferior conducting powers. A moderate charge will produce a bright spark when made to pass through water, and the spark is still more luminous in oil, alcohol, or ether, which are worse conductors than water: on the contrary, in fluids of greater conducting power there is greater difficulty of eliciting electric light. Thus a much higher charge is required to produce a spark in hot water than in cold; a still higher in saline solutions; and in concentrated acids, light can be obtained only when their volume is very small; so that it is necessary for that purpose, to draw a line of the acid upon a plate of glass with a camel's hair pencil. This is illustrated by the following experiment mentioned by Singer. Draw a line with a pen dipped in water on the surface of a slip of glass; place one extremity of the line in contact with the coating of a Leyden jar, and at six inches distance upon the line place one knob of the discharging rod; when the jar is fully charged, bring the other ball of the discharger to the knob of the jar, and the discharge will take place luminously over the six inches of water. Next, trace a line with a pen dipped in sulphuric acid on a slip of glass, as in the former experiment, and place one extremity of it in contact with the outside of the jar; the ball of the discharger may then be placed on the glass at twelve inches distance, and the electric fluid will pass as brilliantly over that interval as over the six inches of water. In either of these experiments, if the line of fluid be wider in any particular part, the light of the discharge will appear less brilliant in passing that portion; this must arise from the greater division of the fluid when passing over an extended conductor than over one that is narrow.

§ 3. *Chemical Effects of Electricity.*

(172.) Electricity exerts a most extensive and important influence in effecting changes in the chemical composition of bodies; but as this influence is most conspicuously exerted in that particular mode of agency, which is known by the name of *Galvanism*, this subject will more properly be considered in the treatise on that branch of electrical science. For the present, we must content ourselves with adducing a few instances, illustrative of the chemical effects of electricity in the forms under which it has now been presented to our notice.

(173.) Some of the chemical changes consequent on powerful electrical explosions, appear to be merely the effects of the heat which is evolved in that process. The surfaces of metallic bodies through which accumulated electricity is made to pass are frequently oxidated; this is seen more especially in the case of wires that have been fused or volatilized by the electric discharge. It is known that metals intensely heated are disposed to combine with the oxygen of the atmosphere, and, consequently, to assume the state of oxides; it is simpler, therefore, to ascribe this effect in the present case to a cause which is known to be in operation at the same moment, than to any peculiar or determining agency of electricity. A multitude of experiments are on record in which the partial oxidation of metals has been effected by electric explosions. This subject was prosecuted with minute and laborious attention by Van Marum, by Cuthbertson, and more lately by Singer. It is remarked by this last experimentalist, that the oxides of metals produced in this way appear to consist of several distinct portions of different degrees of fineness; when a wire is exploded in a receiver, part of the oxide immediately falls to the bottom, but another portion remains suspended in the air for a considerable time, and is at length gradually deposited. It is probable that this circumstance may in part account for the different colours of oxides produced in close receivers and in the open air, for in the latter case a portion of the oxide is always lost.

(174.) Under other circumstances, electricity is found to exert a power the reverse of the former; for it decomposes metallic oxides, extricating their oxygen, and restoring them to the metallic state. This deoxidating power was known to several of the earlier electricians. Beccaria reduced the oxides of tin and of mercury to their metallic state by electricity. In order to effect this change, a quantity of the oxide may be introduced into a glass tube, and pointed conducting wires inserted through corks at the opposite ends of the tube, so that a portion of the oxide may lie between them. This apparatus is then to be placed on the table of the universal discharger, (§136,) and repeated shocks are to be sent through the oxide until its partial or total reduction is accomplished. Vermilion, which consists of sulphur and mercury, is very easily decomposed by this process, and by a very moderate charge.

(175.) When a succession of electric discharges from a powerful electric machine are sent through water, a decomposition of that fluid takes place, and it is resolved into its two elements of oxygen and hydrogen, which immediately assume the gaseous form. This fact was discovered in 1789, by Messrs. Dieman, Paetz, and Van Troostwyck, who had formed themselves into a society for experimental research in Holland; and it completed the chain of evidence by which the great discovery of the composition of water, made five years before by Cavendish, is established. The abovementioned Dutch chemists being occupied, in conjunction with Mr. Cuthbertson, in investigating the effects of electricity when passed through different bodies, were desirous of ascertaining its effect on pure water. They employed for this purpose an apparatus consisting of a glass tube, twelve inches long and one-eighth of an inch in diameter, through one end of which a gold wire was inserted, projecting about an inch and a half within the tube; that end was then hermetically sealed. Another wire was introduced at the other end of the tube, which was left open, and passed upwards, so that its extremity came to a distance of five-eighths of an inch from the end of the first wire. The tube was then filled with distilled water, which had been freed from air by an excellent air-pump, and inverted in a vessel containing mercury. A little common air was let into the top of the tube, in

order to prevent its being broken by the discharge. Electrical shocks were then passed between the two ends of the wires through the water in the tube by means of a Leyden jar, which had a square foot of coated surface. This jar was charged by a very powerful double plate machine, which caused it to discharge twenty-five times in fifteen revolutions. At each explosion bubbles of air were formed, and rose to the top of the tube. As soon as a sufficient quantity had collected to leave the upper end of the wire uncovered by the water, so that the shock had now to pass through a portion of the mixed gases, they were instantly kindled; a reunion of the elements took place; water was again formed, and the space they had occupied was immediately filled with fluid from below, so as to restore every thing precisely as at the outset of the experiment. It was ascertained by the most decisive chemical tests, that the gases thus obtained consisted of a mixture of oxygen and hydrogen gases.

(176.) It may appear somewhat paradoxical that the same agent should, in the course of the same experiment, produce at one time decomposition, and at another combination of the same elements. The simplest way of reconciling this apparent discordance, is to suppose that the combination of the gases is the effect of the heat evolved during its forcible transit through an aeriform fluid that opposes considerable resistance to its passage; while the decomposition of the liquid is the direct consequence of the agency of electricity when not interfered with by heat.

(177.) Until lately, it was thought necessary to employ powerful machines and large jars in order to effect the decomposition of water by electricity, and that mere sparks from a common machine were inadequate to accomplish this purpose. That there is in this respect, however, no essential distinction in the operation of these two forms of electricity has been satisfactorily shown by Dr. Wollaston. This distinguished philosopher, perceiving, with his accustomed sagacity and penetration, that the decomposition would depend on duly proportioning the strength of the charge to the quantity of water, and that the quantity exposed to its action at the surface of communication depends on the extent of that surface, inferred that by reducing the surface of communication the decomposition of water might be effected by smaller machines, and with less powerful excitation than had hitherto been applied to this object. Having procured a small wire of fine gold, and given to it as fine a point as possible, he inserted it into a capillary glass tube; and after heating the tube, so as to make it adhere to the point, and cover it in every part, he gradually ground it down, till, with a pocket lens, he could discern that the point of the gold was exposed. When sparks from a prime conductor of an electrical machine were made to pass through water by means of a point so guarded, a spark, extending to the distance of one-eighth of an inch, would decompose water when the point exposed did not exceed one 700th of an inch in diameter. With another point, estimated at one 1500th, a succession of sparks one-twentieth of an inch in length afforded a current of small bubbles of air. With a still finer filament of gold, the mere current of electricity, without any perceptible sparks, evolved gas from water.

(178.) When a solution of sulphate of copper was subjected to the action of electricity by means of these slender conducting wires, the metal was revived around the negative wire; but upon reversing the direction of the current of electricity, so that the same wire now became positively electrified, the copper which had collected around it was redissolved, and a similar precipitate was deposited on the opposite wire, which was now the negative one. Similar experiments made with other metallic solutions were attended with analogous results; the negative wire always separating oxygen from its combinations, the positive wire always attracting it, and effecting its union with the bases presented to it. With solutions of neutral salts, the alkaline or earthy bases were attracted by the negative, while the acids were attracted by the positive wire. The experiments of Sir Humphry Davy have confirmed these results as far as concerns the chemical action of common electricity; but as this is a subject which bears more immediate relation to chemistry and to galvanism, it would not be right to enlarge upon it in the present treatise.

(179.) The magnetic effects of electricity will likewise form the subject of a distinct treatise, as they now constitute a new branch of science, under the title of ELECTRO-MAGNETISM.

§ 4. *Effects of Electricity upon Animals.*

(180.) Having seen that the effects of electricity on inanimate matter are of various kinds, we should be led to expect that its operation on living bodies would be still more complicated; for in addition to its mechanical and chemical agencies, it can hardly fail of exerting considerable influence on the living powers, and more especially on the functions of the nervous system. It is unnecessary to describe the sensations excited in the body by receiving electric sparks or shocks, since most persons in the present day are familiar with them. It is curious, however, to take a retrospective view of the mode in which the effects of the Leyden phial were announced to the world, on their first discovery. The philosophers who first experienced, in their own person, the shock attendant on the transmission of an electric discharge, were so impressed with wonder and with terror by this novel sensation, that they wrote the most ridiculous and exaggerated account of their feelings on the occasion. Muschenbroek states, that he received so dreadful a concussion in his arms, shoulder, and heart, that he lost his breath, and that it was two days before he could recover from its effects; he declared also, that he should not be induced to take another shock for the whole kingdom of France. Mr. Allemand reports, that the shock deprived him of breath for some minutes, and afterwards produced so acute a pain along his right arm, that he was apprehensive it might be attended with serious consequences. Mr. Winkler informs us, that it threw his whole body into convulsions, and excited such a ferment in his blood, as would have thrown him into a fever, but for the timely employment of febrifuge remedies. He states, that at another time it produced copious bleeding at the nose; the same effect was produced also upon his lady, who was almost rendered incapable of walking. These strange accounts naturally excited the attention and wonder of all classes of people; the learned and the vulgar were equally desirous of experiencing so singular a sensation, and great numbers of half-taught electricians wandered through every part of Europe to gratify this universal curiosity.

(181.) As it is probable that the electric fluid meets with greater impediment in passing from the surface of one bone to another, at the parts where the continuity of substance is interrupted by the joints, this circumstance explains why the shock is often more especially felt at the joints than in any other part of a limb. But if the shock be directed more particularly through muscles, its effects are chiefly shown by exciting a convulsive and involuntary action of those muscles. This is often observed to take place in a paralysed limb, when electric shocks are sent through it, although the nerves of the limb are at the time incapable of conveying the impressions which produce sensation. Mr. Morgan states, that if the diaphragm be included in the circuit of a coated surface of two feet in extent, fully charged, the sudden contraction of the muscles of respiration will act so violently upon the air in the lungs, as to occasion a loud and involuntary shout; but if the charge be small, a fit of convulsive laughter is induced, presenting a most ludicrous exhibition to the by-standers.

(182.) It is on the nervous system, however, that the most considerable action of electricity is exerted. A strong charge passed through the head, gave to Mr. Singer the sensation of a violent but universal blow, and was followed by a transient loss of memory and in distinctness of vision. If a charge be sent through the head of a bird, its optic nerve is usually injured or destroyed, and permanent blindness induced: and a similar shock given to larger animals, produces a tremulous state of the muscles, with general prostration of strength. If a person who is standing receive a charge through the spine, he loses his power over the muscles to such a degree, that he either drops on his knees, or falls prostrate on the ground; if the charge be sufficiently powerful, it will produce immediate death, in consequence, probably, of the sudden exhaustion of the whole energy of the nervous system. Small animals, such as mice and sparrows, are instantly killed by a shock from thirty square inches of glass. Van Marum found that eels are irrecoverably deprived of life when a shock is sent through their whole body; but when only a part of the body is included in the circuit, the destruction of irritability is confined to that individual part, while the rest retains the power of motion. Different persons are affected in very

different degrees by electricity, according to their peculiar constitutional susceptibility. Dr. Young remarks, that a very minute tremor, communicated to the most elastic parts of the body, in particular to the chest, produces an agitation of the nerves, which is not wholly unlike the effect of a weak electricity.

(183.) The bodies of animals killed by electricity, rapidly undergo putrefaction, and the action of electricity upon the flesh of animals is also found to accelerate this process in a remarkable degree. The same effect has been observed in the bodies of persons destroyed by lightning. It is also a well-established fact, that the blood does not coagulate after death from this cause.

(184.) It has not been determined with any degree of certainty, whether electricity, in its ordinary mode of application, exerts any sensible influence on the functions of the animal system. The Abbé Nollet persuaded himself, from the experiments he made on man and animals, that the perspiration was increased during the time they were electrified; and De Bozes had noticed that the pulse was quickened under the same circumstance. But Van Marum, on repeating these experiments in a variety of ways, met with such variable and contradictory results, that he could deduce from them no satisfactory conclusion respecting the real operation of electricity; and, indeed, if we take into account the powerful influence which the imagination exerts on most persons who are the subjects of such experiments, as well as on those who witness them, there appears but little chance, amidst such multiplied sources of fallacy, of arriving at the truth. The only general fact, perhaps, which appears to be established, is that electricity acts as a stimulant both to the muscular and the nervous systems.

(185.) When the energetic effects of the shock from the Leyden phial were first made known, the most sanguine expectations were immediately raised, that electricity would prove an agent of considerable power in the cure of diseases. It was supposed that as a stimulant, it would have many advantages over other remedies; for it can be administered in various degrees of intensity, which may be regulated with great exactness; and its application can be directed especially to the organ we wish to affect, and can be limited to that organ, so as not to interfere with the functions of the general system. Accordingly we find, that at one period electricity was in great repute as an efficacious remedy in a number of diseases; but at present it is seldom employed except in a very few. It is not unfrequently had recourse to in palsy, contractions of the limbs, rheumatism, St. Vitus's dance, and some kinds of deafness, and impaired vision; it has also been applied to discuss tumours, to remove obstructions, and to relieve pain.

(186.) Electricity may be administered medicinally in four different ways. The first and most gentle is under the form of a continued stream, or *aura* as it is termed, derived from a wire or pointed piece of wood connected with the prime conductor of the machine, held by an insulated handle, at the distance of one or two inches from that part to which it is to be directed; an impression is felt similar to a current of air; and in this way it may be borne by parts of great sensibility, such as the eye. The second mode is by directing sparks of various sizes to the affected part, by means of a metallic ball at the extremity of a brass rod, which is within a moderate distance from the part; or else by placing the patient on an insulating stool, and while he is in communication with the prime conductor of the machine, taking sparks from him by another person with a metallic ball at the end of a rod which he holds in his hand. The size and intensity of the spark will, of course, be regulated by the distance at which the ball is placed from the body, provided the machine be steadily worked. The third mode is that by shocks from the discharge of a Leyden phial, which is, of course, the most severe and painful method of applying electricity. Great caution is required against the indiscriminate application of this last method, which is not wholly free from danger. The fourth mode is by Galvanism, hereafter to be noticed.

§ 5. *Effects of Electricity upon Vegetables.*

(187.) It has also been imagined that electricity acts as a stimulus to vegetable life: and many fanciful projects of improvements in horticulture by the aid of artificial electricity have been entertained. It is needless, however, to enlarge upon these visionary speculations, the fallacy of which has been sufficiently shown by the late Dr. Ingenhouz, who,

upon the most accurate inquiry, found that the vegetation of plants was in no sensible degree either promoted or retarded by common electricity. The experiments of Van Marum, however, in which he found that electricity increased the evaporation of plants, appear to be entitled to some confidence; but still the effect observed, may, as he himself remarks, have been occasioned by the increased current of air from the parts of the electrified leaves. His observations on the influence of electricity on the sensitive plant, (*Mimosa pudica*,) deserve also to be noticed. The mere approach of an electrified conductor, whether charged with positive or negative electricity, produced no effect upon the plant; but when sparks were taken from it, the leaves collapsed, just as they would have done by concussions of a mechanical nature, and in other respects the plant underwent no change. In the *Hedysarum gyrans*, a plant remarkable for the continual rotatory motions of its leaves, electricity appeared to have no sensible influence either in accelerating or retarding these movements.

(188.) The passage of shocks through living plants immediately destroys the vitality in the parts through which the shock has been sent. It is, indeed, very easy to kill plants by means of electricity. A very small shock, according to Cavallo, sent through the stem of a balsam, is sufficient to destroy it. A few minutes after the passage of the shock, the plant droops, the leaves and branches become flaccid, and its life ceases. A small Leyden phial, containing six or eight square inches of coated surface, is generally sufficient for this purpose, which may even be effected by means of strong sparks from the prime conductor of a large electrical machine. The charge by which these destructive effects are produced, is probably too inconsiderable to burst the vessels of the plant, or to occasion any material derangement of its organization; and, accordingly, it is not found, on minute examination of a plant thus killed by electricity, that either the internal vessels or any other parts have sustained perceptible injury.

(189.) It appears from the experiments of Mr. Achard, that the fermentation of vegetable matter is accelerated by electricity.

(190.) The general conclusion deducible from these inquiries is, that feeble electricity exerts no perceptible influence on either animal or vegetable life: but when transmitted in powerful shocks, its destructive effects are similar to those which are produced by lightning.

Chapter XII.

Instruments adapted to collect weak Electricity.

(191.) Before we proceed to consider the developement of electricity under various circumstances, it will be proper to give a description of several instruments which have been contrived for the purpose of collecting and exhibiting weak degrees of electricity, that would otherwise escape detection. All these instruments derive their efficacy from the principle of electric induction; and their mode of operation will be best understood by previously directing our attention to the electrophorus.

(192.) The instrument termed the *Electrophorus* was invented about the year 1774 by Professor Volta, a name which is associated with many important discoveries in the science of electricity. It consists of three parts: the essential part, which supplies the electricity, being a cake of some electric substance, (E, *fig.* 39,) such as sulphur,

Fig. 39.



gum lac, sealing-wax, pitch, or other resinous composition; this is melted on a conducting plate S, called *the sole*, which is formed with a rim to contain it, and the fluid then allowed to congeal. The third part of the apparatus consists of a circular metallic plate C, provided with an insulating handle fixed upon its upper surface. This is called *the cover*; and is sometimes made of wood, covered on all sides with tin-foil well rounded at the edges to prevent the dispersion of electricity. In order to bring the apparatus into a state of activity, the surface of the cake is excited by friction with fur or flannel, and is thus rendered negatively electrical. The cover, held by its insulating handle, must now be placed

on the cake: in this situation it does not come sufficiently in contact with the cake to receive its electricity, but acquires by induction an opposite state at its lower surface, and a similar state at its upper; that is, the cake being negative, the under side of the cover will be positive, and the upper side negative. If, while in this state, the upper negative surface be touched with the finger, or with any other conductor communicating with the earth, a spark will pass from the latter to the cover, so as to restore the electric equilibrium; the quantity of electricity thus superadded being retained in the cover by the inductive influence of the cake. But when the plate is raised, provided it be held by its insulating handle, the action of the cake being withdrawn, the cover is found to be charged with positive electricity, which may be imparted to an insulated conductor, or to a Leyden jar. This operation may be repeated an indefinite number of times, since the electricity of the cake continues unimpaired during the process, and thus may a charge be communicated to the jar of an intensity equal to that of the cover of the electrophorus when raised. The instrument has been known, indeed, to retain its power undiminished for months, and may therefore be regarded as a sort of magazine of electricity. It is obvious, that if the cover were simply placed on the cake, and again raised without previously touching it, it would then exhibit no sign of electricity. If the sole of the electrophorus be insulated, a spark may be obtained from it, when the cake has been excited; and if while placed on the cake the cover be touched with the finger, and at the same time the sole be touched with the thumb, a sensible shock will be felt in that part of the hand.

(193.) Volta is also the inventor of an instrument acting on the same principle as the electrophorus, and which he termed *the condenser*, of which the purpose is to collect a weak electricity, spread over a large surface, into a body of small dimensions, in which its intensity will be proportionably increased, and therefore become capable of being examined. A small metallic plate, connected with the substance of which the electricity is to be determined, is brought within a very small distance of another plate communicating with the earth. The small portion of electricity received from the substance to be tried by the first plate, acts by induction on the second plate, and occasions it to acquire the opposite electrical state: this latter state reacts upon the first plate, increasing its capacity for the electricity which it had first received, and tends to accumulate a larger quantity in it, which quantity it must derive from the substance with which it communicates. This mutual action and reaction continues till an equilibrium is attained. If the communication between the substance tried and the first plate be broken off, and the plate thus insulated be removed from the contiguity of the second plate, the accumulated electricity with which it is charged will become evident upon its application to an ordinary electroscope, such as those described in § 13 and 14.

(194.) Various have been the forms given to the condenser, according to the fancy of electricians, without any change in the principle on which it acts. In general, the two plates are merely separated by a thin stratum of air. Sometimes their surfaces are covered with a non-conducting varnish, which prevents any communication of electricity from the one plate to the other, while it allows of a very near approach of the plates to each other; but this method is liable to objection, from the permanent electricity which the varnish sometimes contracts by friction, and which may interfere with the regular operation of the instrument. One of the most convenient forms is that of the condensing electrometer, (*fig.* 40.)

Fig. 40.



in which the first plate of the condenser A, is fixed to the cap of the gold-leaf electroscope; the second plate B, which communicates by a chain with the ground, being moveable round a joint C, and thus capable of being turned back and removed from the first plate, so as to allow its electricity to be manifested by the divergence of the gold leaves.

(195.) The instruments called *Doublers* are so contrived, that by executing certain movements, very small quantities of electricity communicated to a part of the apparatus may be continually doubled, until it becomes perceptible by an electroscope. The first invention of this kind was that of Mr. Bennet, which consists of three brass plates, which we shall call A, B, and C. The plate A has an insulating handle fixed in its centre, while the plate B has a similar handle fixed in its circumference. The under side of A, and both sides of B are covered with varnish. The third plate C is also of brass, and is only varnished on its upper side, the lower side communicating with the gold-leaf electroscope. The body whose electricity is to be tried, is made to communicate with the under side of the plate C, which touches the electroscope, while B is placed upon C, and then touched with the finger: the communication with the electrified body is then removed, and B is lifted up by its insulating handle. A is then placed, by means of its handle, upon B thus elevated. A is then touched, and, after withdrawing the finger, is separated from B. In this process B acquires an electricity contrary to that of C; and A an electricity contrary to that of B, that is, the same as that of C. If the plate A, thus electrified, be next applied to the under surface of C, and B be again applied over C, and touched with the finger as before, it will be acted upon by the electricities contained both in C and A, and thus acquire, by induction, nearly double the quantity which it had done in the first operation. The consequence of this will be that nearly all the free electricities of A and C will be concentrated in C. A may now be removed, and after withdrawing the finger from B, B may also be removed, and C will be left with double the quantity of electricity which it had received from the body with which it was originally made to communicate.

If after this duplication the electricity of the plate C be still too feeble to be indicated by the electroscope, the same series of operations must be repeated ten or even twenty times; when by doubling it every time, the smallest conceivable quantity of electricity must at last be rendered sensible; since, at the end of the twentieth operation, it will be augmented more than 500,000 times. Although the frequent repetition of the operations may appear tedious, yet, by a little practice, the art is readily acquired, and the whole process need not occupy a minute. Great care must be taken in conducting these experiments, not to excite any electricity by the friction of the finger, or by any other means, in the varnished sides of the plates. In order to obviate this source of error, Cavallo contrived a form of the instrument, that enabled the plates to be brought within a very small distance of one another, yet without actual contact, so as to enable him to dispense altogether with the employment of varnish. But notwithstanding every precaution of this kind, it is always found that the instrument exhibits electricity of itself, although none has been previously communicated to it: so that its indications cannot be at all depended upon for the detection of very minute quantities of electricity. It is unnecessary, therefore, to describe the particular mechanisms invented by Dr. Darwin, and improved by Nicholson, for bringing the plates into the requisite positions, and effecting in succession the necessary contacts, by the simple rotation of a winch, aided by wheelwork: instruments which have gone by the names of the *moveable*, or *revolving doubler*, and the *multiplier of electricity*, and which are now superseded in practice by instruments more sensible and certain in their operation.

Chapter XIII.

Developement of Electricity by Changes of Temperature and of Form.

(196.) There are certain mineral bodies, which, from being in a neutral state at ordinary temperatures, acquire electricity simply by being heated or cooled. This property is possessed only by regularly crystallized minerals; and of these the most remarkable is the tourmalin, which is a stone of considerable hardness, found in many parts of the world, and particularly in the island of Ceylon. The Dutch, who first became acquainted with it in that island, gave it the appellation of *Aschentrikker*, from its property of attracting ashes when it is thrown into the fire. It appears from the researches of Dr. Watson, that its attractive properties were known to Theophrastus, who describes it under the name of *Lyncurium*. Linnæus has termed it the *Lapis Electricus*, (Electric stone.) The form of its crystals is generally that of a nine-sided prism, terminated by a

three-sided pyramid at one end, and by a six-sided pyramid at the other. Lemery noticed its electric properties in the year 1717; but the first scientific examination of them was made by Æpinus in 1756, and published in the Memoirs of the Berlin Academy. He found that when a crystal of tourmalin has its temperature raised to between 100° and 212° of Fahrenheit, one extremity, which is that terminated by the six-sided pyramid, becomes charged with positive electricity, while the other extremity is negative; so as to be capable of affecting a delicate electroscope. When the stone is of considerable size, flashes of light may be seen along its surface. Mr. Wilson, who made many experiments on this subject, observed that a flat tourmalin retained its electricity without diminution, after exposure to intense heat for half an hour; but Canton, upon repeating these experiments, did not obtain the same result. Hauy states, that very high degrees of heat destroy the electricity of the tourmalin. After this has been effected, it recovers its electricity as it gradually cools: but in that case the electric states are generally reversed; that extremity, or *pole*, as it has been called, which was before positive, is now negative, and *vice versâ*. It is only at the summits of the pyramids, by which the crystal is terminated, that the electricity is manifested; the intermediate portions exhibiting no sign of electrical excitation, unless the stone be broken in pieces; and then each fragment is found to possess a positive and a negative pole, like the entire crystal. This fact bears a striking analogy to a corresponding property in magnets. At the ordinary temperature of the atmosphere, the tourmalin may be rendered electrical by friction.

(197.) There are several other gems and crystallized minerals which possess the same property as the tourmalin. The luminous appearance of some diamonds, when heated, is ascribed by Sir Humphry Davy to their electrical excitation. The substance called the *Boracite*, composed of borate of magnesia, which crystallizes in cubes, having its edges and angles defective, becomes electrical by heat, and in one variety presents no less than eight sides, alternately in different states; that is, four positive and four negative; the opposite poles being in the direction of the axes of the crystal. In those varieties in which only four of the angles of the crystal are truncated, that is, cut off by planes, while the rest are either entire, or are replaced by more than one plane, it is always the former of these angles that become positive, and the latter negative.

(198.) Similar properties are possessed by the Topaz, which consists of siliceous fluate of alumina; its electric poles are situated upon the two opposite summits of the secondary crystal. In some varieties, Hauy found a series of consecutive poles alternately positive and negative. Axinite, Mesotype, and Prehnite, become electrical by the application of heat: as also the two following metallic oxides, namely Calamine, which is an oxide of zinc, and Sphene, or calcareo-siliceous oxide of titanium. Mr. Dessaignes has lately shown that all metallic bodies are capable of a feeble electric excitation by changes of temperature. It results from the researches of Hauy, that this electrical property in mineral bodies is intimately related to the laws of their crystallization, and also to the direction in which the light is most readily transmitted through them.

(199.) There are a great many substances which become electrified on passing from the liquid to the solid form. This happens to sulphur, gum lac, bee's wax, and in general all resinous bodies. Unless proper precautions be taken, however, we frequently obtain no indications of this electricity, because it is usually *disguised*, that is, rendered inactive by the opposite electricity of the contiguous substances. Thus, if sulphur be melted over the fire in an iron ladle, and then set by to cool and harden, it exhibits no sign of electricity; because the negative electricity of the sulphur is exactly counterbalanced by the positive electricity accumulated in the iron vessel which contains it. But if the sulphur be removed from the vessel, which may be done by again heating it for a short time, so as just to melt the surface in contact with the iron, and allow of its being detached when the ladle is inverted, on suffering the sulphur to cool in this situation, its electricity becomes very apparent. If sulphur be melted in a wine glass, the conical shape of which admits of its being taken out when cold, the opposite electricities of the two surfaces will then manifest themselves, that of the sulphur being negative, and that of the glass positive; but when the sulphur is replaced in the glass, all indications of

electricity disappear. The electricity developed by the process of cooling was called by Wilke, who first observed it, *spontaneous electricity*, in contradistinction to that which, originating from friction, he called *excited electricity*. Van Marum, however, attributes the electricity developed by the separation of the two substances, to a species of friction; for he remarks, that the electricity does not manifest itself till the sulphur begins to contract in the act of congelation, and that it attains its maximum at the point of the greatest contraction.

(200.) It is reasonable to suppose that whatever change was produced in the electrical state by congelation, the reverse would be produced by liquefaction. We are not aware of any experiments which bear directly upon this question.

(201.) The conversion of bodies into the state of vapour, as well as the condensation of vapour, is generally attended by some alteration of their electrical condition; and the bodies in contact with the vapour are thereby rendered electrical. Thus, if a plate of metal strongly heated be placed upon a gold-leaf electroscope, and water be dropped upon the plate, at the moment the vapour rises the leaves of the electroscope diverge with negative electricity. The general fact was noticed by Laplace, Lavoisier, and Volta, in the year 1781; and was found to extend both to solids and to fluids passing into a gaseous form. De Saussure made an extensive series of experiments on the ebullition of water and other fluids, with a view to ascertain the degree and kind of electricity developed during this process. But investigations of this kind are attended with great difficulty, from the multitude of minute circumstances which are liable to affect the results; and we accordingly find, that different experiments of the same kind often afford the most opposite conclusions.

(202.) In general it is found, that the vaporization of water by simple ebullition produces negative electricity in the remaining fluid, or vessel which contains it: the vapour itself being positive. On the contrary, when aqueous vapour is condensed into water, it becomes negative, leaving the bodies with which it was last in contact in a state of positive electricity. Yet in some of De Saussures's experiments, when the heat was communicated to a quantity of water contained in an insulated metallic vessel, by throwing into it a mass of red-hot iron, the electricity was very strongly positive. This difference in the result was probably owing to the chemical decomposition of the water in the latter experiment, a circumstance which, as we shall presently see, is itself a source of electricity. It is principally on account of the interference of chemical actions with the regular operations of temperature, and of the complications introduced by electric induction, that experiments on this subject have hitherto presented such anomalous, and, apparently, discordant results.

Chapter XIV.

Developement of Electricity by Contact, Compression, and other mechanical Changes in Bodies, and also by their Chemical Action.

(203.) It had long been suspected, rather than proved, that a feeble degree of electricity is evolved by the contact or collision of different metals: but this important fact was established in the clearest manner by Volta, about the year 1801. The apparatus he employed in his investigations on this subject consisted of two discs, the one of zinc, the other of copper. (*fig.* 41.) rather more

Fig. 41.



than two inches in diameter, ground perfectly plane, and having in their centres insulating handles perpendicular to their surfaces, by means of which the plates could be brought into contact, without being actually touched with the hand. With this precaution the discs were made to approach till they touched one another; they were then separated, by keeping them parallel as they were drawn back. The electricity they possessed after this separation was then examined by means of the condenser; and, that the effects might be rendered more distinct, the electricity produced by a number of successive contacts, (taking care to restore the discs to the neutral state after each contact,) was accumulated in the same condenser. It was constantly found that the copper disc charged the condenser with negative, and the zinc disc with positive elec-

tricity. Thus it was established as a general fact, that these two metals, insulated, and in their natural state, are brought, by mutual contact, into opposite electrical states; the zinc acquiring positive electricity, and the copper becoming, in an equal degree, negative.

(204.) No explanation has yet been given of this curious fact, which seems to be at variance with all the previously ascertained laws of electric equilibrium. The transfer of electricity from one metal to the other during their contact, implies the operation of some new force which no theory has yet embraced. While the contact is preserved, neither of the metals gives any indication of its electrical state, the electricity being *disguised*; as would be the case of that of the coatings of a Leyden jar, if we could suppose them both in actual contact, but yet incapable of allowing any transfer of the electricity from the one to the other, so as to restore both to the state of neutrality.

We shall have occasion to resume the consideration of this curious subject in the treatise on Galvanism, with the theory of which it appears to have an intimate relation.

(205.) There are some bodies which are rendered electrical by pressure, This property is possessed in the most remarkable degree by that transparent variety of carbonate of lime which is known by the name of *Iceland spar*. According to Hauy, if a crystal of this spar, which has the form of a rhomboid, be held in one hand by two of its opposite edges, and if at the same time two of its parallel planes be lightly touched by two fingers of the other hand, and then brought near to the small needle of the electroscope, (§ 12) a decided attraction will be perceptible. By applying a more powerful pressure, the electrical effects will be still more considerable; the electricity being in all cases positive. Hauy observes that this property resides principally in those crystalline minerals that are capable of being reduced by mechanical division to plane and smooth laminæ: such as the Topaz, especially the colourless variety; Euclase, Arragonite, Fluate of lime, and Carbonate of lead. Among those substances in which friction excites negative electricity, there are some which require only to be pressed, for the production of the same effect. An instance occurs in elastic bitumen, when it has been cut into a proper shape for the experiment. Mr. Becquerel has lately discovered that many other substances, such as cork, bark, hairs, paper, and wood, possess the property of producing electricity by compression.

(206.) Many substances, when reduced to powder, exhibit electricity, if they are made to fall upon an insulated metallic plate. This fact was first noticed by Mr. Bennet, after he had invented his gold-leaf electroscope. He found that powdered chalk, put into a pair of bellows, and blown upon the cap of the electroscope, communicates to the instrument positive electricity, when the pipe of the bellows is about six inches from the cap; but the same stream of powdered chalk electrifies it negatively at the distance of three feet. On being blown in a more copious stream from a pair of bellows without the pipe, the electricity is always negative; and the same effect takes place when the powder is let fall from another plate upon the cap of the instrument. This subject was pursued by Cavallo; but the most complete set of experiments relating to it is that of Singer, who employed in his researches the two following methods: first, that of sifting the powders on the cap of a delicate electrometer through a fine sieve, which was thoroughly cleaned after each operation; and secondly, that of bringing an insulated copper plate repeatedly in contact with extensive surfaces of the powders spread on a dry sheet of paper; the copper plate being brought in contact with the condenser after every repetition of the contact, until a sufficient charge was communicated.

(207.) The following substances, according to Singer, produce negative electricity when sifted on the cap of the electrometer: *viz.* copper, iron, zinc, tin, bismuth, antimony, nickel, black lead, lime, magnesia, barytes, strontites, alumine, silex, brown oxide of copper, white oxide of arsenic, red oxide of lead, litharge, white lead, red oxide of iron, acetate of copper, sulphate of copper, sulphate of soda, phosphate of soda, carbonate of soda, carbonate of ammonia, carbonate of potash, carbonate of lime, muriate of ammonia, common pearl-ashes, boracic acid, tartaric acid, cream of tartar, oxymuriate of potash, pure potash, pure soda, resin sulphur, sulphuret of lime, starch, orpiment.

(208.) The following substances produce positive electricity under the same circumstance: *viz.* wheat flour, oatmeal, lycopodium, quassia, powdered cardamom, charcoal, sulphate of potash, nitrate of potash, acetate of lead, oxide of tin.

(209.) The following catalogue exhibits the results of the experiments of contact with a copper plate; the different substances being arranged under the head of the electricity they really acquire, which is contrary to that of the copper plate. *Positive:* lime, barytes, strontites, magnesia, pure soda, pure potash, common pearl-ashes, carbonate of potash, carbonate of soda, tartaric acid. *Negative:* benzoic acid, boracic acid, oxalic acid, citric acid, silex, alumina, carbonate of ammonia, sulphur, resin. These experiments were several times repeated with uniform results.

(210.) The above mode of electrical excitation is probably merely a species of friction, differing only from the more ordinary instances by the mode of its application. But in other cases the electrical effects of contact are more distinctly exhibited, as when zinc filings are poured through holes in a plate of copper, upon the cap of an electrometer.

(211.) The following experiment, founded on one devised by Professor Lichtenberg of Gottingen, is an elegant illustration of the opposite electrical states of different powders. With the knob of a charged jar, trace on the surface of a smooth plate of glass, or of any resinous substance, various lines at pleasure; and then repeat the same operation in other parts with the knob of a jar charged with the opposite electricity. Let the surface thus prepared be gently dusted, by means of a powder-puff, with a mixture of powdered sulphur and red lead, previously triturated together in a mortar. By the contact and friction thus produced, the sulphur has been rendered negative, and the red lead positive; and each of the powders, when projected on the plate, will attach itself to the oppositely electrified lines, forming a series of red and yellow outlines. It is also observable, that the configurations assumed by these and other powders differ according to the species of electricity impressed upon the plate; positive electricity producing an appearance resembling feathers, and negative electricity an arrangement more like stars.

(212.) The most important circumstance in this inquiry, is the connection between electricity and the chemical properties of matter. It is observed by Sir H. Davy, that most of the substances that act distinctly upon each other electrically, are likewise such as act chemically, when their particles have freedom of motion: this is the case with the different metals, with sulphur and the metals, with acid and alkaline substances. Of two metals in contact, the one which has the greatest chemical attraction for oxygen acquires positive electricity, and the other the negative: so that if arranged in the order of their oxidability, as follows, zinc, iron, tin, lead, copper, silver, gold, platina, each will become positive when brought into contact with any that follow it in the series, and negative with any of those which precede it. In contacts of acids with bases, as of crystals of oxalic acid with dry quicklime, the former is negative, the latter positive. All acid crystals when touched by a plate of metal render it positive, the crystals themselves becoming negative.

(213.) Bodies that exhibit electrical effects by mutual contact, previous to their chemical action on each other, lose this power during combination. Thus if a polished plate of zinc be made to touch a surface of dry mercury, and quickly separated, it is found positively electrical, and the effect is increased by heat; but if it be so heated as to amalgamate, that is, unite chemically with the mercury, it no longer exhibits any signs of electricity. The case is analogous with copper and sulphur; and iron, when applied to mercury, produces more electricity than zinc, apparently from its being incapable, under ordinary circumstances, of forming a chemical combination with mercury.

(214.) On the other hand, there can be no question that electricity is occasionally, if not universally, elicited during chemical action. We have just seen that a dry acid becomes negative by contact with a metal, which is consequently thereby rendered positive. In this case no chemical combination had taken place. But Becquerel has shown that if the acid, instead of being in a dry crystalline form, be in a liquid state, and capable of acting chemically on the metal, the acid will become positive and the metal negative. The same conclusion may also be deduced from the experiments of Lavoisier and Laplace, on the action of dilute sulphuric acid on iron filings. That the oxidation of metals gives rise to electricity has been also shown by the experiments of Dr. Wollaston, from which it would appear that the electricity obtained in the com-

mon electrical machine is derived principally from this source. When he employed as the rubbing substance an amalgam of silver or of platina, which are metals very little subject to oxidation, he could obtain no electricity. An amalgam of tin, on the other hand, supplied a large quantity of electricity. Zinc acts still better than tin; but the best amalgam for this purpose is made with both tin and zinc, a mixture which oxidates more readily than either metal separately. As a further trial whether oxidation assists in the production of electricity, a small cylinder with its cushion and conductor was arranged in a vessel so contrived that the contained air could be changed at pleasure. After ascertaining the degree of excitement produced in atmospheric air, carbonic acid was substituted, but the excitement could not be renewed; while it was immediately reproduced on the readmission of common air. It must be acknowledged, however, that Sir H. Davy, in repeating these experiments, arrived at opposite results; for he states, that the machine acted equally well in hydrogen gas as in atmospheric air, and was even more active in carbonic acid gas, a circumstance which he attributes to the greater density of this gas.

(215.) Electricity is often developed by processes quite independent of chemical changes. This is evident from its production by the friction of two bodies of the same kind upon one another, as has been already noticed, (§ 35;) and also by the strong electricity which is manifested on the separation of the parts of the same body. Thus, if a piece of dry and warm wood be suddenly rent asunder, the two surfaces which have separated are found to be electrified, the one positively, the other negatively; and a flash of light is perceived if the experiment be made in the dark. The same phenomenon is observed when the plates of mica (Muscovy glass) are suddenly torn asunder; and even when a stick of sealing-wax is broken across; the two surfaces of fracture being in each case positive and negative respectively. Dr. Brewster discovered that the fracture of the unannealed glass tears, called *Prince Rupert's drops*, was attended with the evolution of electrical light, which pervaded the whole drop, so that its form was distinctly visible in the dark. The light appears even when the experiment is made under water.

(216.) There is every reason to presume that electricity is essentially concerned in the processes that are carried on in the living system both of animals and vegetables. In the animal economy more particularly, the operation of this agent is indicated in the processes of secretion, in the actions of the muscles and nerves, and probably, indeed, in all the vital functions. There are several kinds of fish, which are endowed with the power of accumulating large quantities of electricity, which they can discharge at pleasure through conducting bodies that come in contact with them, and thus communicate powerful shocks. This power is possessed in an eminent degree by the torpedo, which is a species of ray; but it is also met with in the Gymnotus electricus, the Silurus electricus, the Trichiurus indicus, and the Tetraodon electricus. But as this, as well as other subjects relating to animal electricity, involve considerations which properly belong to Galvanism, we must defer treating of them until this branch of electrical science is before us.

Chapter XV

Electricity of the Atmosphere.

(217.) As the subject of atmospheric electricity is more especially a branch of the science of Meteorology, we shall content ourselves, in this place, with a very brief outline of the principal facts relating to it.

(218.) The atmosphere is very generally in an electrical state. This may be ascertained by employing a metallic rod elevated to some height above the ground, and communicating at its lower end, which should be insulated, with an electroscope. In order to collect the electricity of the higher regions of the air, a kite may be raised, in the string of which a slender metallic wire should be interwoven, so as to conduct the electricity. If the electroscope be sufficiently sensible it will usually indicate the prevalence of positive electricity in the atmosphere, the intensity of which increases according as the stratum examined is more elevated. In the ordinary state of the atmosphere its electricity is invariably found to be positive: and is stronger in winter than in summer; and during the day than the night. From the time of sunrise it increases for two or three hours, and then decreases towards the middle of the day, being generally weakest between noon and four o'clock. As the sun declines its intensity is again augmented, till about the time of sunset, after which it diminishes, and continues feeble during the night. In cloudy weather the electrical state is much more uncertain; and when there are several strata of clouds, moving in different directions, it is subject to great and rapid variations, changing sometimes from positive to negative, and back again, in the course of a few minutes. On the first appearance of fog, rain, snow, hail, or sleet, the electricity of the air is generally negative, and often highly so; but it afterwards undergoes frequent transitions to opposite states. On the approach of a thunder-storm these alternations of the electric condition of the air succeed one another with remarkable rapidity. Strong sparks are sent out, in great abundance, from the conductor; and it becomes dangerous to prosecute experiments with it in its insulated state.

(219.) The analogy between the electric spark, and more especially of the explosive discharge of the Leyden jar, with atmospheric lightning and thunder, is too obvious to have escaped notice, even in the early periods of electrical research. It had been observed by Dr. Wall and by Gray, and still more pointedly remarked by the Abbé Nollet. Dr. Franklin was so impressed with the many points of resemblance between lightning and electricity, that he was convinced of their identity, and determined to ascertain by direct experiment the truth of his bold conjecture. A spire which was erecting at Philadelphia he conceived might assist him in this inquiry; but, while waiting for its completion, the sight of a boy's kite, which had been raised for amusement, immediately suggested to him a more ready method of attaining his object. Having constructed a kite by stretching a large silk handkerchief over two sticks in the form of a cross, on the first appearance of an approaching storm, in June 1752, he went out into a field, accompanied by his son, to whom alone he had imparted his design. Having raised his kite, and attached a key to the lower end of the hempen string, he insulated it by fastening it to a post, by means of silk, and waited with intense anxiety for the result. A considerable time elapsed without the apparatus giving any sign of electricity, even although a dense cloud, apparently charged with lightning, had passed over the spot on which they stood. Franklin was just beginning to despair of success, when his attention was caught by the bristling up of some loose fibres on the hempen cord; he immediately presented his knuckle to the key, and received an electric spark. Overcome with the emotion inspired by this decisive evidence of the great discovery he had achieved, he heaved a deep sigh, and conscious of an immortal name, felt that he could have been content if that moment had been his last. The rain now fell in torrents, and wetting the string, rendered it conducting in its whole length; so that electric sparks were now collected from it in great abundance.

It should be noticed, however, that about a month before Franklin had made these successful trials, some philosophers, in particular Dalibard and De Lors, had obtained similar results in France, by following the plan recommended by Franklin. But the glory of the discovery is universally given to Franklin, as it was from his suggestions that the methods of attaining it were originally derived.

(220.) This important discovery was prosecuted with great ardour by philosophers in every part of Europe. The first experimenters incurred considerable risk in their attempts to draw down electricity from the clouds, as was soon proved by the fatal catastrophe, which, on the 6th of August, 1753, befel Professor Richman, of Petersburg, whose name has already been before us, (§ 123.) He had constructed an apparatus for observations on atmospherical electricity, and was attending a meeting of the Academy of Sciences, when the sound of distant thunder caught his ear. He immediately hastened home, taking with him his engraver, Sokolow, in order that he might delineate the appearances that should present themselves. While intent upon examining the electrometer, a large globe of fire flashed from the conducting rod, which was insulated, to the head of Richman, and passing through his body, instantly deprived him of life. A red spot was found on his forehead, where the electricity had entered, his shoe was burst open, and part of his clothes singed. His companion was struck down, and remained senseless for some time; the door-case of the room was split, and the door itself torn off its hinges.

(221.) The protection of buildings from the effects of lightning, is the most important practical application of the theory of electricity. We have only room for a few observations on the principles on which conductors for this

purpose should be constructed. They should be formed of metallic rods, pointed at the upper extremity, and placed so as to project a few feet above the highest part of the building they are intended to secure; they should be continued without interruption till they descend into the ground, below the foundation of the house. Copper is preferable to iron as the material for their construction, being less liable to destruction by rust, or by fusion, and possessing also a greater conducting power. The size of the rods should be from half an inch to an inch in diameter, and the point should be gilt, or made of platina, that it may be more effectually preserved from corrosion. An important condition in the protecting conductor is, that no interruption should exist in its continuity from top to bottom: and advantage will result from connecting together by strips of metal all the leaden water pipes, or other considerable masses of metal in or about the building, so as to form one continuous system of conductors, for carrying the electricity by different channels to the ground. The lower end of the conductors should be carried down into the earth till it reaches either water, or at least a moist stratum.

For the protection of ships, chains made of a series of iron rods linked together, are, by their flexibility, most conveniently adapted. They should extend from the highest point of the mast some way into the sea, and the lower part should be removed to some distance from the side of the ship, by a wooden spar or outrigger.

The air of close rooms, vitiated by respiration, is found to be negatively electrified.

Chapter XVI.

Theoretical Views of the Nature of Electricity.

(222.) The preceding history of the phenomena relating to electricity, may prepare us for the discussion of some interesting inquiries concerning the real nature of this powerful and mysterious agent, and the theory of its operation.

The first question that presents itself is with respect to its materiality. Besides the well-known mechanical forces which belong to ordinary ponderable matter, the phenomena of nature exhibit to our view another class of powers, the presence of which, although sufficiently characterised by certain effects, is not attended with any appreciable change in the weight of the bodies with which they are connected. To this class belong heat, light, electricity, and magnetism; each of which, respectively, produces certain changes on material bodies, either of a mechanical or chemical nature, which it is natural to regard as the effects of motion communicated by the impulse of material agents, of so subtile and attenuated a kind, as to elude all detection when we apply to them the tests of gravity or inertia. If we admit heat and light to be material, analogy will lead us to ascribe the same character to electricity and to magnetism, notwithstanding their being imponderable.

(223.) But the materiality of electricity has also been maintained on other grounds. The pungent sensation of the electric spark, the smart blow which accompanies the shock, the vivid line of light which marks its course, the varied sounds which attend its passage through the air, and the irresistible fury with which it bursts asunder the densest textures, all seem to denote the mechanical effects of sudden and powerful impulse; all seem to imply the rushing of a stream of fluid possessed of momentum adequate to produce these energetic motions. Can we refuse to ascribe the character of materiality to that which we not only see and hear, but feel also?

(224.) This argument has been endeavoured to be strengthened by a variety of experiments, from which the communication of impulse in a particular direction with respect to the species of electricity has been inferred. The stream of air, which proceeds from a pointed conductor when electricity is issuing from it, appears as if the air were carried forward along with the electric fluid. The direction of its motion is still more decidedly indicated by the different luminous appearances which accompany the escape of the fluid from, or its reception by, a pointed conductor. (See *fig.* 23.) We have already had occasion to notice the manner in which this curious fact appears to support the hypothesis of Franklin, implying the singleness of the electric fluid, (§ 98.)

(225.) The following experiment has also been adduced by Cavallo and by Singer, in support of the same opinion. Place on the table of the universal discharger a card bent lengthwise over a round ruler, so as to form a hollow cylindrical groove; or, what is still better, two straight sticks of sealing-wax, laid parallel to each other, so that the junction of their rounded edges may form a groove. In this groove place a pith-ball

of about half an inch in diameter, and arrange the wires of the discharger with their points in the direction of the groove, and at four inches from each other, the ball being equally distant from each. On passing a small charge from one wire to the other, the ball will be driven from the positive to the negative wire, and this effect will be constant if the wires terminate in points; but if they are knobbed, the ball frequently vibrates between them, because the influence of the attracting surfaces upon the ball interferes with the regularity of the effect, and often renders the result equivocal.

(226.) The nature and place of the perforation effected in a card by the passage of an electric charge, of which we have already given an account (§ 159), appear to favour the same view of the subject. The following experiment, also, shews that the impulse is communicated most forcibly in the direction from the positive towards the negative conductor. A light float-wheel, the vanes of which are made of card paper, inserted in the circumference of a cork turning freely on a pin passed through its centre as an axle, will be put in motion by presenting to it an electrified point, apparently in consequence of the impulse of the stream of air which issues from the point. Whether the point be positively or negatively electrified, the direction of the motion, as well as of the stream of air, is always the same. But if the wheel be placed on an insulating stem, as in *fig.* 42, and introduced between the pointed

Fig. 42.



wires of the universal discharger, which are to be placed as accurately as possible opposite to each other, and at the distance of an inch or more from the upper vanes; on connecting one of the wires with the positive, and the other with the negative conductor of an electrical machine, and exciting it, the wheel will move as if impelled by a stream from the positive to the negative wire. On reversing the connections, so that the electricity of each wire is changed, the motion of the wheel will likewise be reversed.

(227.) If a card be placed vertically, by inserting it in a small piece of cork that may form a base of about a quarter of an inch wide for it to stand upon, but so that it may be overthrown by the smallest impulse; and the pointed wires of the universal discharger be brought opposite to each other, and about a quarter of an inch below the upper edge of the card, which stands at an equal distance between them; on connecting the wires with a machine, or with an insulated jar, so as to effect an electric discharge between them, the card will be thrown down, and will constantly fall from the positive, and towards the negative wire.

(228.) The determination of a stream of electrified air in this direction is also rendered very sensible by the motions of smoke or vapour placed in the circuit of the electricity. Thus the flame of a taper placed between two oppositely electrified balls will constantly be blown from the positive to the negative side. *Fig.* 43 represents two hollow metallic

Fig. 43.



balls, about three quarters of an inch in diameter, insulated on separate glass pillars, by which they are supported at a distance of two inches from each other: the upper part of each ball is hollowed into a cup, into which a small piece of phosphorus is to be put. A small candle has its flame situated mid-way between the balls, one of which is connected with the positive, and the other with the negative conductor of the machine. When the balls are electrified, the flame is agitated, and inclining towards the one which is negative, soon heats it sufficiently to set fire to the phosphorus it contains, whilst the positive ball remains perfectly cold, and its phosphorus unmelted. On reversing the connections of the balls with the machine, the phosphorus in the other ball will now be heated and will inflame.

(229.) However plausibly it may have been inferred, from a superficial view of these facts and experiments, that the electric fluid actually possesses momentum, and that it moves in a particular direction, a more rigid analysis of the phenomena will show that they in no

degree warrant such an inference. All the mechanical effects that attend the transfer of electricity are ultimately resolvable into the sudden action of a repulsive power exerted among the particles of matter which are situated in the line of its course. They are only particular instances of the fundamental law of electric action, that bodies charged with the same kind of electricity repel one another. Thus the particles of air electrified by a pointed conductor are repelled by that conductor, and repel it also; and, moreover, repel one another: and the same effect takes place whether their electric state be of the positive or negative kind. Hence the stream of air which proceeds from any electrified point is very naturally accounted for. If the quantity of electricity which is transferred is considerable, it excites a more violent commotion among the particles which it influences in its passage. The intense energy of its repulsive action produces the most sudden and forcible expansion of that portion of the air which occupies this line; this air thus expanding must be impelled laterally against the surrounding particles, and must occasion their sudden compression. The evolution of heat and light is the necessary consequence of this violent compression; and the vibratory impulse being propagated in all directions is the source of the sound which attends the electric explosion. The sensation to which the passage of the electric shock through our bodies gives rise, is also, evidently, referable to an impression made on the nerves by the same repulsive action. In all this we can discern no positive proof of the operation of a material agent extraneous to the body itself and acting by mechanical impulse. The materiality of electricity, therefore, must still rest upon a similar foundation with that of heat, or of light.

(230.) If the electric power, or fluid, if we choose to consider it as such, does not act by its mechanical momentum, the arguments in favour of the motion of a single fluid from the positive to the negative body, derived from the appearances of the streams of electric light, (§ 97, 98,) the impulsion of a pith-ball, (§ 225,) the perforation of a card, (§ 159,) the rotation of a windmill, (§ 226,) and the determination of the flame of a taper (§ 228) in one constant direction, must fall to the ground, and can evidently be of no avail in deciding the great question, whether there be two electric fluids or only one. But, still, it is incumbent upon us to inquire upon what principle these remarkable differences in the phenomena of positive and of negative electricity can be accounted for, consistently with either hypothesis.

(231.) On an attentive examination of the phenomena they appear to be explicable on the supposition that the air, or medium through which the electricity passes, is, in the language of one theory, more disposed to admit of the passage of the vitreous than of the resinous electricity; or, to speak consistently with the Franklinean theory, that it is more disposed to receive the electric fluid from a conductor which is charged with it, than to part with it to an uncharged conductor which absorbs it. The consequences of this hypothesis are, that the vitreous electricity meets with less resistance in passing out from a body into the air, and is therefore carried forward more readily and more directly than the resinous electricity. The latter, in consequence of meeting with greater resistance to its exit, is more diffused in the surrounding space.

On the Franklinean theory the same effects will follow with reference to the propulsion of the electric fluid from the positive, and its absorption by the negative body.

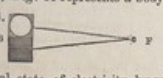
(232.) That the peculiarity of the mechanical effects of the different species of electricity depends upon the properties of the air, which is the vehicle of its agency, and not upon any specific power in the agent itself, is shown by a modification of the experiment described in § 159, in which a varnished card, suspended between two conductors, was perforated at the point where it was touched by the negative wire. On repeating the same experiment under the receiver of an air-pump, Mr. Tremery found, that in proportion as the air is exhausted, the place where the card is perforated by the electric shock approaches nearer to the positive wire. When the pressure of the air is reduced to one-half, the hole is at the middle point between the two wires. At every discharge, a flash is seen to pass from each conductor to the place of perforation. The curious appearances presented by the edges of the perforations made in the leaves of a quire of paper, already detailed (§ 160, 161,) are not reconcileable with the supposition of a mechanical impulse acting only in one direction, but indicate the equal repulsive action of both kinds of electricity, when the disturbing influence of the

air is withdrawn. It is a confirmation of this hypothesis, respecting the peculiar kind of obstruction which air opposes to the passage of electricity, that other substances have been discovered in which a similar property exists. Mr. Ermann, of Berlin, has found that the flame of alcohol is possessed of a greater conducting power with regard to positive, than to negative electricity. Alkaline soap, on the contrary, conducts negative electricity better than positive; and will, therefore, serve to insulate a feeble degree of the latter, at the same time that it permits the passage of the former.

(233.) It has always been urged as a strong objection to the theory of a single electric fluid, that it necessarily involves the condition of a mutual repulsion among the particles of ordinary matter. See § 52. Before attempting to combat this objection, it will be proper to enter into a somewhat fuller illustration of the position than we have already done; and for this purpose we shall avail ourselves of the assistance of a few diagrams, calculated to aid our conceptions of the forces concerned in the mutual actions of electrified or neutral bodies. For the sake of greater distinctness, we shall suppose the whole of the matter in the body, of which we are studying the actions, to be concentrated in a small space, and we shall represent this matter by a black square. In like manner, we shall suppose that the whole of the electric fluid contained in the same body is condensed into a small space, denoted by a white circle. The mutual actions of the matter or electric fluid in two adjacent bodies, are expressed by lines passing from the one to the other respectively; the attractions being distinguished by unbroken lines, and the repulsions by dotted lines.

(234.) *Fig.* 44 represents a body B in

Fig. 44.



a neutral state of electricity, by which is to be understood, that the quantity of fluid it contains exists in a proportion so exactly adjusted to the quantity of matter, as that its repulsion for a particle F of electricity at any distance, precisely balances the attraction of the matter for that same particle. While this equilibrium is preserved among the forces which would impel any electric fluid external to the body both from it and towards it, it is evident that the body will neither acquire nor lose electricity, but remain quiescent, whether it be insulated or not.

(235.) The state of the forces operating between two similar neutral bodies is shown in *fig.* 45. Here it

Fig. 45.



follows *from the condition of neutrality, as above defined*, that the two attractive forces, denoted by the two whole lines, are *each of them* equal to the repulsive force between the two fluids, denoted by the upper dotted line. Actuated by these forces only, therefore, the two bodies would attract each other. The addition of a second repulsive force between the two portions of matter, as represented by the lower dotted line, is therefore necessary to account for the state of equilibrium which we find, under these circumstances, really obtains. Some persons have conceived, that by assuming the repulsive force of the electric particles to be double the attractive forces of the same particles for matter, the equilibrium might be explained without having recourse to the mutual repulsion of the particles of matter: forgetting, that such an assumption is incompatible with that of the neutral state of the bodies, which is the condition under which we are now examining them.

(236.) The repulsion of two bodies, each containing twice the quantity of electric fluid requisite for the saturation of their respective matter, is illustrated by *fig.* 46. All the forces represented

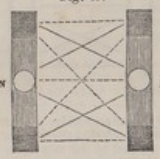
Fig. 46.



by the lines must, from the hypothesis, be regarded as equal in point of intensity: but the number of repulsive forces is as five, while that of the attractive forces is only as four: the former therefore will prevail.

(237.) Precisely the same result will obtain in the case of two negatively electrified bodies, in which, as represented in *fig.* 47, the quantity of matter

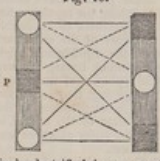
Fig. 47.



is twice as much as the fluid can saturate. In the former case it was the repulsion between the two portions of fluid which were in excess that destroyed the equilibrium; while in this case the same effect is produced by the mutual repulsion of the unsaturated portions of matter.

(238.) Lastly, we may collect from an examination of *fig.* 48, where a body

Fig. 48.



positively electrified is supposed to be placed near one that is negatively electrified, that the ultimate effect will be determined by the attraction between the fluid in excess in the former, and the unsaturated matter in the latter: all the other attractions and repulsions exactly compensating each other.

(239.) It is a great, though a common error to imagine, that the condition assumed by Æpinus, namely, that the particles of matter, when devoid of electricity, repel one another, is in opposition to the law of universal gravitation established by the researches of Newton; for this law applies, in every instance to which inquiry has extended, to matter in its ordinary state, that is, combined with a certain proportion of electric fluid. By supposing, indeed, that the mutual repulsive action between the particles of matter is, by a very small quantity, less than that between the particles of the electric fluid, a small balance would be left in favour of the attraction of neutral bodies for one another, which might constitute the very force which operates under the name of gravitation: and thus both classes of phenomena may be included in the same law.

(240.) An objection has been urged by Biot against the hypothesis of a single fluid, on the ground that it implies an equal degree of attraction between the fluid and every species of matter, whereas in the case of other agents, such as heat and magnetism, the degree of their attraction is very different towards different kinds of matter. This objection does not apply to the hypothesis of the two fluids, for they are assumed as acting independently of any specific attractions for the bodies which contain them: hence their distribution in those bodies follows the same law, whatever be the specific nature of the materials of which the latter are composed.

(241.) We arrive, then, at the conclusion that there is no fact in electricity which cannot be explained on either of the two hypotheses: but to which side the balance of probabilities may incline, when the respective merits and demerits of each are taken into account, remains, perhaps, to be decided more by the taste than the judgment of the inquirer.

ERRATA IN PART I.

Page.	Col.	Line.	
6.	1.	3.	*from bottom, omit the line*—"Ice above—15° Fahrenheit."
7.	1.	10.	*omit*—" of six inches, that is."
9.	1.	26.	*for* " resinous," *read* " viteous."
10.	1.	37.	*for* " viteous," *read* " resinous."
20.	1.	1.	*for* " silkes," *read* " silk."
22.	1.	16.	*for* " spheroids," *read* " spheroid."
43.	2.	10.	*from bottom, for* " smaller," *read* " greater."

MECHANICS.

TREATISE I.

ON THE MECHANICAL AGENTS OR FIRST MOVERS.

Chapter I.—*Introduction.*

(1.) Whatever communicates or tends to communicate motion to a body, is called a *force*. The object of Mechanics, in the most extended sense of that term, is the investigation of the effects of forces on bodies.

If a body which is absolutely at rest be submitted to the action of two or more forces, one of two effects must ensue; either the body must continue in its state of rest, or it must commence to move in some determinate direction, and with some determinate force. If the body continue at rest, it necessarily follows, that the forces which act upon it are so related as to their directions and intensities, that they neutralise each other, or mutually destroy each other's effects. Under such circumstances, the body is said to be in a state of *equilibrium*,* and we also commonly apply the same term *equilibrium* to the forces which act upon the body.

It is, therefore, a very important problem or rather class of problems, to assign in every particular case that relation between the intensities and directions of the forces acting upon a body under given circumstances, which will keep the body in a state of equilibrium. By the solution of such a problem, we shall always be able to predict whether a body urged by given forces shall receive any motion or not.

If the forces which act upon the body be not so related as to neutralise each other's effects, motion must ensue, and the body will be urged with some determinate force in some determinate direction. To assign the force with which the body will thus be moved, and the direction of its motion, the intensities and directions of the forces impressed on the body being given, is another important class of problems, and of a nature altogether distinct from the former.

(2.) These considerations suggest the division of the science into two parts. In the first, which is called *statics*,† bodies are considered as submitted to the influence of forces which are in equilibrium.

(3.) In the second part, which is called *dynamics*,‡ bodies are considered as submitted to the action of forces which are not in equilibrium. In the former, therefore, bodies are considered at rest, and in the latter as in motion.

(4.) Although this be unquestionably the most philosophical division of the subject, and that which should be adopted in a treatise designed for the use of certain classes of students; yet, considering the objects which we have in view in the present series of works, and the persons for whose instruction they are intended, we think it expedient to pursue a different course, and do not hesitate to sacrifice system to utility.

In all the various changes which the raw productions of nature must undergo in order to adapt them to supply the wants of civilized life, *motion* is the principal agent. The wool which is shorn from the sheep, requires a rotatory motion to form it into threads. These threads must be submitted to a variety of other motions, in order to produce that arrangement which gives them the form of cloth; and cloth when woven must pass through many other processes, in all of which motion is the chief agent, before it is prepared for use. To obtain these motions, we avail ourselves of the forces which we find actually existing in nature, such as the falling of water, the force of wind, the strength of animals, and numerous others. As, however, the forces and motions which are required for the various manufactures, are generally different in many respects from those forces with which nature has supplied us, it is

* Equilibrium is originally a Latin word signifying balance, the forces, as it were, balancing each other.

† From the Greek word στατος, *status*, signifying *standing still*.

‡ From the Greek word δυναμις, *dunamis*, signifying *force*.

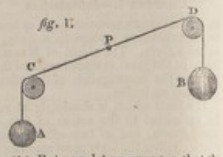
necessary that means should be contrived of modifying them so as to suit them to our wants. It may so happen that we have at our command a natural force of variable intensity, when it is necessary to apply to the work which we design to execute one of a perfectly uniform intensity. We are, therefore, compelled to contrive some means by which, in transmitting the force from the natural mechanical agent, whatever it be, to the working point, it may be so modified as to be rendered uniform in its action. Again, the natural force may act constantly in one direction, as for example, a running stream, or a perpendicular fall of water, or a current of air, when it may be required that the force on the working point should be alternate or reciprocating, as for example, that which is necessary to work the piston of a common pump. In such cases, therefore, some apparatus must be interposed between the natural agent and the working point, which is capable of converting the one species of motion into the other. Such a contrivance is called a *machine*, and the natural force which it is designed to modify is called its *first mover*; that part of the machine at which the required modification is produced, being generally called the *working point*.

In that part of Mechanics which is confined to the consideration of the nature and principles of machinery, there are two objects intimately related each to the other, and each of which strongly demands our attention; first, the natural *mechanical agents* or *first movers*; secondly, *machines*, or the means whereby these powers are modified and rendered applicable to our purposes. We propose in this *first* treatise to confine the attention of the reader to the explanation of the nature and laws of those powers in nature which furnish first movers, and to the properties of motion and force in general. In conformity with this method, we shall devote the *second treatise* to the *elements of machinery*.

Chapter II.—*On the composition and resolution of Motion and Force.*

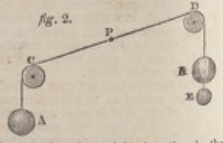
(5.) If two equal forces act upon the same point of a body, in directions immediately opposite, they will keep that body at rest. Such forces, then, are the most simple example of equilibrium, and the truth of this principle is self-evident. Thus, if to a point P two threads be attached, and that two wheels C D, turning on fixed centres, and having grooves on their edges, be so placed that when the strings are passed over them the parts P C and P D shall be in the same straight line, equal weights A and B suspended from the strings will draw the point P equally in the opposite directions P C and P D, and they will thus evidently neutralise each other, and the body P will be in equilibrium.

fig. 1.



(6.) But now let us suppose that the weight B is greater than the weight A. In that case the point P will be drawn in the direction P D with a greater force than that which draws it in the opposite direction P C, and it will evidently have a tendency to move in the direction P D. But what tendency? To what amount, or, in other words, with what force is P pulled in the direction P D? This is easily determined. Suppose that the weight B is divided into two parts, one of which is equal to A; the other part will be evidently equal to the difference of the weights A and B, or to the excess of the weight B above the weight A. Call this excess E, and let the apparatus assume the form *fig.* 2. Now, it appears

fig. 2.



by (5.), that the weight A acting in the direction P C, exactly balances the weight **B** acting in the direction P D; so that the combined effect of these weights is nothing. The consequence is, that the point P is pulled in the direction P D only by the force E, or the excess of the greater weight B above the lesser weight A.

Hence we may, in general, infer, that

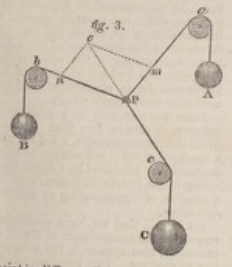
when a body is drawn in directions immediately opposite by two unequal forces, it is affected exactly in the same manner as if it were drawn by a single force equal to the difference between the two forces, and acting in the direction of the greater force.

(7.) This single force, whose action is equivalent to the combined action of two or more forces, is called their *resultant*; and the process by which a single force equivalent in its effect to two or more other forces is found, is called the *composition of force*.

(8.) On the other hand, two or more forces may be found whose combined effects are equivalent to that of a single given force; the process by which these are determined is called *the resolution of force*; and the two or more forces which are equivalent to the single force, are called its *components*.

(9.) Having considered the simpler instance in which the directions of the forces are in the same straight line, let us now examine the more complex case in which two forces act on the same

fig. 3.



point in different directions. Let P (*fig.* 3.) be a fixed point to which three strings are attached; and let the strings P *a* and P *b* be passed over fixed grooved wheels as before, and let any weights A and B be suspended from them. The point P is now drawn by two forces A and B, in the directions P *a* and P *b*. The question is, what single force would produce the same effect upon it? Take lengths P *m* and P *n* on the strings, so that they shall be in the same proportion as the weights A and B, that is, so that P *m* : P *n* : : A : B; and upon the board to which the wheels *a*, *b* are supposed to be attached, draw the parallelogram P *m o n*. Draw the diagonal P *o*. A single force acting in the direction of the diagonal P *o*, and having the same ratio to the weight A or B as the diagonal P *o* has to the side P *m* or P *n* of the parallelogram, will produce the same pressure on the point P as the combined actions of A and B produced. To prove this, let a third wheel *c* be so placed that the thread P *c* shall, when stretched over it, be in a direction immediately opposite to P *o*, and suspend from it a weight C which shall have the same proportion to A or B as the diagonal P *o* has to P *m* or P *n*. If the point P, hitherto supposed to be fixed, be disengaged and left free to move, it will be found to maintain its position and remain at rest. Hence it follows, that the weight C neutralises the effects of A and B, and keeps them in equilibrium. But it would also keep in equilibrium a force equal to C in the direction P *o* (5.); from whence it follows, that a force equal to C in the direction P *o* is equivalent to the united actions of the forces A and B, in the directions P *m* and P *n*. Hence we derive the following important theorem:*—

If two forces acting on the same point in the directions of the sides of a parallelogram be proportional in their intensities to these sides, their united effects will be equivalent to that of a single force acting on the same point in the direction of the diagonal of that parallelogram, and whose intensity is proportional to the diagonal.

This single force in the direction of the diagonal is therefore their resultant.

(10.) It will very easily appear that two forces have but one resultant; for, if the force C be in the least degree altered, either in its magnitude or in its direction, the point P, when disengaged, will no longer maintain its position, but will move until it settles into such a position that the magnitudes of the diagonal and sides of the corresponding parallelogram shall be proportional to those of the forces A B C.

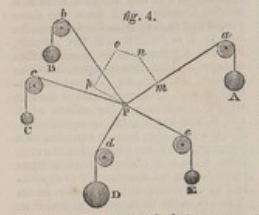
(11.) We can now extend our investigation to the combined action of three or more forces on the same point. Let P, (*fig.* 4.) as before, be a fixed point to which several strings are attached, and

* This theorem admits of rigorous demonstration independently of the experimental proof which we have given. The demonstration is, however, of too complex a character, and requiring the aid of mathematical reasoning of a kind which we cannot properly introduce here.

passing these strings over wheels *a b c d*, let weights A B C D be suspended from them.

Take any part P *m* on the string P *a*, and from *m* on the board to which the apparatus is attached, draw a line parallel to the string P *b*, and take a part *m n* upon that parallel, such that P *m* : *m n* :: A : B. Again, through *n* draw a parallel to the string P *c*, and on that parallel take a part *n o*, such that *m n* : *n o* :: B : C. In like manner draw *o p*

fig. 4.



parallel to P *d*, and such that *n o* : *o p* :: C : D. Finally, join the points *p* and P by a right line. A single force, acting in the direction of the line P *p*, and having the same ratio to each of the other forces as the line P *p* has to the side of the polygon, which is parallel to that other force, will produce a pressure on the fixed point P equivalent to the combined actions of the forces A B C D. This may be established by the same means as were used in the former case. Let a string, attached to the fixed point P, be carried over a wheel *e*, so that the string P *e* shall be the continuation of the line *p* P, and let a weight E be suspended from it which shall have the same proportion to the weights A B C D, as the side P *p* has to the sides of the polygon parallel to the strings respectively. If the point P be then disengaged from the board, it will be found to maintain its position, and remain at rest; so that the force E in the direction P *e*, immediately opposite to P *p*, counteracts the combined effects of the forces A B C D; and it would also counteract the effect of a force equal to E, in the direction of the line P *p* (5.) Hence such a force is equivalent to the combined effects of A B C D, and is therefore their resultant. From whence we infer the following general theorem:—

If several forces act on the same point parallel and proportional to all the sides of a polygon taken in order except one, a single force proportional to, and in the direction of, that one side will be their resultant.

It may be proved that this is the only resultant, in the same manner as in the former case; for if either the direction of the string P *e*, or the magnitude of the weight E, or both, be in any way changed, the point P, when disengaged, will no longer maintain its position, but will move until it settles into that position in which the sides of the corresponding polygon are proportional to the weights suspended from the strings to which they are parallel.

(12.) Hitherto we have supposed that the forces applied to the point are in the same plane. This, however, is not at all necessary, and the same principles exactly will apply when the forces act in different planes.

(13.) It must be evident from the reasoning in the preceding articles, that if any number of forces acting on a point, be proportional to the sides of a polygon which are severally parallel to the direction of the forces, and that the forces are in the directions of the sides, taken successively in the same order, the point will be kept at rest, and the forces will be in equilibrium, and will neutralise each other's effects.

Since any one side of a triangle or polygon is always less than the sum of all the remaining sides, it follows that a mechanical effect will always be more economically produced by a single force acting in the proper direction, than by a number of forces acting in different directions.

(14.) All that we have established respecting the composition of forces or pressures, also applies to the composition of motions. Two impulses, which, separately communicated, will cause a body to move over the sides of a parallelogram in the same time, would, if communicated at the same instant, cause the body to move over the diagonal of the parallelogram in that time. This may be submitted to actual experiment.

Let a level table, A B C D (*fig.* 5.), in the form of a parallelogram, be provided, furnished with a ledge to prevent a ball from rolling off; and let two spring guns, G G′, be placed at one of the corners A, so that when G strikes the ball X, it shall move along the side A B in a certain

time, and that when G′ strikes the ball it shall move along A D in the same time. Now, if both the guns strike X at the same instant, it will be found to move along the diagonal, and to do so

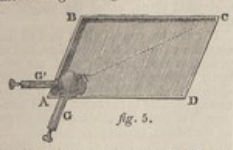


fig. 5.

exactly in the same time as, by the impulse of each gun separately it moved along the sides. In order that the ball X should move along the sides A B and A D in the same time, it is necessary that the force of the springs should be proportional to the lengths of the sides. In constructing such a table it is usual to make it square, and, therefore, to make the springs of equal force.

In like manner, if several impulses, which, communicated separately to a body, would make it move parallel to the several sides of a polygon taken in order, the last side alone excepted, and with velocities proportional to those sides, be communicated to it at the same instant, it will move in the direction of the last side, with a velocity proportional to that side.

There are numerous effects, familiar to every one, which are examples of the composition and resolution of motion. If, in walking along one side of a street, we desire to reach a distant point at the opposite side; the direct method would be to pass in a straight line to the point, moving diagonally across the street; but wishing to be for as short a space as possible off the foot-path, we first pass across the street in a direction perpendicular to the foot-path, and then pass down the opposite side to the desired point. This is, in fact, nothing more than a resolution of the diagonal motion first mentioned into its two components, viz. the sides of the parallelogram.

Again, if a boat be rowed directly across a river, when there is no current, it will pass over in a straight line, perpendicular to the banks. But, if there be a current, the boat will be carried by the current parallel to the banks, while it is impelled by the oars in a direction perpendicular to the banks: the consequence will be, that it will pass across in a diagonal direction, arriving at the other bank not at the point immediately opposite to where it started, but at a point considerably below it: it moves, in fact, in the diagonal of a parallelogram, one side of which is a straight line drawn across the river from the point where it started perpendicular to the banks; and the other side is so much of the bank itself measured from the point where it started as the current moved with the boat down the river in the time taken to cross it. This, therefore, is an example of the composition of motion, as the former was of its resolution.

The facility with which many of the feats of horsemanship exhibited in the circus are performed may be accounted for on this principle. When the man and horse are moving with great speed, it sometimes excites surprise, that when the man leaps directly upward, the horse does not pass from under him, and that he does not, in descending, alight upon the ground perpendicularly under the point at which he sprang from the saddle. But it should be considered, that, on leaving the saddle, the body of the rider has the same velocity as that of the horse: the spring which he takes perpendicularly upward in no degree diminishes this velocity; so that, while he is ascending from the saddle, he is still advancing with the same speed as the horse, and continues so advancing until his return to the saddle. In this case, the body of the rider describes the diagonal of a parallelogram, one side of which is in the direction of the horse's motion, and the other perpendicularly upward, in the direction in which he makes the leap.

In the common feat of jumping through a hoop, and alighting again on the saddle, an inexperienced rider would be likely to project his body forward in the same manner as he would do in leaping through the same hoop from the ground. In such a case, instead of alighting on the saddle, he would alight either before the horse or on his head or neck; for he would, in fact, then advance forward more rapidly than the horse, his body having, besides the speed of the horse, in which it always partakes, the additional speed derived from the muscular exertion by which the rider projects his body forward. All that is requisite to execute this feat is, to leap directly up-

wards from the saddle, to a sufficient height to clear the lower part of the hoop with the feet. By the speed which the rider has in common with the horse, his body will, without any exertion on his part, pass through the hoop, and he will alight again in the saddle, on the other side, in his descent. These are striking instances of the composition of motion.

Chapter III.—*On the Force of Gravity.*

(15.) Although the force of gravity cannot be considered, properly speaking, as itself a first mover or mechanical agent, yet it is the means of producing and giving effect to so extensive a class of first movers, that it becomes necessary to explain the laws which regulate its action, in order to render the agency of some of the principal first movers intelligible.

The earth which we inhabit is a mass of matter, nearly, but not exactly, of a globular form, the diameter being about 8000 miles in length. This enormous mass possesses the property of attracting towards its centre all smaller bodies placed near its surface; so that if they be perfectly free to move and opposed by no obstacle, they will move in straight lines towards the centre of the globe, and will continue so to move until they reach the surface. If the part of the surface which they meet be solid, or even a liquid specifically heavier than the descending bodies, their further approach to the centre will be obstructed; but in that case the attraction towards the centre will be manifested by the force with which the bodies press upon the resisting surface. If the bodies thus supposed to have met the surface in their approach towards the centre happen to meet a liquid, as the sea, and be specifically heavier than it, they will still continue to approach the centre, moving through the liquid until, in fine, they be stopped either by a liquid heavier than themselves or a hard surface. All lines which are drawn from points without a globe to its centre are evidently perpendicular to its surface; and hence bodies, in moving towards the centre of the earth, attracted by its influence, move perpendicularly to its surface; and when their progress is obstructed by that surface they press on it perpendicularly with a force equal to that with which they are attracted towards the centre.

This attraction which the earth exerts upon all bodies placed near its surface is called *terrestrial gravity*: and the force with which any body drawn towards the centre is pressed upon an horizontal plane, called the *weight* of that body.

It must be very obvious that all the common effects of falling bodies, and of pressures produced by weight, are perfectly accounted for in the preceding observations. This attraction is by no means peculiar to the earth, but is common to all material substances, whatever be their form, quantity, or position. In this respect the force of gravity differs from magnetism, and other attractions which are only resident in substances of particular species. If the earth were a large magnet, those peculiar substances only which are affected by the loadstone would have weight, or would fall to the surface when unsupported. All other bodies would rest indifferently in any position in which they might happen to be placed, and would move upwards just as readily as downwards. But every material substance is susceptible of the attraction of gravity, and what is more, it is susceptible of this in the exact proportion of its mass. Thus, if the mass of the earth were doubled, it would exert a double attraction on all bodies placed near it, and consequently the weights of all bodies would in that case be doubled. If its mass were tripled, the weights of all bodies would be tripled, and so on. In general, therefore, the attraction which the earth exerts on a body in its vicinity is proportional to its mass.

We have stated that gravity is an attraction common to all material substances; if so, then it may be asked why do not the various bodies placed near the earth's surface attract the earth towards them? If a body be disengaged at any height from the surface, it will be drawn by the attraction of the earth, and will consequently descend in a straight line perpendicular to the surface; but since the body attracts the earth, why does not the surface *ascend* towards the body, being drawn by the attraction of the body on the earth; in which case, the surface of the earth and the body would meet at some place intermediate between their first positions? We answer that, in fact, this very effect takes place. The surface of the earth *does* approach the descending body, and that descending body not only

attracts the mass of the earth towards it, but attracts it with exactly as much force as that by which the earth attracts the descending body. Why then, it will be asked, is not the rapid approach of the earth to meet the descending body perceptible? To explain this we must go into some details.

(16.) If two bodies A and B be moving with the same velocity, the forces with which they move will be equal provided their masses or quantities of matter be equal, but not otherwise. If the mass of A be greater than the mass of B its force will be greater in the same proportion. This will be very evident if we consider the forces with which they would strike any obstacle opposed to them. If B be a musket-ball and A be a cannon-ball of one hundred times the weight, both being projected with the same speed, A will strike any obstacle with one hundred times the force with which B would strike it. In general, then, "when the velocities with which bodies are moved are the same, their forces are proportional to their masses or quantities of matter."

Now, let us suppose that the masses of the bodies A and B are equal, but that they move with unequal velocities; that is, that they move through different spaces in the same time. Let the space described in one second by the body A be a, and let the space described in the same time by the body B be b; these spaces are called the velocities of the bodies. The equal bodies thus moving with different velocities will move with different forces. It is evident that the body which has the greater velocity will have the greater force; and that also in the same proportion as its velocity is greater. If two equal bullets be successively projected from the same gun, but with different charges of powder, that which is projected by the stronger charge will strike the mark with a proportionally greater force. But in this case the only difference in the motions of the bullets is, that one has a greater velocity than the other. Hence we perceive that "when equal masses are in motion their forces are proportional to their velocities."

(17.) We have thus separately considered the cases in which unequal masses are moved with equal velocities, and in which equal masses are moved unequal velocities; and we have seen that the forces are, in the one case, proportional to the masses, and in the other, to the velocities. Now, if unequal masses be moved with unequal velocities, it is natural to expect that we should, in comparing the forces, take into account both the velocities and the masses. It appears that the moving force of a body may be increased or diminished by increasing or diminishing either its mass, or its velocity, or both. In fact, if the number representing the mass be multiplied by the number representing the velocity, the product thus obtained will represent the moving force. Thus, if the masses of two bodies A and B be in the ratio of the numbers 8 and 5, and the velocities of these bodies be in the ratio of the numbers 7 and 3, their moving forces are as the product of 8 and 7 to the product of 5 and 3, that is, as 56 to 15. It appears, therefore, that in this instance the force of A bears a much higher ratio to the force of B than either the mass of A bears to the mass of B, or the velocity of A to the velocity of B; the reason of which is, that the mass and velocity conspire in imparting to A a superior moving force. In general, then, we conclude, "that the moving forces of bodies are proportional to the products of their masses and their velocities."

(18.) Since then the moving force of a body depends conjointly on its mass and its velocity, it necessarily follows that if, while we increase its velocity in any proportion, we diminish its mass in the same proportion, its moving force will be the same; for it will lose as much force by the diminution of its mass as it gains by the increase of its velocity. In like manner, if, while we increase its mass, we diminish, in the same proportion, its velocity, the moving force will be unaltered; for as much will be lost by the diminished velocity as will be gained by the increased mass.

(19.) The several theorems which we have just expressed, relative to the forces of bodies in motion, do not rest entirely upon reasoning, but may very easily be submitted to the test of actual experiment.

Let two strings be attached to the centre C of a graduated arch X Y; and let two balls A B, formed of clay or any other inelastic substance, be suspended so as to hang in contact at the middle of the arch. Let us first suppose that the balls are equal: if they be separated, moved from the middle of the arch in opposite directions towards its extremities, and permitted to descend from

any distance to the lowest point 0, they will, when they meet there, have velocities proportional to the arches through which they have descended.* Now, if the equal balls be permitted to descend through equal arches, they will, therefore, impinge each upon the other with equal velocities; and they will be found, after impact, to remain quiescent, each having destroyed the force of the other. This proves that, when equal masses have equal velocities, they have equal forces; for if their forces were not equal in this case, the united masses would, after impact, move in the direction of that which had the greater force.

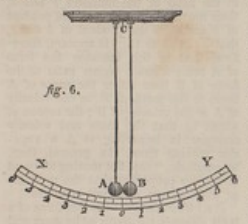


fig. 6.

(20.) Now suppose that the ball A (*fig.* 6.) is double the weight of the ball B; let A be raised towards X to the division 3, and let B be raised towards Y to the division 6; when allowed to descend from those positions their velocities will be as 3 to 6, but their masses are as 2 to 1, and therefore their forces ought to be as 2×3 to 1×6; that is, as 6 to 6, or equal. We accordingly find, that after impact they will be quiescent; the equal and opposite forces having destroyed each other. In like manner, if balls, whose weights are as 2 to 3, fall from distances which are as 6 and 4, their forces being as 2×6 to 3×4, or as 12 to 12, will be equal, and after impact the united masses will be quiescent.

In the same manner, however the experiment may be varied, it will be found that the product of the numbers representing the mass and velocity always truly represents the moving force.

(21.) To return, then, to the case of the earth and a body near its surface, they attract each other with equal forces; and, therefore, in their consequent approach to each other, the earth must have a velocity as many times less than that of the falling body, as the mass of the earth is greater than that of the falling body. Since all bodies which can be submitted to these circumstances must be infinitely smaller than the earth, the space through which the earth approaches them in their fall must be infinitely smaller than the space which they fall through.

To take a very improbable and extreme case: suppose a ball of earth of a diameter equal to the tenth part of a mile were to be placed at an height above the surface equal to the tenth part of a mile; let us consider what space the earth would move through to meet it. The earth's diameter being about 8000 miles, and spheres being as the cubes of their diameters, the mass of the earth would have to the mass of the ball the ratio of 512,000,000,000,000 to 1; consequently, if the tenth part of a mile were divided into 512 millions of millions of equal parts, one of these parts would be pretty nearly the space through which the earth would move towards the falling body. In the tenth part of a mile there are somewhat less than 6400 inches: if this were divided into 512 millions of millions of parts, each part would be the eighty millionth part of an inch; it is therefore through a space less than this that the earth would move, under the circumstances which we have supposed.

It is, therefore, quite evident that, with respect to falling bodies, the earth is to be considered at rest.

(22.) We have stated that bodies attract each other in proportion to their quantities of matter. Hence the earth attracts different bodies with different forces. A piece of lead contains a considerably greater quantity of matter in the same bulk than a piece of cork, and accordingly we find that the earth attracts it with a proportionally greater force; in other words, it has greater weight. It is for this reason that *weight* is justly assumed as the measure, or exponent of the quantity of matter in any substance, whatever, in other respects, be the species or qualities of that substance.

(23.) But it is not *alone* the masses of bodies which determine their mutual attractions. Their distances from each other affect this force. It is found that the force of attraction decreases as the distance is increased, but in a still greater proportion. Thus, for example, a body placed upon the surface of the earth, at the distance of 4000 miles from its centre, is attracted with a certain force towards that centre. At double that distance, or at 4000 above the surface, it would be only attracted with the fourth part of that force, and it would, in fact, lose three-fourths of its weight.

We shall not, however, pursue this investigation further, since it more properly belongs to another department of the science. The motions to which we shall have to call the attention of the student, all take place upon the surface of the earth, or so near it that the change in the intensity of the force of gravity arising from the difference of distance is altogether insignificant. We shall, therefore, consider gravity as an uniform force, that is, as an attraction which affects the same body in the same degree, whatever its position may be, and which affects equal bodies equally.

(24.) The earth being globular, or nearly so, it follows, that the lines in which its attraction acts converge towards its centre, and that at different parts of the earth the lines in which falling bodies descend are not parallel, but are such as, if continued, would intersect at the centre. In considering, however, the action of gravity on bodies, at places not far distant on the surface of the earth; we may assume, without sensible error, that the directions in which it acts are parallel, and that they are all perpendicular to the same horizontal plane. A distance so great as one mile will only produce a deviation from parallelism amounting to less than one minute, or the sixtieth part of a degree.

(25.) If a body be put in motion by an impulse, the consequence would be, that it would continually move in the direction of that impulse, with the same uniform velocity with which it commenced its motion, provided that it were free from resistances, such as those of friction, air, &c. The force of gravity, or any other attraction, differs essentially from an impulse. An impulse acts instantaneously, and produces all its effect at once, and time does not change that effect. On the other hand, attraction, such as gravity, requires *time* to produce any effect at all, and the effect produced increases exactly in the same ratio as the time of producing it. When a body, suspended at any height above the surface of the earth, is first disengaged, it commences to move with an infinitely small velocity, but, by the continual action of the attraction of the earth, that velocity is increased, and is constantly increasing during the descent of the body. This peculiar species of motion is therefore called *accelerated motion*, and the force which produces it is called an *accelerating force*.

(26.) To explain the uniformity of the attraction of the earth upon a falling body, let us suppose that, at the end of the first second of the fall, the body has received a certain velocity. At the end of the first two seconds it will be found to have received twice that velocity; at the end of the first three seconds, three times that velocity, and so on, the velocity continually increasing, and in the same ratio, as the time from the commencement of the descent increases.

There will, therefore, be no difficulty in calculating arithmetically the velocity which a falling body will acquire in any time from the commencement of its fall. Let g express the velocity which it would acquire in one second, and let T be the number of seconds from the commencement of its fall, and V be the velocity acquired. From what we have stated, it must be evident that V is as many times g as there are seconds in T. Hence, expressing this algebraically, we have $V = g\,T$.

(27.) We have stated that the earth's attraction acts on all bodies in proportion to their quantities of matter; in fact, it would seem that it impressed a separate force upon each particle of a body, and equal forces on all the particles. Thus, if it impress a certain force on a solid body, that force is made up of the forces which it impresses on all its several parts, so that if the solid body be broken into small pieces, each piece will be attracted as strongly by gravity as it was when united in one solid mass with the other pieces. From this a very remarkable, and, apparently, false consequence follows: viz. that all bodies whatever, large and small, heavy and light, must descend with the same speed. We know, however, that under ordinary circumstances, a feather and a piece of gold will not fall with the same speed; and we know further, that some bodies, an inflated balloon for example, will, instead of falling, actually rise.

* Strictly, the velocities are as the chords of the arches; but as the arches used in this case are small compared with the radius, they may be considered to be nearly proportional to their chords. It is another property of this apparatus, that, from whatever distance from the middle of the arch the balls fall, they will arrive at the middle in the same time. This, however, like the property just mentioned, is only true when the arches used are small compared with the radius.

These examples appear to contradict the conclusion to which our reasoning has conducted us, but they *only* appear to do so. It is perfectly true, that gravity, as far as its attraction is concerned, accelerates the descent of all bodies equally; but when bodies fall under ordinary circumstances, another force opposed to gravity is produced, which is the resistance of the air on the surface of the descending body. Now this resistance, unlike the force of gravity, is *not* proportional to the weight or quantity of matter in the body, but depends on the surface which the body happens to oppose to the air. A feather exposes, in proportion to its weight, a much greater surface to the air than a piece of gold does, and therefore suffers a much greater resistance to its descent. That it is the weight of the air prevents the descent, and causes the ascent of the balloon, will be seen by reference to the sixth chapter of our treatise on Pneumatics, art. (51.)

(28.) It may, however, be satisfactory to establish, by immediate experiment, the theorem that gravity, acting independently of other forces, causes all bodies to descend with the same velocity.

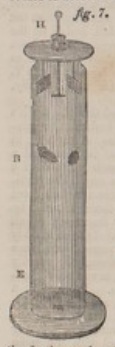


fig. 7.

On the plate E (*fig. 7.*) of the air pump, place a tall glass receiver R, open at the top. On the top place a brass cover, fitting it air-tight. Through this cover let a wire pass, air-tight also, and bearing a small stage, on which a feather and a piece of metal are placed, the stage being so contrived as to fall when the wire is turned by the hand at H. This being arranged, let the receiver be exhausted by the pump, which having been effected, turn the wire at H, so as to let the stage, on which the feather and metal are placed, fall. It will be found that the feather and metal strike the pump plate E at the same instant.* If we could construct a small balloon of materials strong enough to resist the elastic force of the gas, which would tend to burst it when placed in the exhausted receiver, we should find not only that it would not remain at the top, but that it would fall as rapidly as a piece of lead.

(29.) Having shown that the velocity acquired by a falling body is proportional to the time, it is natural to inquire whether any rule can be obtained by which we may compute the spaces through which a body will fall in any given time. Such a rule may be easily derived by mathematical reasoning from the rule already given for the velocity, but the reasoning cannot be properly introduced here.* The rule itself, however, is easily understood. If a falling body descend through a certain space in the first second of its fall, it will descend through four times that space in the first two seconds, nine times that space in the first three seconds, sixteen times that space in the first four seconds; and in general, to find the space it will fall through in any given number of seconds, multiply the space through which it falls in one second by the square† of the number of seconds in the time of the fall.

Thus if m be the space through which a body would fall in one second, $m\,T^2$ is the space through which it will fall in the number of seconds expressed by T; and if S be this space, we have $S = m\,T^2$. We, therefore, commonly say, that the spaces through which a body falls, are as the squares of the times from the beginning of its fall.

(30.) We shall find the space through which a body falls in the second *second* of its descent, by subtracting the space fallen through in the first second from that fallen through in the first two seconds. The former being expressed by m, the latter is $4\,m$ and the difference is $3\,m$. Again, the space it falls through in the third second will be found by subtracting the space described in the first two seconds which is $4\,m$, from that described in the first three seconds which is $9\,m$, and the difference $5\,m$ is the space described in the third second. In the same way we shall find that $7\,m$, $9\,m$, $11\,m$, &c. are the spaces which it

* This experiment is called the "guinea and feather experiment," a guinea having been commonly used for the piece of metal.

* Let S be the space described by the falling body. $V = \frac{ds}{dT} = g\,T$. Hence, $d\,S = g\,T\,d\,T$, which being integrated gives $S = \frac{1}{2}\,g\,.\,T^2$.

† The square of a number is the number found by multiplying the proposed number by itself, thus 2×2 or 4 is the square of 2, 3×3 or 9 is the square of three, and so on.

falls through in the fourth, fifth, sixth seconds, &c. respectively. The spaces, therefore, through which a body falls in the successive seconds, or any other equal portions of time, are as the odd integers, 1, 3, 5, 7, &c.

(31.) From these investigations it appears, that the calculation of the velocity which a falling body acquires in any given time, depends on that which it acquires in one second, which, therefore, it is absolutely necessary to know in order to be able to compute any other velocity. In like manner, in order to be able to compute the space through which a body will fall in any given time, it is necessary to know the space through which a body would fall in one second. The velocity acquired in one second, and the space fallen through in one second, are therefore the fundamental elements of the whole calculation, and are all that are necessary for the computation of the various circumstances attending the phenomena of falling bodies.

(32.) But even these two elements are not independent. If we knew either, we should immediately detect the other. This circumstance arises from a very remarkable relation which is found to subsist between the space through which a body falls in any time, and the velocity which it acquires in that time. If, after a body has fallen by the action of the force of gravity for any time, say one second, the action of the soliciting force were suddenly suspended, what would be the consequence? No further velocity would be communicated to the body, since the cause from which its constant accession of velocity proceeded is suspended; but, on the other hand, the body will not lose that velocity which it has already acquired. It will consequently continue to fall, but instead of descending with an accelerated motion, it will descend with the velocity which it has acquired, continued uniform through the whole of its descent, describing equal spaces in equal times. In this case, it will be found that the space through which it falls in each second after the first will be exactly equal to twice the space through which it fell in the first second by the force of gravity.* Now if the velocity be estimated by the space described uniformly in one second, it will follow that the velocity acquired in one second is equal to twice the space through which a body will fall freely by the action of gravity in one second. Thus the space which we have expressed by m is equal to half of that which we have expressed by g.

(33.) The two formulæ expressing algebraically the relation between the space, time, and the velocity acquired, become therefore $V = g\,T$, $S = \frac{1}{2}\,g\,T^2$, where g represents the velocity acquired in one second; or $V = 2\,m\,T$ $S = m\,T^2$, where m represents the space through which a body falls freely in one second.

The following TABLE exhibits the relation of the spaces, velocities, and times, conformably to the laws which we have just laid down. The space fallen through in the first second is taken as the unit of length:

Seconds from the beginning of the descent.	Velocity acquired at the end of that time.	Space fallen through in that time.	Space fallen through in the last second of the fall.
1	2	1	1
2	4	4	3
3	6	9	5
4	8	16	7
5	10	25	9
6	12	36	11
7	14	49	13
8	16	64	15

and, in the same manner, the table might be continued to any extent.

(34.) To submit the several laws which we have now explained, as governing the descent of heavy bodies, to direct experiment, would be attended with considerable difficulties. A body will fall, in a single second, through the height of about sixteen perpendicular feet.* In two seconds it will therefore fall through sixty-four feet; and in four seconds through about 256 feet. Thus if our experiments are limited to four seconds, it would be necessary that we should command an height of 256 feet. But further; in observing the velocity, considerable difficulty would arise from its magnitude. The velocity acquired in one second would be one of 32 feet per second; and, therefore, the velocity acquired in four

* By art. (26.) we found $V = g\,T$; and in note on art (29.) we obtained $S = \frac{1}{2}\,g\,T^2$. Eliminating g by these equations, we obtain $S = \frac{1}{2}\,V\,T$. But $V\,T$ is the space which would be described with the uniform velocity V in the time T, and is, therefore, twice the space S through which the body falls in the time T.

* Accurately 16 feet and one inch or 193.09 inches in the latitude of London.

seconds would be 128 feet per second, or 7680 feet per minute.

Independently of these difficulties, the resistance which the atmosphere would offer to such rapid motions, would be so considerable as to produce a great discordance between the effects observed, and the laws which have been laid down on the supposition that all resistances to the free descent of the body are removed.

(35.) Nevertheless, the truth of these laws can be established by the most rigorous experiments; and although the impediments to which we have just alluded cannot be directly removed, they may be evaded. It occurred to Mr. George Attwood, that, if a force of *the same kind* with the force of gravity, but of a much less intensity, could be obtained, the descent of bodies, actuated by such a force, while it would be regulated by the *same laws* as the descent of heavy bodies by the force of gravity, would be so slow that the resistance of the air would produce no sensible effect, and at the same time all the particulars of space, time, and velocity might be deliberately observed, and accurately measured. To realize this conception, he passed a fine silken thread over a groove in the edge of the rim of a wheel which turned freely on an horizontal axle, and from the ends of the thread he suspended equal weights. In this state, the weights were necessarily in equilibrium. To one of the weights he added a small quantity, so as to give it a slight preponderance. It consequently commenced to descend, causing the lighter weight to ascend. Setting aside the effects of the friction of the wheel on which the string connecting the weights rested, the descent of the weight was, in this case, one of uniform acceleration, similar exactly to the descent of a heavy body, but differing in this, that the acceleration might be rendered as slow as might be thought necessary for the purposes of convenient and accurate observation, by diminishing to any degree the preponderancy given to the heavier weight.

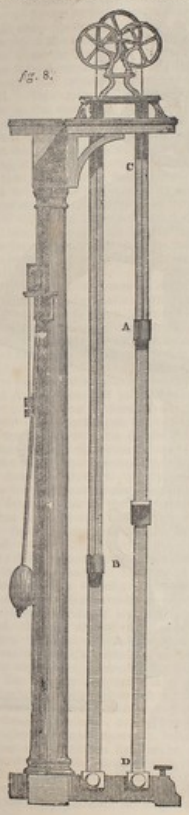
(36.) As we have stated that light and heavy bodies are equally accelerated by gravity, it might be supposed, that, since the equal weights first suspended from the thread counterpoise each other, the additional weight suspended from one end should descend with as great velocity as it would have by the immediate action of gravity. This, in fact, would be the case were the force which gravity exerts upon it wholly spent in producing its descent; but it should not be forgotten that the ascent of the weight at the opposite end of the thread is to be accomplished; and since the original weight placed upon the descending end is only sufficient to counterpoise it, it can have no share in raising it. Its elevation, therefore, is entirely effected by the force which gravity impresses on the additional weight placed at the descending end of the string; and all the force thus spent in drawing up the opposite weight is necessarily subtracted from the force with which the additional weight at the descending end falls. The additional weight has also to draw down the descending weight, and to give it as much moving force in its descent as it gives to the ascending weight in its ascent. Hence it follows, that the smaller this additional weight is in comparison with the equal weights originally suspended, the slower will be the rate of its descent.

It still remained, however, to remove the effects of the friction of the wheel, on which the thread connecting the weights turned. Mr. Attwood accomplished this, by an ingenious combination of wheels, called friction-wheels, by which the axle of the wheel carrying the thread, instead of turning in cylindrical holes, rested on the edges of other wheels, by which means, the friction against the inner surface of the holes in which the axle turned, was entirely avoided; and, if all friction was not removed, as far as it affected the motion of the weights, it was so far diminished as to produce no sensible effect upon the motion of the weights in the experiments for which the apparatus was used.

(37.) A representation of this beautiful and useful contrivance is given in *fig.* 8, (and on an enlarged scale in *fig.* 9,) *b c d* is the rim of the wheel over which the thread sustaining the weights passes. The ends of the axle of this wheel rest upon the rims of two pairs of wheels, as is represented in the figure, and already described. The stand carrying the apparatus is supported by a strong pillar, and immediately under this stand is placed an upright shaft C D, divided to inches, half inches, and tenths, for the purpose of measuring the rate of descent. A

and B are two equal cylindrical weights suspended from the ends of the thread,

fig. 8.



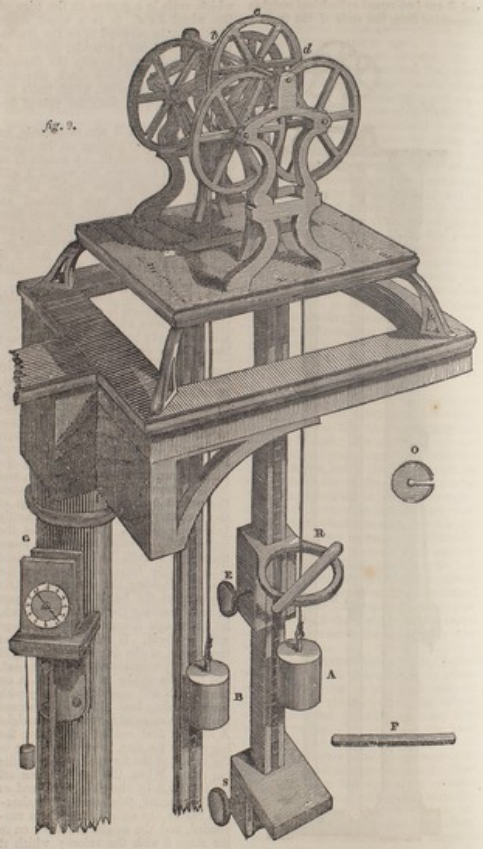
which rests in a groove on the edge of the wheel *b c d*. S is a small stage which can be screwed upon the graduated shaft, at any particular division at which it is designed to stop the descent of the weight. G is a clock, attached to the principal pillar, which beats seconds, in order to mark the rate of descent.

The weights A B are, commonly, so adjusted, that, by placing on the top of the cylindrical weight A a weight O of a quarter of an ounce, the weight A will descend through three inches in one second. Thus we have obtained an accelerating force, which is sixty-four times less than that of gravity, and yet which retains all the characteristic peculiarities of that force. In fact it is the force of gravity correctly represented in miniature.

(38.) We shall now show how this machine is applied to establish by experiment the laws which regulate the descent of heavy bodies and which have been already explained.

Ex. 1. To establish these laws by experiment, a ring R is provided, attached to a block E, which can be fixed by a screw to any division of the graduated shaft. A bar of metal *f* is also provided, weighing a quarter of an ounce, and longer than the diameter of the ring R. Let the ring R be fixed by the screw to any division of the scale, and let the stage S be so fixed, that when the weight A rests upon it, the top of the weight will be six inches exactly below the ring R. This done, let the weight A be elevated by drawing down the weight B until the top of the weight A is exactly three inches above the ring R. Holding the weight A in this position, let the bar F be placed upon it, and observing the beats of the clock, let the weight A commence its descent with any beat. It will be found that the stroke of the bar F on the ring R will exactly coincide with the next beat, and that the stroke of the weight A on the stage S will coincide precisely with the succeeding beat. It will be observed that the accelerated motion of the weight A for the first second, and before the bar strikes the ring, is entirely owing to the action of the force of gravity on the bar (36). When the bar is taken off the weight A by the ring at the end of the first second, this cause of acceleration ceases, the action of gravity is suspended, and the weight A moves on to the stage S with the velocity which it

fig. 9.



had acquired at R. Now we have seen that this velocity was such that it moved through six inches in one second.

Ex. 2. Again, let the stage be placed so that when the weight A rests upon it, the top of the weight will be twelve inches from the ring R, and let the weight B be depressed until the top of the weight A is twelve inches above the ring R. This done, let the bar F be placed on the weight A, and let that weight be disengaged at the moment of any beat of the clock; it will be observed that the stroke of the bar F upon the ring R will coincide exactly with the third beat, the descent through twelve inches being made in two seconds, and that the stroke of the weight A upon the stage S will coincide precisely with the fourth beat, the weight moving through the twelve inches below the ring with the velocity it has acquired in two seconds.

Ex. 3. Now let the stage S be once more removed, and placed so that, when the weight A stands upon it, the top of the weight will be eighteen inches below the ring R. Let the weight B be depressed until the top of the weight A is twenty-seven inches above the stage S. Let the bar F be then placed upon the weight A as before, and permitting the weight to commence its descent with the first beat of the pendulum, the bar will strike the ring R with the fourth beat, and the weight A will strike the stage S with the fifth beat. The weight, therefore, descends through twenty-seven inches with an accelerated motion in three seconds, and at the end of that time has acquired such a velocity, as to move through eighteen inches in a second.

(39.) Now let us review the results of these three experiments. By the first it appears, that the velocity acquired in one second is such as to make the weight A move at the rate of six inches per second. By the second experiment it appears, that the velocity acquired in two seconds is twelve inches per second; and by the third experiment it appears, that the velocity acquired in three seconds is eighteen inches per second. Thus the velocities acquired in one, two, and three seconds, are as six, twelve, and eighteen, which numbers are as one, two, and three. Hence the law before explained, that "the velocities acquired are as the time of acquiring them," is verified.

In the first experiment the weight fell through three inches in one second; in the second experiment it fell through twelve inches in two seconds, and in the third it fell through twenty-seven inches in three seconds. Now the numbers three, twelve, and twenty-seven are as one, four and nine, which are the squares of one, two, and three. Hence the law already explained, that "the spaces fallen through are proportional to the squares of the times," is verified.

In the first experiment it was shown that the velocity acquired in falling through three inches, was such as would carry the weight in the same time through six inches when continued uniform and without further increase. In the second experiment it was shown that with the velocity acquired in falling through twelve inches in two seconds, the weight A would move through twelve inches in one second, and it would, therefore, move through twenty-four inches in two seconds. In like manner, in the third experiment, it appeared that with the velocity acquired in falling through twenty-seven inches in three seconds, the weight A moved through eighteen inches in one second; and, therefore, would move through fifty-four inches in three seconds. Each of these experiments, therefore, verifies the law, that, " with the velocity which a body acquires in any time, it would, if that velocity were continued uniform, move through twice that space in the same time."

Also by the first experiment it appeared that the space fallen through in the first *second* of the descent was three inches. By the second experiment it appeared, that the space fallen through in the first two seconds was twelve inches. It consequently follows, that the space fallen through in the second *second* must have been nine inches. By the third experiment the space fallen through in three seconds was twenty-seven inches. Taking from this the space fallen through in the first two seconds, which is twelve inches, the remainder, fifteen inches, is the space fallen through in the third second. Thus the spaces described in the first, second, and third seconds of the fall are three, nine, and fifteen inches respectively, which are as the numbers one, three, and five. This verifies the law before explained, that " the spaces described by a falling body in the successive equal intervals are as the odd integers."

Since the heights from which bodies

fall are proportional to the squares of the times of the fall (29.), and the times themselves are proportional to the velocities (26.), it follows that the heights are proportional to the squares of the velocities. That a body may acquire a double velocity, it is requisite that it should fall from a fourfold height, and so on.

Chapter IV.—*On the Centre of Gravity.*

(40.) We have stated that, at a given place upon the surface of the earth, the force of gravity acts on all bodies in lines which are parallel to each other, and perpendicular to an horizontal, or level plane. When it acts upon a single body, it does not act, as it were, by a single effort, but impresses a separate force upon each particle of the body; and its total effect is composed of the sum of all its effects thus produced upon the particles. Now there is in the body a certain point, at which, if the attraction of gravity impressed a single force, equal in intensity to the sum of all its separate actions on the component parts of the body, the ultimate effect would be the same as it is under the system of separate action which really obtains. This point, the existence of which we shall prove experimentally, is called the *centre of gravity*.

(41.) If the attraction of gravity were confined in its action to one particular point, there are certain effects which would very evidently ensue.

First, if that point were supported or fixed, the body would rest in any position whatever in which it should be placed. For the only cause which we suppose to affect it so as to produce motion, acts upon a point which we suppose fixed.

Secondly. If the body be perfectly free to move, the point on which the attraction acts will commence to move in the direction of that attraction, and in this case will, therefore, commence to move in a line perpendicular to an horizontal plane.

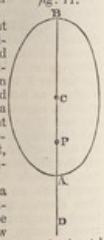
Thirdly. If the body be suspended by any point different from that at which alone the attraction of gravity is supposed to act, it will only remain at rest in two positions, viz. when the attracted point is immediately under or immediately over the point of suspension. If the attracted point be in any other position, the body will move round the point of suspension, all its parts describing circles round that point, until the attracted point settles directly under the point of suspension.

These effects will be evident from a little consideration. Let A B be the body, and P the point at which it is suspended, and round which it is capable of moving. Let C be the point at which the whole attraction of gravity is supposed to act.—First, suppose this point to be placed in a line P D, vertically under the fixed point P. The attraction then acting in the direction of the line C D, will only produce a *pull* on the point P, which will resist it, and no motion will ensue.

fig. 10.



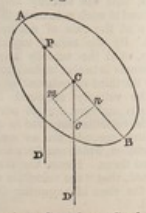
fig. 11.



Next, let the point C be in a line vertically *above* the fixed point P. The whole attraction will now act in the direction C D, and will therefore produce a *pressure* on the point P, which will be resisted by that point, and no motion will ensue.

Lastly, let C be in a position neither directly *above* nor *below* the fixed point P. Draw C D′ perpendicular to an horizontal plane, and parallel to C D, and taking

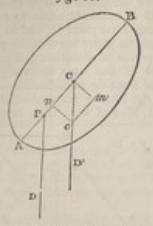
fig. 12.



any portion C o from C, draw the parallelogram C *n o m*, the sides *n o* and *m* C being perpendicular to P C B.

By (9.) it appears, that if C *o*, (*fig.* 13), be taken to represent the whole attraction on the point C, it is equivalent

fig. 13.



to two separate attractions represented in intensity and direction by the lines C *n* and C *m*, and its effect is the same as the united effects of these two would be. Now it is obvious, that a force acting from C, in the direction C *n*, would have no effect in producing motion, but would be resisted by the fixed point P, against which it would press, while the other force C *m*, perpendicular to C P, would tend to turn the body round C P, so as to bring the point C to the line P D, directly below the point of suspension P, in which position, after some oscillations, it would rest.

(42.) From this investigation, it follows, that if the parallel actions of the force of gravity on the particles of a body be capable of being represented by an equivalent force, acting at a single point, that point may be determined by the properties which we have just explained. Let a body which is bounded by two parallel planes, be suspended from any point taken at pleasure in it. It will be found that there is but one position in which it will hang steadily at rest, and without swinging. To the point of suspension let a plumb line be attached, and let the line in which it touches the plane surface of the suspended body be marked. Let the body be now suspended from some other point in its plane surface, and let another line be drawn upon it in the direction of the plumb line. This process being applied to any number of different points in the surface of the body, and a number of such lines being drawn upon it in the direction of the plumb line, it will be found that all these lines will intersect each other in the same point. It follows, therefore, that this point has the property mentioned in (41.), of settling itself vertically under the point of suspension when the body is in equilibrium.

Next let the point thus determined be made the point of suspension, and it will be found that the body will rest in any position in which it may be placed, and that it will not, under any circumstances, vibrate or swing.

Again, let the body be suspended by any point different from that which we have here determined, and let it be so placed that this point shall be placed vertically over the point of suspension. It will be found that the body will remain in equilibrium so long as its position is not changed; but upon the least impulse which moves the point in question from its position, it will turn round the point of suspension, and settle, after some vibrations, into the position directly under the point of suspension.

The point, the existence and properties of which are thus established, is then the *centre of gravity*.

In the preceding experiment, we have selected a body bounded by parallel planes, for the purpose of simplifying the experimental process. Strictly speaking, the centre of gravity is not at the intersection of the lines determined by the plumb line on the plane surface, but, if a line be drawn perpendicular to the plane surface through the body, it will be at the middle point of this line.

If we could conveniently pierce the dimensions of a body by straight lines, the centre of gravity of any body, whatever be its figure, could be found experimentally by the same process. If it be successively suspended by several points, and pierced by straight lines, in each case passing in a vertical direction through the point of suspension, it would be found that, however numerous these lines might be, they would all intersect in one point, which would be the centre of gravity of the body.

(43.) By these properties of the *centre of gravity*, mechanical problems respecting the effects of the weights of bodies are susceptible of considerable simplification; for, instead of taking into consideration the separate effects of the attraction of gravitation on the several particles of which a body is composed, it will be

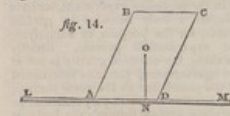
sufficient to consider a single force equal to the sum of all these separate attractions, drawing the centre of gravity in a line perpendicular to an horizontal plane, which line is called the *line of direction*. In this line the centre of gravity will always either move, or endeavour to move, and *it will always assume the lowest position which the circumstances under which the body is situated will admit of*.

(44.) If by the application of external force a body be so adjusted, that the centre of gravity be placed in the *highest* position which the circumstances under which the body is situated permit, the body will remain at rest so long as it be perfectly undisturbed; but, as in the case of suspension already mentioned, the slightest disturbance will cause the centre of gravity to descend to the lowest position. Of these two positions in which it is possible for the body to rest, the former is called *instable*, and the latter *stable*, equilibrium.

(45.) If a body be placed upon a plane, its stability will be determined by the position of the *line of direction* with respect to the base.

Let A B C D (*fig.* 14.) be a body resting on the level plane L M. Let O be

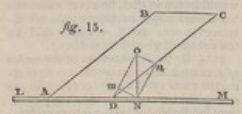
fig. 14.



its centre of gravity, and O N the line of direction falling within the base A D. Since the whole force which gravity exerts upon the body may be conceived to be applied at O, in the direction O N, that force will be supported or resisted by the plane L M, and the body will stand firm.

But if the line of direction O N (*fig.* 15.) fall *without* the base A D, the case will

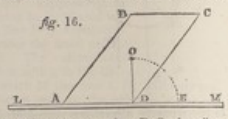
fig. 15.



be different. The force of gravity will now act upon the body, so as to make it turn over the edge D, and fall upon the side D C. For draw O D, and from N draw N *m* perpendicular to D O, and complete the parallelogram N *m* O *n*. The diagonal N O being taken to represent the whole force of gravity, it may be resolved (9.) into two forces, represented by O *m* and O *n*. The force O *m* is resisted by the plane L M at D, and the force O *n* evidently tends to turn the body round the point D, and to make it fall upon the plane towards the point M.

If the line of direction fall upon the edge D of the base, the body is in a state of instable equilibrium. For let O D (*fig.* 16.) be perpendicular to the plane L M, and with D as centre, and

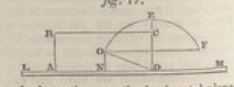
fig. 16.



the distance or radius D O, describe a quadrant of a circle. It is evident that if the point O be moved towards M, it will move through a part of the circular arc O E, and every part of this arc is nearer to D M than O, and, therefore, the point O must descend. The slightest disturbance in this case will make the body fall towards M.

(46.) In general, the higher the centre of gravity of a body is, compared with the extent of its base, the more easily will it be overturned. This will be easily explained. Let A B C D, (*fig.* 17.) be

fig. 17.

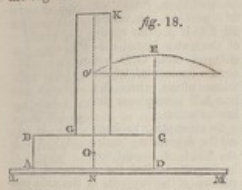


a body resting on the horizontal plane L M, and on the base A D. Let O be the centre of gravity, and O N the line of direction. Draw O D, and with D as centre, and the radius D O, let the circular arch O F be described. In order that the body A B C D should turn over the edge D, it will be necessary that the edge A be lifted off the plane L M to such an height, that the point O shall be raised through the arch O E, beyond the point E.

Now let us suppose that, by placing a load G K, (*fig.* 18.) over A B C D, the centre of gravity be raised from O to O′, it will be only necessary to raise the

centre of gravity O′ through the arch O′ E, in order to turn the body over the edge D.

fig. 18.



It is evident that a much less elevation of the edge A will effect this, than that which would be necessary to raise the centre O through the arch O E in the former case.

The danger of loading carriages heavily at the top, when the lower parts of the vehicle are comparatively unloaded, is accounted for in this way, and also the danger arising from persons standing up in a boat. In these cases, the centre of gravity is raised, and the facility with which the vehicle may be overturned is proportionally increased.

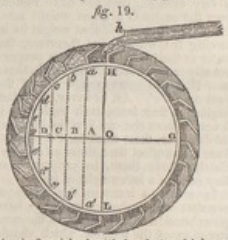
If it be attempted to support a body upon a sharp point, considerable difficulty will be felt owing to the practical impossibility of keeping the centre of gravity of the body vertically over the point on which it is sustained. If, however, a motion of rotation be communicated to the body, and it be made to spin on the point, it will be found to be balanced with comparative ease. In this case, the centre of gravity in each revolution of the body assumes every possible position round the point, and has an equal tendency to make the body incline in all directions round it. Consequently, its tendency to make the body incline in any one direction, is after half a revolution counteracted by an equal tendency to make it incline in the opposite direction; and provided the motion of rotation be sufficiently rapid, these opposite tendencies follow in such quick succession, that they counteract each other as effectually as if they acted simultaneously.

Chapter V.—*On Water considered as a Mechanical Agent.*

(47.) When water descends from any level to a lower one, its weight during the descent may be used as a mechanical agent. That this may be possible, it is only necessary that there should be a sufficient supply of water at the superior level, and that there should be means of carrying it off after its descent, so as to prevent, by its accumulation, the equalization of the two levels. The most usual means of giving motion to machinery by this power is a wheel, on the circumference of which the weight of the water is made to act in its descent, in a direction as nearly as possible at right angles to the radii; this pressure, however, acting only at one side of the wheel. Wheels driven by this power are of two kinds, the *overshot wheel* and the *breast-wheel*.

The diameter of an overshot wheel is nearly equal to the difference of the levels of the water by which it is moved. A section of such a wheel at right angles to its axle is represented in *fig.* 19. The

fig. 19.



rim is furnished with buckets which receive the water as it descends from the superior level *h*. The buckets from the top H of the wheel to the end F of the horizontal diameter F G are constantly full of water, while those from F to a point *a*′, where the side of the bucket becomes level or horizontal, are only partially filled; those from *a*′ to the lowest point L being empty. It is evident that the buckets on the other side, G, of the vertical diameter H L, will be all empty.

In this state the wheel will be turned round by the weight of the water in the buckets, since that weight acts entirely on one side, H F L, of the wheel, and is not counterpoised by an equal weight on the other side; and the wheel will continue to be turned so long as a supply of water suf-

ficient for the purpose is received from the superior level *h*.

The weights of the water in the several buckets, however, are not equally effective in turning the wheel; this will be easily perceived. If any water were contained in the highest bucket H, its weight would press upon the axle O in the direction H O. This weight would be entirely sustained by the supports of the wheel, and would contribute in no degree to its motion. From the several buckets *a b c*, &c., conceive the lines *a* A, *b* B, *c* C, &c., drawn perpendicular to the horizontal diameter F G. The weight of the water in the bucket *a* has the same effect in making the wheel revolve as if that weight acted at A, by the arm or lever A O. In the same way the weights of the water in the several buckets *b c d* and *e* have the same effect as if they acted at the points B C D E. Now it is very evident, that the more remote from the centre O a given weight acts, the more effective will that weight be in turning the wheel; and therefore, the water in the buckets near F is proportionally more effective than that in those near H. The same may be said of the buckets *e' d' c'*. As, however, the water begins to flow from each bucket as it descends from the end F of the horizontal diameter, these buckets, *e' d' c'*, produce a less effect than those *e d c* immediately above them, in proportion as they contain a less weight of water.

In order to increase the power of overshot water-wheels, engineers have given considerable attention to the construction of the buckets, which should be so shaped as to retain as much of the water as possible until they reach the lowest point L, but to retain *none* after they pass that point: in fact, each bucket should be empty on arriving at the lowest point L, but should remain filled until it come as near as possible to that point: to attain this, various forms of buckets have been suggested. That which has been generally considered best is represented in *fig.* 20.

This bucket is formed of three planes; A B is in the direction of the radius of the wheel, and is called the *start*, or *shoulder;* B C is called the arm, and C H the *wrist*. These buckets are so constructed, that when A B makes an angle of 35° with the vertical diameter of the wheel, the line A D is horizontal; and the area of the figure A D C B is equal to that of F C B A; so that as much water is retained in the bucket in this position as would fill F C B A: the whole of the water is not discharged until C D becomes horizontal, which takes place when the line A B is very near the lowest point.

fig. 20.



In attempting to keep *all* the descending buckets filled, it should not be forgotten, that the increased pressure upon the supports of the axle produces an increased resistance from friction; and therefore, that there is necessarily a certain distance from the highest and lowest point, within which a weight in a descending bucket is a positive impediment to the motion of the wheel. This will be readily understood by commencing with the extreme cases of the highest and lowest buckets themselves. If these be filled, the weight of the water which they contain will, as we have before stated, have no effect whatever in turning the wheel, but will press on the supports of the axle with its entire force; the friction, being proportional to the perpendicular pressure, will therefore be increased; and hence an additional resistance to the effect of the water in the descending buckets will be created: thus it appears, that water in the highest and lowest buckets is a positive resistance to the motion of the wheel. Now, suppose the buckets *a a'* near the highest and lowest points be filled, two effects will then be produced; an additional pressure on the axle; and therefore an increased resistance will be created on the one hand, and a moving force with the leverage A O will be brought into action on the other hand: but when the buckets *a a'* are very near the highest and lowest points, the leverage A O will be very small, while the increased pressure on the axle will be very great. Thus the increased resistance may be greater than the moving force which is gained; and therefore, on the whole, a loss of power will ensue.

From this reasoning, it is apparent that there is a certain distance from the highest and lowest points at which the momentum, or moving power of the water in the buckets is only equal to resistance arising from friction, which its own weight creates; and it is very

plain, that, within this distance from the highest and lowest points, a full bucket occasions a positive loss of power, and even beyond this limit, but near it, very little advantage can be gained.

There is a certain velocity with which an over-shot wheel should move, in order to produce the greatest effect. This will be evident from considering two extreme cases. If the wheel be so loaded as to render the weight of water insufficient to move it, the velocity becomes nothing; and it is evident that the effect becomes nothing. If, on the other hand, the wheel be supposed to turn as rapidly as the water would fall freely, it is evident that the effect of the weight of the water in the buckets will be nothing, since they descend as fast as the water itself would. Between these limiting cases there is an intermediate velocity, which will give the best possible effect.

Mr. Smeaton concludes from experience, that the best general rule for the velocity of the circumference of an overshot wheel is three feet per second; and he considers that this equally applies to large and small wheels. In deviating, however, from this rule, he considers that high wheels lose less of their effect, in proportion to their whole power, than smaller ones.

(48.) In cases where the height of the fall is considerable, and the supply of water very limited, a contrivance of the kind represented in *fig.* 21 is frequently used.

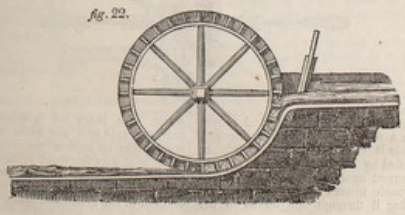
An endless chain, carrying a series of buckets C F E D, is made to revolve on two wheels A B, called *rag-wheels*. The water flows into the highest bucket at N; and when it descends, the next bucket D takes its place, and is likewise filled, and thus every bucket on the side C is filled, while those on the side E, being inverted, are empty; the chain of buckets is therefore constantly carried round in the direction C F E D by the weight of the water.

fig. 21.



(49.) The *breast-wheel* is another means by which the weight of water is applied as a mechanical agent. This wheel is furnished at its edge or rim with flat boards, called *float-boards*, the planes of which are at right angles to the plane of the wheel, and in the direction of the radii. The water is delivered at some point near the end of the horizontal diameter. The float-boards are fitted to the mill-course, as represented in *fig.* 22, so as to leave only as much play as is absolutely necessary for the free motion

fig. 22.



of the wheel, so that the water may be retained between the float-boards and the mill-course, and that it may act by its weight until it has arrived nearly at the lowest point of the wheel.

(50.) An *undershot-wheel* is driven exclusively by the momentum or moving force of water, and is quite independent of its weight. Like the breast-wheel it is furnished with float-boards, against which the water is delivered by a sloping canal at the under part of the wheel, as represented in *fig.* 23.

fig. 23.



The effect of such a wheel depends on the quantity of water in the mill-course, and the velocity with which it strikes the float-boards. The velocity will depend on the height of the fall, which therefore should be as much increased as the peculiar circumstances of the situation will admit.

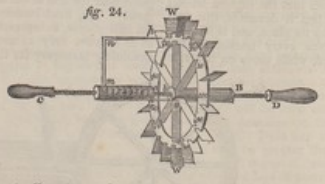
Much difference of opinion has subsisted among mechanical writers respecting the best number of float-boards in undershot-wheels. Bossut shows, that when the velocity of the wheel is given, there is a certain number of float-boards, which produces the greatest effect.

The rule of Bossut, however, is not simple enough to be of use to the practical mechanic. In general, it may be observed that the wheel may be furnished with as great a number of float-boards as the strength of the rim to which they are attached will conveniently admit, care being taken at the same time not to overload the wheel by their weight. The injury arising from having too limited a number of float-boards is much greater than any which could possibly arise from the opposite error.

(51.) In estimating the power of a stream on an undershot-wheel, it is frequently necessary to measure the velocity of the stream, and the quantity of water which flows through its bed. Various methods have been suggested of measuring the velocity of a stream. One of the most simple is to stretch two strings across it, each perpendicular to its course, and at as great a distance one from the other as may be found convenient. Let a light floating body be flung into the stream, above the higher string, and let the moment of its passing under each string be observed by a clock which beats half or quarter seconds. The time of the passage of the floating body from the one string to the other, will thus be obtained, and by measuring the distance between the two strings, the *rate* at which it was carried along by the stream will be found, which will be the velocity of the stream.

A more accurate method of determining the velocity of a stream is, by a small wheel, furnished with float-boards as represented in *fig.* 24. This wheel is

fig. 24.



about one foot in diameter, and moves upon a fine screw *a b*, passing through its axle B *b*. When the float-boards are impelled by the stream, the axle B *b* will be turned upon the screw *a b*, and will approach toward D, each revolution moving it through one thread of the screw. An index *o h* is fixed to the movable axle at *h*, and when the wheel commences its motion, the point of the index is at 0 on the fixed scale *m a*. As the wheel moves towards D, each revolution moves the index *o h* over one division of the graduated scale, so that

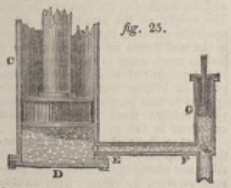
the number of revolutions of the wheel performed in a given time may be thus found. Another rectangular index *m n p* shows the parts of a revolution. At the commencement of the motion, the point *p* is directed to 0 on the graduated rim of the wheel.

Having found by this instrument the number of revolutions and fractional parts of a revolution which have been performed in a given time; multiply the circumference of the wheel by that number, and we shall then find the velocity with which the circumference of the wheel moves.

(52.) The third property, in virtue of which water becomes a mechanical agent, is that power which, in common with all fluids, it possesses of transmitting pressure equally in every direction. If water be confined in any vessel, and a pressure to any amount be exerted on a square inch of that water, a pressure to an equal amount will be transmitted to every square inch of the surface of the vessel in which the water is confined.

One of the most remarkable instances of the employment of this property as a mechanical agent, is in Bramah's hydrostatic press, the theory of which is extremely simple. A large solid plug or piston A B (*fig.* 25.) is constructed so as to move water-tight in a cylinder C D. The space beneath the piston is filled with water, and communicates by a pipe E F with a small forcing-pump, worked by the piston G, and by which the water is forced into the chamber of the cylinder

fig. 25.



C D below the great piston. Let us now suppose the entire space between the two pistons to be filled with water, and a pressure of one pound exerted on the water by means of the piston G of the forcing-pump. Let us also suppose that the diameter of the piston G is a quarter of an inch, and that the diameter of the piston B is one foot. In that case, the base of the piston B, which is pressed by the water, is 2304 times the base of the piston G, which presses the water, and in virtue of the power of transmitting pressure to which we have already alluded, a pressure of one pound will be transmitted to every part of the base of the greater piston which is equal to the base of the less. Thus an urging pressure of one pound on the base of the lesser piston G will produce a pressure of 2304*lbs.* against the base of the greater piston B. This property of fluids, therefore, seems to invest us with a power of increasing the intensity of a pressure exerted by a comparatively small force, without any other limit than that of the strength of the materials of which the engine itself is constructed.

This property of liquids also enables us with great facility to transmit the motion and force of one machine to another, in cases where local circumstances preclude the possibility of instituting any ordinary mechanical connexion between the two machines. Thus merely by means of water-pipes the force of a machine may be transmitted to any distance, and over inequalities of ground, or through any other obstructions.

Chapter VI.—*Air considered as a Mechanical Agent.*

(53.) Air may become a mechanical agent by means of its four properties, weight, inertia, fluidity, or power of transmitting pressure, and its elasticity.

In our treatise on Pneumatics, Chapter III., it was proved, that a column of air, whose base is one square inch, and whose height is that of the atmosphere, weighs about fifteen pounds. Consequently, it follows, that an horizontal surface sustains a weight or pressure amounting to fifteen times as many pounds as there are square inches in its extent. If then we have a solid substance with an horizontal surface, for example, a piston placed in a vertical cylinder, and that we are able by any means to remove all resistance from *below* it, it will be forced down by a mechanical pressure of fifteen times as many pounds as there are square inches in its upper surface, and in this way a mechanical agent of a power limited only by the magnitude of the piston will be obtained.

But peculiar difficulties in giving efficacy to this power arise from two

other properties of air, its fluidity and its elasticity. By the former it transmits the pressure arising from the weight of the incumbent atmosphere equally in every direction, so that it is not only an horizontal surface which sustains the pressure of 15lbs. per inch, but surfaces in all possible directions and positions suffer the same pressure. Also, by reason of air being an elastic fluid, it expands itself, so as to fill every open space not actually occupied by other bodies, whether solid or fluid. Consequently in the case we have supposed, air must occupy the space in the cylinder below the piston as well as above it, and if so, the fluidity of the air will transmit the pressure arising from the weight of the atmosphere to the lower surface of the piston with undiminished force, and thus we shall have the piston pressed upwards and downwards with equal forces, and consequently no mechanical advantage will be obtained.

(54.) It appears, therefore, that before the weight of the atmosphere, whether acting immediately downwards, or transmitted laterally, obliquely, or upwards, by means of its fluidity, can be used as a mechanical agent, it is indispensably necessary that the air be removed from the other side of the body on which this weight or pressure is designed to act. Recurring to the exampie of a piston in a cylinder, it is necessary to remove the air from one side of the piston before its weight or pressure can take effect upon the other side. Now if this removal, as is often the case, be effected by mechanical means, it must, on the slightest consideration, be quite apparent that it will require exactly as much force to remove the air from one side of the piston, as will be subsequently gained by the pressure of the atmosphere on the other side. Suppose, for example, that from two feet in length of the cylinder below the piston, the air which it originally contained be withdrawn by mechanical force. To effect this will require a force of at least 15lbs. for every square inch in the section of the cylinder, acting through the space of two feet, and after it has been effected the piston will be forced into the vacuum with exactly the same force.

It appears, therefore, that in order to render the atmospheric pressure an available mechanical agent, a vacuum, or a partial vacuum, must always be produced; and further, that if this vacuum, or rarefaction, be produced by mechanical means, no power will be gained, since it will always require as much force to accomplish this, as will be exerted by the atmospheric pressure when it has been accomplished. In the use of mechanism, however, the gaining of power is not always the end to be attained. It is frequently a matter of great convenience, and, in a certain sense, of great mechanical advantage, to be able, by a power which acts in some particular manner, to obtain another *equal* power, whose mode of action may be different, and better suited to the purpose to which mechanical agency is to be applied. This is, in fact, the case in every instance in which the atmospheric pressure is obtained by mechanical rarefaction, and in every such case the atmospheric pressure should not be looked upon as the prime mover, but rather as an intermediate agent deriving its entire efficacy from that power, whatever it may be, which is used to produce the rarefaction. A most obvious instance of this may be observed in the common suction-pump, described in our Treatise on Pneumatics, Art. 40. This machine is introduced into that treatise, not because it owes its original mechanical efficacy to the pneumatical principle of atmospheric pressure, but because this principle is involved in the detail of its operation. In this machine, the first mover is the power, whatever it be, which works the piston. This power, at the commencement of the operation, produces a rarefaction in the space between the piston and the surface of the water in the well. The weight of the atmosphere acting upon the external surface of the water in the well forces into the pump-barrel just so much water as the power applied to the pump-rod would have been capable of lifting, were it immediately applied to that purpose. This appears very evident from the investigation contained in Art. 42. PNEUMATICS.

What we have observed of the suction-pump may be applied in general to all cases where the atmospheric pressure receives its efficacy from mechanical rarefaction. Strictly speaking, we cannot consider the atmospheric pressure as a first mover at all; the first mover is the cause, whatever it be, whether mechanical or otherwise, which produces the rarefaction.

(55.) By that quality called inertia, air, when in motion, exerts a force upon

any solid body, which obstructs its course. (PNEUMATICS, Art. 9.) This force is used as a first mover, by means analogous to water-wheels, viz. by flat surfaces exposed to the impact of the wind, by that impact made to revolve on a centre. When this rotatory motion is once produced, it may be easily transmitted, and modified by machinery, and applied to any required purpose.

If the sails of a windmill be constructed in a manner analogous to the float-boards of an undershot-water-wheel, the plane of the wheel must be in the direction of the wind; and it is evident that one half of the wheel must be sheltered from the action of the wind, for otherwise equal forces would tend to turn the wheel in opposite directions, and no motion would ensue. Besides this, the wind would act with very little advantage on those sails whose planes are nearly in its own direction. For this reason windmills of this construction are not generally used. On the other hand, the arms which carry the sails revolve in a plane facing the wind. In this arrangement, if the sails were in the same plane with the arms, the wind would fall perpendicularly upon them, and merely press the arms against the building perpendicular to the plane in which they are designed to move. If, on the other hand, the sails were perpendicular to the plane in which the arms move, their edges would be presented to the wind, and would, therefore, offer no resistance, and there would be no motion. In order to make the arms revolve, the sails must, therefore, be placed in some direction intermediate between those of the wind and the plane in which the arms revolve.

The most accurate experimentalists and the most profound mathematicians have instituted inquiries, practical and theoretical, to determine that position which should be given to sails of windmills, in order to produce the best effect. Most of the theoretical calculations on this difficult subject have been vitiated by conditions and hypotheses, which are inadmissible in practice. The angle which *Parent* and others deduced from mathematical calculation to be the best at which the planes of the sails could be inclined to the axis of motion or the direction of the wind, was found to be one of the worst in Mr. Smeaton's experiments. The position determined by *Parent*, was the best at the beginning of motion, but his calculation proceeded on the supposition, that the wind struck the sail *at rest*; and was, therefore, inapplicable to the continuance of its action.

When the wind acts upon the sail in motion, it is necessary to take into account the velocities both of the sail and the wind. For if the sail moved before the wind with a speed equal to that of the wind itself, no effect would be produced. The effect will depend on the difference of the velocities, that being the velocity with which the wind strikes the sail. Now as the obliquity of the sail to the wind should depend on the force with which the wind acts upon it, and as those parts of the sail which are nearer to the centre of motion move more slowly than those which are more remote, it follows that the position of the sail should vary at different distances from the centre of rotation. From several experiments executed on a large scale, Mr. Smeaton concluded the following positions to be among the best.* Let the radius be conceived to be divided into six equal parts, and let the first part, beginning from the centre, be called 1; the second 2, and so on; the extreme part being 6.

No.	Angle with the axis.	Angle with the plane of the motion.
1	72°	18°
2	71	19
3	72	18
4	74	16
5	77½	12½
6	83	7

(56.) The last property, in virtue of which we have stated that air becomes a mechanical agent, is its *elasticity*. The nature of this property, and the laws by which it acts, have already been explained in our treatise on PNEUMATICS, Chap. IV. When this property is considered as a mechanical agent, it is subject to nearly the same observations as we have already applied to the weight and pressure of the atmosphere. To give effect to the elastic force of air, it is necessary that it should predominate over the weight of the atmosphere, a pressure to which, as we have before stated, all bodies in their ordinary state

* The general resemblance which the best form of windmill sails bears to the arrangement of the feathers in the wings of birds is very striking, and one of those beautiful instances of the truly mathematical principles on which the works of the creation are constructed.

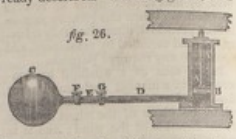
are subject. If increased elasticity be communicated to air by mechanical means, it must be by compression or condensation. It is evident, that in this case, no power whatever will be gained, in as much as it will require exactly as much power to produce a given degree of condensation in a given quantity of air, as is equal to the increased elasticity with which that condensed air will be endued. However, in this case, as in that of the ordinary use of atmospheric pressure, although no power be gained by mechanical condensation, yet considerable advantage may be derived from this as a method of transmuting one power into another, and as means of accumulating the effects of a small intermitting power, so as to convert it into a severe or continued pressure.

We have already seen an instance of this in the air-gun. (PNEUMATICS, Art. 52.) If we attempted, by mere manual force, to project a bullet, we should find our efforts attended with but a small effect; but if it were possible to unite in one impulse the combined force of a vast number of separate impulses, we should produce the desired effect. The air-gun, then, is nothing more than a contrivance, by which a great number of separate exertions of our strength are accumulated and combined, and made to act simultaneously. The process of condensing the air is conducted by a number of successive muscular exertions; and the elastic force which the condensed air thus receives, is exactly equal to the sum of these several exertions of human strength, and may, therefore, be considered as a magazine in which these separate exertions are contained in such a manner, that their combined intensity may be, at any moment, applied to the ball or other missile to be projected.

In this instance, the object to be attained is the production of a severe but instantaneous effect. The elastic property of air is also sometimes used to convert an intermitting or reciprocating action into a continued and uniform one. The fire-engine, described in our treatise on PNEUMATICS, Art. 48, is an instance of this. The force which works the pistons is intermitting or reciprocating, while the pressure of the condensed air in the air-vessel, produced by that intermitting force, is continuous in its action. Its total action, however, must be precisely equal to the sum of the forces which depress the pistons.

The force of condensed air may be applied to produce a severe and continued pressure, on a principle similar to that of Bramah's hydrostatic press, already described. Let B (*fig.* 25.) be a

fig. 26.



large cylinder, in which a solid piston or plunger moves air-tight. Let D E be a small tube, having a stop-cock at G, and terminated in a screw at E. Let C be a strong metal ball, capable of bearing an intense bursting pressure, having a small tube, terminated by a screw at E, by which it may be connected occasionally with the tube D E, or with a condenser, (PNEUMATICS, Art. 38,) and also furnished with a stopcock at F.

By means of a condenser screwed upon E, the stopcock F being opened, let air be forced into the ball C, until it presses against the cock F, when closed, with a force of more than one ton. The condenser being then removed from E, the air cannot escape, the cock F being closed. Let the ball and tube C F E be then screwed upon the tube D E, and the cocks F and G both opened. The condensed air will expand through the tube D, and fill the part of the cylinder below the piston. If, after this expansion, the elastic force of the compressed air is such that it would press on the stopcocks with a force exceeding that of the atmosphere by one ton, there will be an effective pressure against the piston A, of as many tons as the number of times that the section of the tube D is contained in that of the piston. Suppose the section of the tube to be a quarter of an inch in diameter, and the piston to be one foot, the pressure on the piston will then be equal to 2304 tons.

In this case, like all the former, air is only used as a convenient means of accumulating mechanical force; and ought not, properly speaking, to be looked upon as the prime mover. As in using the weight or pressure of the atmosphere, we consider that cause, whatever it be, that produces the vacuum, or the rarefaction, to be properly the prime

mover, so also in using the elastic force of the air as a mechanical agent, we consider the means whereby the necessary degree of elasticity is imparted to it, whatever those means may be, as the real prime mover. We shall see hereafter that, for this reason, *heat* assumes an important rank in the class of first movers.

CHAPTER VII.—*Of Animal Strength.*

(57.) ONE of the most obvious, and therefore one of the earliest, although, perhaps, the least efficient of the prime movers, is *animal strength*.

From our ignorance of the nature and principle of animal life, it is evident that we cannot attempt to explain, on scientific principles, the laws which regulate animal strength: and, on the other hand, owing to the very fluctuating nature of this force, the various physical causes which produce differences in its manifestations in different individuals, and even in the same individual, at distances of time by no means great, considerable difficulties obstruct the investigation and development of these laws by the process of actual observation and experiment. The whole analogy of nature, the beauty, order, and singular harmony of all her works, however, convince us that this force, like every other, is regulated by fixed laws.

To simplify our investigations, we shall consider every exertion of animal strength to be represented by that which is necessary to carry a load or weight. It is not difficult to imagine that, in whatever way strength be used, we can find a certain load carried with a certain speed, which may be considered as an equivalent exertion.

In estimating the exertion of animal strength in this way, one law is very obvious, which is, that as the load is increased (all other things being the same), the velocity of the animal must necessarily be diminished. But then, it becomes a more difficult matter to determine in what proportion the velocity should be diminished with a given increase of load, in order that the expenditure of animal labour should be the same. Different formulæ have been suggested, each agreeing more or less with experience, and we shall here attempt to explain in a popular way that formula which seems to represent the results of experiments most accurately.

There are two extreme cases of animal exertion. There is a certain speed at which the animal can carry no load, and can barely move its own body; let this speed be called X. There is some load so great that the animal can barely sustain it, without being able to move it; call this load L. What is technically called the *useful effect* depends on two things—the *load* which is borne, and the speed or velocity with which it is carried. The useful effect is, in fact, estimated by multiplying the load by the speed. This will be easily understood by an example. Suppose one horse carry two hundred weight six miles an hour, and another carry three hundred weight four miles an hour. The load of the former is two, and the speed six; the product or useful effect being twelve. The load of the latter is three, and the speed four; the useful effect being twelve. The propriety of considering the useful effect to be equal in these two cases, will appear very evidently, if we consider both horses to be employed in transporting weights between two places, distant one mile asunder, for six hours. The first horse will carry in the six hours 72 hundred weight between the two places, for he will make thirty-six turns, travelling for six hours at six miles an hour, and at each turn he will carry two hundred weight. The other horse will make but twenty-four turns, since he travels only four miles an hour; but then, in each turn, he will carry three hundred weight; and, therefore, he will also transport in the given time 72 hundred weight between the two places. Thus the useful effects of these horses are equal, and hence the propriety of estimating the useful effect by the product of the numbers which express the load and the speed with which that load is carried.

Recurring now to the load L, and the speed X, it is apparent that, with the load L, the useful effect is nothing, because there is no speed; and again, with the speed X, the useful effect is nothing, because there is no load. But with a load less than L there will be a speed less than X; and therefore, there will be an useful effect. These, then, are two limiting cases, in which the useful effect vanishes, approaching which it diminishes, and at some point between which it is a *maximum*. To determine where this maximum lies, it is necessary that we should know in what proportion the velocity diminishes as the load increases.

Let l be any load less than L, and let x be the greatest speed with which this load can be carried. The useful effect will be $l \times x$; that is, the load multiplied by the speed. The rule which seems best to agree with experience is that the load l increases in the same ratio as the square of the difference between the greatest velocity X, with which the animal can move unloaded, and the greatest velocity x with which it can move the load; that is, l increases as $(X - x)^2$. Assuming this rule, therefore, it follows, that the useful effect is represented by the product $(X - x)^2 \times x$. This will probably be more easily understood by reducing it to an arithmetical table. Let us suppose that the number 15 represents the greatest unloaded speed, and that the square of 15, or 225, represents the greatest load which can be sustained without moving. The signification of the units which compose the number 15, will be found, by dividing the space through which the animal would move in a given time, suppose one hour, into 15 equal parts: each of these parts will be expressed by an unit of the number 15, which expresses the greatest unloaded speed; and the signification of the units of 225 will be found, by dividing the greatest load which can be sustained without moving, into 225 equal parts: one of these parts will be expressed by an unit of the number 225, which expresses the greatest load. The following Table gives for each degree of speed from 1 to 15, the corresponding load and useful effect.

Speed - - -	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Load - - - -	225	196	169	144	121	100	81	64	49	36	25	16	9	4	1	0
Useful effect	0	196	338	432	484	500	486	448	392	324	250	176	108	52	14	0

From the inspection of this Table it appears that a much greater useful effect is to be attained by the slower motions with heavier loads than by the quicker motions with lighter loads. The greatest useful effect is produced by the speed 5 with the load 100; that is, with a velocity which is one-third of the greatest unloaded speed, and a load which is four-ninths of the greatest load which can be sustained without moving. We shall find this result, whatever be the number we take, to represent the greatest speed.*

Thus, if the greatest unloaded speed of a horse be 15 miles an hour, and that the greatest weight which he is capable of sustaining without moving be divided into 225 equal parts, his labour will be most advantageously employed if he be loaded with 100 of these parts, and travels at the rate of 5 miles per hour. If he be thus employed, it will be found that he will carry a greater weight through a given distance in a given time than under any other circumstances.

The average value of human strength, considered as a mechanical agent, has been variously estimated. Desaguliers considers that a man can raise the weight of 550 lbs. 10 feet high in a minute, and continue to do so for 6 hours. Smeaton considers that this is too high an average, and thinks that six good English labourers will be required to raise 21,141 solid feet of sea-water to the height of four feet in four hours. In this case they will raise very little more than six cubic feet of fresh water each, 10 feet high in a minute. The labourers whom Smeaton supposes capable of executing this work he considers to be equal to twice the number of ordinary men. It would, therefore, perhaps, be a fair average value of a man's work to estimate it, for a continuance, at half an hogshead of water raised through 10 feet in a minute.

The efforts of men differ with the manner in which these efforts are employed. It has been shown by Mr. R. Buchanan that the same quantity of human labour employed in working a pump, turning a winch, ringing a bell, and rowing a boat, are as the numbers 100, 167, 227, and 248.

The most advantageous manner of applying human strength is in the act of rowing.

The most useful of quadrupeds, as a mechanical agent, is the *horse*. The relative values of the labour of a horse and man are variously stated. Some estimate them as five to one, some six to one, and some seven to one. Perhaps the medium may be nearest to the true average, and that we may generally consider six men equivalent to one horse.

The most advantageous method of using the strength of the horse is in the act of *drawing*. The worst method in which this animal can be employed is in *carrying* a weight up a steep hill; while, on the other hand, the peculiar disposition of the limbs of a man, renders him well-fitted for this species of labour. It has been observed that three men climbing a hill, loaded with 100lbs. each, will ascend with greater speed than one horse carrying 300lbs.

Chapter VIII.—*On the Mechanical Agents depending on Heat.*

(58.) In order to explain the several ways in which heat is rendered subservient to the production of mechanical agency, it will be necessary, in the first instance, to offer a few observations on its properties, and particularly those properties which have relation to that quality of matter called *cohesion*. The necessity of entering into very minute details on this subject, however, is superseded by our treatise on *heat*, to which we refer the reader who desires to proceed with the subject beyond the general view of it which we shall give.

There is supposed to exist between the particles of matter, whatever be their form or situation, a certain mutual attraction, by which, if it be unresisted by any opposing force, they have a tendency to approach each other, to collect together, and to form themselves into solid concrete masses. *Heat*, or *caloric*, is supposed to be a subtle and highly elastic fluid, which transfuses itself through the dimensions of bodies in a greater or less degree, and by its intense elasticity has a tendency to force the particles asunder. Whatever be the nature of heat, however, and whether it be *material* or not, it is an undisputed fact, that it is a *cause*, which produces an effect exactly opposite to the effects of cohesion, and that, in proportion as it pervades any body, it gives the particles of that body a tendency to repel each other and fly asunder, which tendency, in some cases, prevails over the cohesive force and actually produces that effect.

When we find a body in the solid state, we therefore conclude, that the cohesive force by which its particles attract each other greatly predominates over the repulsive energy of the caloric which may pervade its dimensions, and that, consequently, the particles cohere with a force equal to the difference between these cohesive and repulsive forces. If, then, by the external application of fire, we transfuse through the dimensions of the body an increased quantity of heat, we naturally expect that, the repulsive effect of the caloric being increased, the particles which compose the body will be more separated, and will retire from each other to increased distances, so as to enlarge the dimensions of the body.

This effect we find actually to obtain; for if a cylindrical bar of metal, C D, be gauged by means of a flat piece of metal *b*, (*fig.* 27.) furnished with a

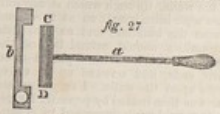


fig. 27

circular hole, in which the bar exactly passes, and having a notch in its side, corresponding to the length of the bar, it will be found that, after the bar is heated, its length and thickness will be so much increased that it will no longer fit in the notch, nor pass through the circular aperture.

In general, when heat is communicated to solids, their bulk is increased from the cause which we have assigned; but this effect is more perceivable in metals than other solids.

This effect of heat, however, is not confined to solids, but is observable in liquids, and still more in aëriform substances. The thermometer is an instrument in which the expansion of a

* The mathematical investigation is not difficult. Let u be the *useful effect*. Then by the empirical formula already explained we have $u = (X - x)^2 x$. Differentating this we obtain

$$\frac{du}{dx} = (X - x)^2 - 2(X - x)x.$$

Supposing this $= 0$ we shall obtain the value of x, which corresponds to a maximum or minimum value of u. This gives the equation,

$$(X - x)(X - 3x) = 0$$

the roots of which are

$$x = X \qquad x = \frac{1}{3}X.$$

For $x = X$ the load and useful effect are each $= 0$. This root, therefore, corresponds to a minimum; and for $x = \frac{1}{3}X$ $l = (X - \frac{1}{3}X)^2 = \frac{4}{9}X^2$; that is, the load corresponding to one-third of the greatest speed is $\frac{4}{9}$ of the greatest load; for $L = X^2$. That this is a maximum is easily shown by taking the second differential, which gives

$$\frac{d^2u}{dx^2} = -3(X - x) - (X - 3x)$$
$$= -4X + 6x$$

in which, if we substitute $\frac{1}{3}X$ for x, we find

$$-4X + 2\tfrac{2}{3}X = -2X.$$

which, being negative, shows that the value $\frac{1}{3}X$ corresponds to a maximum value of u.

fluid by heat is used as an indication, or measure, of the degree of heat to which the instrument is exposed (see HEAT, Chap. IV.), and the fluid which is used in thermometers may be either liquid or aëriform, although most frequently the former.

(59.) Bodies whether solid, liquid, or aëriform, exert a certain degree of mechanical force, in the process of enlarging their dimensions, on receiving an accession of heat; and any obstacle which opposes this enlargement sustains an equivalent pressure. This force is frequently used as a mechanical agent, and has this to recommend it, that it may be produced to almost any degree of intensity, without the expenditure of any other mechanical force in its production. In this respect it has the advantage over the mechanical agency of air, arising from its pressure and condensation, (53, 54.)

A remarkable instance of the use of the power with which solids expand by heat, occurred in Paris some years since, in a method which was used to force together the walls of a gallery in the Abbey of *St. Martin*, now the *Conservatoire des Arts et Métiers*. The weight of the roof was forcing the walls of this building asunder, and they were restored to their perpendicular position by the following method:—Holes were made at opposite points, in several parts of the walls, through which strong iron bars were introduced, so as to extend across the building, and so that their extremities should extend beyond the walls. Large nuts were placed upon their ends, and screwed up so as to press upon the walls. Every alternate bar was then heated by powerful lamps, so that its length increased by expansion, and the nuts, before in close contact with the walls, retired to some distance from them. The nuts were then screwed up to the walls, and the bars cooled. The process of cooling restored the length of the bars to what it had been before the heat had been applied, and the nuts were drawn together by an irresistible force, and consequently the walls drawn towards each other. The same process being repeated with the intermediate bars, and this being continued, the walls of the building were gradually restored to their perpendicular position.

In the processes of shoeing wheels, and hooping barrels, the same force is used mechanically. The iron hoop, or rim, is put on hot, and made to fit the wheel or the barrel exactly, and being then cooled, it contracts and binds the parts of the wheel or the barrel together with immense force.

It is evident, however, that these forces of expansion and contraction of bodies by heat and cold, act through spaces so limited that they can be used as mechanical agents but very rarely, and under peculiar circumstances.

(60.) Heat is productive of mechanical agents of much greater power, by the influence which it has upon the form of bodies, than by its power of enlarging their dimensions. We have stated that, in a solid body, the cohesive force of the particles predominates over the repulsive influence of the caloric which pervades its dimensions. Supposing the cohesive force to continue unincreased, what will be the effect if we transfuse through its dimensions, by the application of fire, such an abundant portion of caloric that the repulsive force of it will become equal, or nearly equal, to the cohesive force of the particles? We should evidently anticipate that the particles, having no tendency, or very little, to cohere, they would move freely among each other, and fall asunder by their own weight, unless they were prevented by the sides of the vessel which might contain them; in fact, we should predict that, by the application of such a quantity of heat, as we have supposed, the *solid* would become a *liquid*. And such we find to be the case: solids liquefy by exposure for a sufficient time to the action of fire.

It would appear, therefore, that the solid and liquid forms in which we find bodies, are maintained by the proportion which subsists between the force of cohesion peculiar to the particles, and the repulsive force of the caloric which pervades them, the former greatly predominating in solids, and these forces being nearly in equilibrium in liquids.

We accordingly find, by experience, that if a sufficient portion of heat be withdrawn from a liquid it becomes solid, the cohesive force of its particles receiving a sufficient predominance over the repulsive force of the caloric, by diminishing the quantity of the latter.

(61.) This, however, is not the only, nor the most important, change of form in bodies, which depends on the proportion which subsists between these two forces.

In a liquid, as we have already explained, the repulsive energy of the caloric nearly balances the cohesive force of the particles. Now, if we increase the quantity of caloric considerably, its repulsive effect will predominate over the cohesive attraction of the particles; and instead of being nearly in a state of indifference as to mutual attraction, we may expect to find that they strongly repel each other, and that the liquid will assume a form in which it will be necessary that it should be closely confined in order to prevent its total dissipation by the dispersion of the particles owing to this repulsive effect.

Accordingly we find that if a liquid be exposed for a considerable time to the action of fire, it will be gradually converted into steam; a fluid totally differing in its mechanical character from a liquid. If the liquid be inclosed in any vessel, it will press with no other force upon the surface which confines it, than with those pressures which are produced by its weight; but when the same liquid is converted into vapour and confined in a close vessel, it will press on the confining surface with its elastic force, which is quite independent of its gravity, and arises from the effort which its particles exert to repel each other; and which, therefore, exert a bursting pressure on the inner surface of the vessel which contains it.

The degree of elasticity or the pressure which confined steam exerts upon the surface of the vessel which contains it, will, according to our theory, and which is confirmed by experience, increase with the heat which is communicated to the steam; and, on the other hand, according as the temperature of the steam is lowered, the elastic pressure will be proportionally diminished.

The evaporation of liquids, however, is effected by a force, whose effects are not sensible in the liquefaction of solids. The atmospheric pressure has an effect in binding together the particles of a liquid; and, therefore, conspires with the cohesive force in opposing the effects of the caloric. When the caloric has been communicated to a body in such a quantity as to form a balance for the cohesive force; the body, according to our theory, ought to be in a state in which the slightest increase of caloric would convert it into an elastic vapour. Under these circumstances, however, the atmospheric pressure opposes the change, and is the means, and the only means, by which the particles are bound together and retained in a state of liquidity. In proof of this, we have only to remove the atmospheric pressure, and many bodies which are now held in the liquid state, by the mechanical action of that pressure, will evaporate.

Let water at 180° of temperature, or alcohol, or ether, be placed under the receiver of an air-pump, and they will boil and evaporate on removing or rather diminishing, by rarefaction, the pressure of the air on their surfaces. Indeed, ether will evaporate if exposed to the atmosphere without any diminution of pressure.

On the other hand, it would follow from this theory, that if the pressure be increased, the evaporation will be resisted by it; and such, in fact, we find to be the case. Water under the atmospheric pressure, when the barometer is at 30 inches, will boil and vaporize at 212° of Fahrenheit's thermometer; but if the same water be submitted to increased pressure, it will not boil or evaporate until it has reached much higher temperatures.

If a sufficient quantity of heat be withdrawn from the vapour which has been raised from a liquid, it will be restored again to its liquid form; and it is a very important fact, that, in this case, its bulk is reduced in a very high ratio. A cubic inch of water, when converted into steam at the usual atmospheric pressure, will form a cubic foot of steam; and it follows, therefore, that if the caloric be withdrawn from a cubic foot of such steam, by application of cold bodies, or otherwise, it will be reconverted into a cubic inch of water. Now this property is rendered subservient to the production of a very important mechanical agent. If a cubic foot of steam be inclosed in a vessel, and that the vessel be cooled until the steam be *condensed* or reconverted into water, we shall have 1727 cubic inches of empty space or vacuum; for the steam, which, before condensation, filled a cubic foot, or 1728 cubic inches, will, after condensation, be reduced to one cubic inch, leaving 1727 cubic inches void of any material substance.

The condensation of vapour, or its reconversion into the liquid state, is thus rendered an easy and effectual method of producing a vacuum, and is free from the objections to the mechanical method of producing the same effect alluded to in Chap. VI., inasmuch as a vacuum may thus be obtained

without the expenditure of any mechanical force.

This was the principle from which the earlier steam-engines derived their efficacy. In the engine constructed by Savery, about the year 1700, the atmospheric pressure was used for elevating water into a tube, in which a vacuum was produced by first blowing the air out by means of hot steam; and when the tube was filled with pure steam, and the air had been completely expelled through a valve which opened outwards, the steam was condensed by cooling the external surface of the vessel which contained it. A vacuum was thus produced, into which the air was prevented from entering, by the circumstance of the valve opening *outwards;* and, consequently, the pressure of the atmosphere on the surface of the water in the well or reservoir, forced it up into the vessel or tube.

Shortly after this, Newcomen used the same means of producing a vacuum in his atmospheric steam-engine, but availed himself of the atmospheric pressure in another way. He provided a cylinder and a piston moving steam-tight in it. He connected the piston rod with the end of a great beam turning on a centre, the other end of which was connected with pump-rods, which he proposed to work. The weight of the pump-rods was sufficient to draw the piston to the top of the cylinder. He then filled the cylinder with steam, by which the air was blown out. Upon cooling the cylinder, the steam was condensed, and a vacuum was produced beneath the piston; and, consequently, the atmospheric pressure taking effect above it, forced it down and drew up the pump-rod at the opposite end of the beam, and so the process was continued.

In this case, the direct or elastic force of steam was not employed, the atmospheric pressure being the effective agent, but receiving its efficiency from the vacuum produced by the condensation of the steam. At a much earlier period, however, the mechanical agency of steam, arising from its elasticity, was suggested as a power, whose extent was almost unlimited. In 1663, the then Marquess of Worcester asserts that he constructed a machine which raised a great quantity of water to a considerable height, and which was more powerful than the atmospheric pressure, inasmuch as this could only act through a limited space: whereas the elastic force of steam "hath no other bounder than the strength of the vessels which contain it."

In modern times, the improved steam-engines, commonly called *low pressure engines*, employ both the powers of steam which we have mentioned. A piston is moved in a cylinder, and the elastic force of steam acts on one side of it, while a vacuum is produced by the condensation of steam on the other side, and thus the piston is urged forward.

In *high pressure engines*, the elastic force of steam is used to urge a piston against the atmospheric pressure on the opposite side. The advantage which this has over the low pressure engine is, that all the apparatus for condensing the steam, in order to produce a vacuum, is dispensed with, and the machine is consequently cheaper and lighter. On the other hand, it is attended with the disadvantage, that all the elastic force of the steam which is expended in balancing the atmospheric pressure is lost, since that pressure must be overcome before motion is produced; and, consequently, it becomes necessary to use steam of a very high temperature and pressure in these engines, which increases the expense of fuel, and renders the operation more dangerous.

Having once obtained, in any of the ways which we have mentioned, the power of moving a piston in a cylinder, it will be no difficult matter to apply that power by a working-beam, or various other ways, to any mechanical purpose.

In this *First Treatise*, we have merely attempted to give the reader a succinct account of the most important properties of motion and force, and to offer a rapid sketch of the principal mechanical agents, or first movers. Our design being that the treatise should be adapted for the more popular purposes, we have not entered into any mathematical details on the subject; and in the same popular form, we propose, in the *Second Treatise*, to give an account of the *Elements of Machinery*, or the means whereby the natural powers which we have explained here, may be rendered available for mechanical purposes. In that treatise, the MECHANIC POWERS will hold a prominent part.

MECHANICS.

TREATISE II.

ELEMENTS OF MACHINERY.

CHAPTER I.—*Machines—Power and weight—Principle of virtual velocities—Simple Machines or Mechanic Powers.*

(1.) NATURE has placed at the disposal of man various mechanical agents, endued with different kinds and degrees of power. The weight of solid bodies, and their momentum when in motion; the weight and pressure of liquids; the weight and pressure of air and other gases; the elastic force of vapour raised from liquids by heat; the elasticity of springs, and the muscular strength of animals, furnish striking examples. In applying these forces to overcome resistances, or to communicate motion to bodies, it seldom happens that, without some previous modification, they are capable of accomplishing the end we desire to attain. The power which we may happen to have at our disposal may not act in the proper direction, or may not have that velocity or intensity which suits our purpose; and some contrivance must be found by which, in transmitting it to the working point, its direction, velocity, or intensity, may be regulated in such a manner as to be suitable to the purpose to which it is to be applied. Such a contrivance is called a *Machine*.

(2.) Notwithstanding the infinite variety of ways in which machinery is employed, and the great diversity of ends which it appears to attain, yet it will be found that every machine, whether simple or complex, can only be designed to produce one or more of the three following effects: 1. To change the *direction* of the moving power so as to accommodate it to overcome a given resistance, or to produce in some body to which it is applied a given species of motion. 2. To render a power which has a certain *velocity* capable of producing a *different velocity* in the work to be performed or the body to be moved. 3. To render a power of a certain *intensity* capable of overcoming a resistance or of exerting a force upon the body to be moved of a *different intensity*, and frequently of a much greater intensity.

(3.) In order to simplify the development of the nature and properties of Machinery, we shall consider the moving power, as well as the resistance to be overcome, as represented by equivalent weights; that weight which is taken to represent the moving force being technically called the *power*, and that which represents the resistance being called the *weight*. It is easy to conceive that, whatever species of force the moving power and the resistance may be, weights equivalent to them can be assigned. Thus, if the moving power be the elastic force of steam pressing upon a piston, we familiarly say that the pressure amounts to so *many pounds* per square inch, meaning that it produces the same effect in forcing the piston through the cylinder as a weight of so many pounds laid upon the piston would produce. Again, if the resistance be that which timber offers to the wedge which splits it, there is no difficulty in conceiving a weight acting against the wedge so as to offer an equal resistance. We shall therefore henceforward express the moving power and the resistance to be overcome, whatever be their nature, by the terms *power* and *weight*.

(4.) In transmitting the influence of the *power* to the *weight* through the intervention of a machine, it has various resistances to encounter which oppose its action, and which impair its effects. Such are, for example, the roughness of surfaces which move in contact, the stiffness of cordage, the yielding or flexibility of bars, and numerous others. If the calculation of the effects of these forces were introduced into the elements of the science, and constituted a part of our first investigations of the properties of machines, the investigations would become extremely complex, and present difficulties which most students

would be deterred from encountering. To avoid this, it is usual, in the first instance, to omit the consideration of these obstructions to the action of the power, and to consider a machine as free from them. Surfaces are considered as perfectly smooth, cords as perfectly flexible, bars and levers as perfectly inflexible, and so on. Although these suppositions are absolutely false, yet they are found to be, in the end, the shortest road to truth. For having determined what would be the relation between the power and weight in any machine, were there no friction or rigidity, it will be easy to correct the result when the effects of these forces are subsequently ascertained, and the process is found to be, on the whole, not only more simple and intelligible to the student, but more expeditious in actual practice by taking this course, than if the real state of the machine were taken under consideration in the first instance.

These observations apply more or less to every part of physical science. The results which we obtain are rather to be considered as constant approximations to truth, than truth itself. In our first essays, false suppositions are ever mixed up with true ones, and our first conclusions are more or less tainted with the errors of the source from which they flow. Being, however, aware of the deviations from the truth in our primitive hypotheses, we are enabled to perceive the consequences which they produce and the errors which they entail upon our results, and we gradually remove these errors as they are detected, and our conclusions thus constantly come nearer to that truth which is the great end of all our researches. Thus the progress of the mind in the acquisition of the knowledge of physical science resembles that of an artist in the production of a picture or statue; the first rude attempt bears but a remote and uncouth resemblance to the original, while every successive stroke of the pencil or the chisel removes some deviation from perfect similitude, and the work gradually approximates to a faithful copy of nature.

(5.) Viewing a machine, then, divested of those considerations to which we have alluded, the problem which first presents itself is the determination of the *power*, which by its means would be capable of supporting a given weight. Now it happens, that notwithstanding the great variety of machines which have actually been constructed, and the infinitely greater variety which it is possible for human invention to produce, there is one great principle, simple in itself and easily intelligible, which applies indifferently to all, and by which the power, which is capable of supporting a given weight, may be determined. The power being connected with the weight so as to act upon it by means of the machine, if any motion be given to it, the weight will receive a corresponding motion, and a certain proportion will be found to subsist between the velocity with which the power descends in the vertical direction, and that with which the weight ascends in the vertical direction; which proportion depends entirely on the nature and construction of the machine. But whatever proportion this may be, in order that the power may be capable of sustaining the weight, it is only necessary that it should have to the weight the same ratio as the velocity of the weight just mentioned has to the power; or, to express the same condition in other words, THE POWER MULTIPLIED BY THE SPACE THROUGH WHICH IT MOVES IN THE VERTICAL DIRECTION MUST BE EQUAL TO THE WEIGHT MULTIPLIED BY THE SPACE THROUGH WHICH IT MOVES IN THE VERTICAL DIRECTION.*

This great principle, which is known under the name of "the principle of virtual velocities," may be considered as the *golden rule* of mechanics. Indeed, we may say that it implicitly contains the whole science, statics and dynamics; and equally includes the resolution of all problems respecting bodies and systems of bodies in equilibrium and in motion: for it applies immediately and most evidently to all questions respecting equilibrium or *statical problems*, and by means of another principle, known by the name of *D'Alembert's principle*, the whole region of dynamics is brought under its dominion. We cannot pretend, in a short popular treatise like the present, to make the full value of this principle apparent, nor even to offer a general demonstration of it; not because it is incapable of rigorous proof, nor because its results are few or unimportant, but because its general proof requires the aid of algebraic investigations of too difficult a

* The principle of virtual velocities is much more general than that which is announced above; but we shall not have to apply it in its full generality.

nature to be introduced here; and its most striking results are spread over departments of physical science, far beyond the necessary limits of this treatise. Nevertheless, even within our narrow limits, the student will have numerous instances of the truth and power of this principle.

(6.) Every machine, however complex it be, must consist of some combination of the following simple machines, which are commonly called the *mechanic powers*:—

1. THE LEVER,
2. THE WHEEL AND AXLE,
3. THE PULLEY,
4. THE INCLINED-PLANE,
5. THE WEDGE,
6. THE SCREW.

This classification of the ELEMENTS OF MACHINERY, although very simple when considered with respect to the extent and power of the results which spring from it, may be still further simplified; not because any of the six machines which we have just enumerated admits of being resolved into more simple parts, but because some of them are identical in principle, and different only in appearance. We shall show hereafter that the wheel and axle is in fact a lever, and that the wedge and screw are only modifications of the inclined plane; so that it follows, that all the varieties of simple machines may be reduced to three:—

1. THE LEVER,
2. THE PULLEY,
3. THE INCLINED-PLANE.

CHAPTER II.—*Of the Lever.*

(7.) A LEVER is sometimes defined "an inflexible right line, void of gravity, and turning on a certain point as a centre." It is also defined "an inflexible bar or rod resting upon a fulcrum or prop, on which it is capable of turning as on a centre." We shall, however, take a more general view of this machine, and consider it as any solid body having a fixed axle on which it is capable of turning, and round which all its parts describe circles. In considering such a machine as applicable to mechanical purposes, we usually conceive its axis to be placed at right angles to the plane in which the power and weight or resistance act. In order, also, to simplify the investigation, we shall, in the first instance, omit the weight of the machine itself, or, what will amount to the same effect, we will consider the fixed axle as passing through the centre of gravity of the machine, which will therefore rest indifferently in any position. (*Treatise* I. 42.)

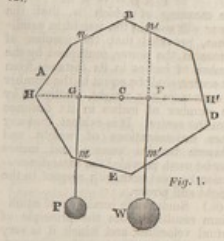


Fig. 1.

Let us suppose that A B D E (*fig.* 1.) is the section of a solid body, moveable on a fixed axis, and taken in a plane perpendicular to that fixed axis; and suppose the axis passes through the plane of the section at C. The axis being supposed horizontal, the section A B D E will be vertical. Through C suppose the horizontal line H C H' to be drawn, and let the weight W, to be sustained, be applied at F, and the power P which supports it be applied at G. Let us consider, then, under what conditions P can support W, conformably to the principle of *virtual velocities*. If the machine be put in motion round the centre C, so that P shall descend and W ascend; the points G and F, to which the power and weight are applied, will commence to move through similar circular arcs, having C as their common centre, and C G and C F as their radii. These arcs, if taken of small magnitudes, will then be the spaces through which the power and weight will move in the vertical direction; and whatever be their magnitudes, they will be proportional to the vertical motions of these weights. But these arcs being similar, are proportional to their radii; and hence follows, what indeed is otherwise abundantly evident, that the perpendicular descent of P is to the corresponding ascent of W, as the distances C G and C F of the points, at which these forces are applied, from the centre C. These distances C G and C F may be taken to represent the vertical velocities of the power and weight; and if C G

and C F be called p and w, the condition on which the power P shall support the weight W, will, according to the principle of virtual velocities, be

$$P : W :: w : p,$$

or $P \times p = W \times w$.

The meaning of which is, that the power will sustain the weight in equilibrium, provided that the number of ounces in the power, multiplied by the number of inches in its distance from the centre, shall be equal to the number of ounces in the weight, multiplied by the number of inches in its distance from the centre. It is evident, that any other denominations of weight and measure besides ounces and inches may be used, provided the *same denomination* be used both with respect to the weight and power.

(8.) Such is the condition of equilibrium resulting from the principle of virtual velocities, and which it is very easy to submit to the test of experiment. Let a weight W, amounting to any number of ounces, be suspended at the point F, and let the number of inches in C F be exactly measured. Suppose that 12 ounces are suspended, and that C F is 8 inches. Now take any distance C G on the other side, and suppose that distance 32 inches, and that a weight of three ounces be suspended, it will be found, that equilibrium shall be preserved, and that the power shall exactly balance the weight; and, accordingly, the product of 3 and 32 is exactly equal to the product of 12 and 8.

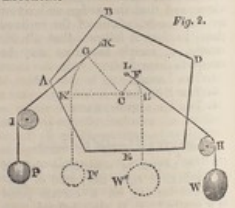
Again, if instead of 32 inches C G is 24 inches, it will then be found to require a power of 4 ounces to balance the same weight. The product of 4 and 24 is 96, as before. In the same way, however we may change the distance of the power from the centre, it will be necessary to change its amount, so that the product of the number of ounces in it, by the number of inches in the distance, shall be equal to 96, in order that it shall exactly balance the weight. If in any case the product exceed 96, the power will preponderate; and if the product be less than 96, the weight will preponderate.

It appears, therefore, that the same weight W, at the same distance C F from the centre, may be balanced by innumerable different powers. In fact, a power of any magnitude whatever, great or small, may balance it, provided that the distance of that power from the centre be so regulated, that when multiplied by the power itself, the product shall be equal to the product of the weight multiplied by *its* distance from the centre.

It is evident, that the efforts which the power and weight make to turn the machine round the centre C, will be the same, to whatever point in the lines G m or F m', the strings supporting the power and weight may be attached, or even though they be attached to points in the lines G n and F n' above the points G and F. Thus it appears, that in estimating the distances of the power and weight from the centre, we are not to take the distances of the points of suspension; but the perpendiculars drawn from the centre C to direction $n\,m$ and $n'\,m'$ in which the power and weight act. Thus, if the power and weight were suspended from n and m', we should still consider C G and CF to be their distances from the centre.

In like manner, the directions of the power and weight may not happen to be parallel, as in the example we have taken; but still their distances from the centre of motion are estimated by perpendiculars from that point upon their directions.

Fig. 2.



Let the point of application of the weight be L (*fig.* 2.) and let the string by which the weight acts pass over a wheel H; and in like manner let the power act by a string at K passing over a wheel I. In this case, L H is the direction of the weight, and K I that of the power. Suppose the perpendicular C F and C G drawn upon their directions; the condition of equilibrium will still be the same; viz. that the product of the power P, and the perpendicular C G shall be equal to the product of the weight W and the perpendicular C F. This may easily be established experimentally.

From all that we have stated, it follows, that the effort of any force to turn a body round an axis, is to be measured by multiplying the force by the perpendicular from the axis on its direction. The product thus obtained is called the *moment* of the force round that axis. This is a principle of such extreme importance, that we shall develop it somewhat further.

(9.) To establish satisfactorily the proposition, that the efficacy of a force to turn a machine round an axis is measured by its *moment*, we ought to prove, that if the moment be doubled or halved, or increased, or decreased, in any proportion, the efficacy of the force in turning the machine round the axle is doubled or halved, or increased or decreased in exactly the same proportion: this may be very easily proved by experiment.

Let the weight W act perpendicularly to the line C F. We shall assume as a self-evident truth, that if the weight W be doubled or halved, or increased or decreased in any proportion, its effort to turn the machine round C will be doubled or halved, or increased or decreased in the same proportion.

Let the power P at the distance C G balance the weight W at the distance C F. Hence the product P × C G must be equal to W × C F. Now, suppose that the power P, or its distance C G from the centre, or both, be so increased, that the moment P × C G shall be doubled, it is evident, that, in order to preserve equilibrium, it will be necessary that the moment W × C F shall be also doubled; and if the distance C F be preserved, this can only be done by doubling W. Hence the double moment P × C G will balance a double weight acting at the same distance C F, and therefore must have a double effect in turning the machine round its centre. In the same manner exactly it may be proved, that in whatever manner the moment P × C G may be varied by the change of the power P, or the distance C G, or both, the weight W must suffer a proportional change, the distance C F remaining unaltered: but the effort to turn the machine round the centre is in this case proportional to the weight W.

(10.) We therefore conclude that the effort of any force to turn a machine round its axis, is rightly measured by the moment of that force round that axis.

Hence, if several forces tend to turn any body round its axis, they will sustain it in equilibrium *if the sum of the moments of those forces which tend to turn it round in one direction, be equal to the sum of the moments of the forces which tend to turn it round in the other direction.* For then, according to what we have just proved, the sum of the efforts which tend to turn the body round in one direction, will be exactly equal to the sum of the efforts which tend to turn it round in the other direction.

This, which is the most general view which can be taken of the lever, may be illustrated by experiment as follows:—

Let a circular board be placed with its plane vertical, and turning upon an horizontal axle C (*fig.* 3.) and let strings

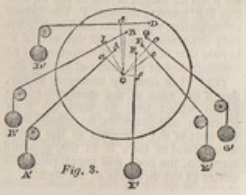


Fig. 3.

be attached to pins A, B, D, E, F; and let these strings be drawn by weights in different directions, passing over fixed wheels as represented in the figure. Let the board drawn by these strings settle itself until it come to a state of equilibrium. Then draw from the centre C perpendiculars C a, C b, C d, C e, &c. on the directions of the strings, and measure the lengths of these lines. Multiply the weights A′, B′, D′ by the perpendiculars C a, C b, C d, and the products A′ × C a, B′ × C b, D′ × C d, will express the effort of each weight to turn the board round in one direction. Multiply the weights E′, F′, G′, by the perpendiculars C e, C f, C g; and the products E′ × C e, F × C f, G′ × C g, will express the effort of each of these weights to turn the board round in the other direction. Now, it will be found that the sum of the former products is equal to the sum of the latter; that is,*

* We have endeavoured, as far as possible, in these treatises on MECHANICS, to give the various conditions in a popular form, and divested of gross

$A \times Ca + B \times Cb + D \times Cd = E \times Ce + F \times Cf + G \times Cg$; that is, that the sum of the efforts to turn the board round in one direction, is equal to the sum of the efforts to turn it round in the other direction.

(11.) We have hitherto neglected to consider the weight of the machine itself, the axis being always supposed to pass through the centre of gravity. If this be not the case, we have only to consider the weight of the machine itself as one of the weights or forces which are applied to it, and that this force is applied in a vertical direction at the centre of gravity. Thus, for example, in the last experiment, let us suppose the weights A', B', D', E', G' to be the forces which act upon the board. Let F be the centre of gravity of the board, and let F be its weight acting in the vertical line F F' passing through F. The former investigation will remain unchanged, the only difference being that the weight F is now that of the board conceived to be concentrated at its centre of gravity F.

(12.) It is scarcely necessary to say, that if the sum of the moments of the forces which tend to turn the body round in one direction, be greater than the sum of the moments of the forces which tend to turn it in the opposite direction, the body will move round its centre in the direction of the former.

Chapter III.—*Straight Levers—three kinds—Lever bearing several Weights—Beam bearing a Weight and resting on two Props—Pressure on the Fulcrum of a Lever—Load borne on Poles.*

(13.) A Lever considered as a bar or rod, supported on a prop or fulcrum, is of three kinds, according to the position of the power and weight with respect to the prop.

If the prop be in the middle, the lever is said to be of the *first kind*; if the weight be in the middle, it is of the *second kind*; and if the power be in the middle, it is a lever of the *third kind*.

(14.) A lever of the first kind is represented in *fig.* 4. If we neglect in

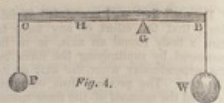
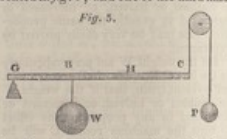


Fig. 4.

the first instance, the weight of the bar itself, or suppose the centre of gravity to be placed immediately over the prop G, the efforts of the power and weight to turn the lever in opposite directions are $P \times p$ and $W \times w$, p and w being C G and B G; and in order that equilibrium should subsist, these must be equal (7.) that is $P \times p = W \times w$.

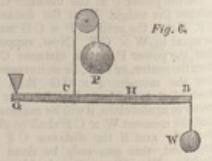
A lever of the second kind is represented in *fig.* 5; and one of the third kind

Fig. 5.



in *fig.* 6. What we have just observed respecting the power and weight

Fig. 6.



in levers of the first kind, also applies to those of the second and third kinds.

(15.) The condition of equilibrium in the straight lever being that the product $P \times p$ should be equal to $W \times w$, it follows, that the power P may be diminished indefinitely by increasing its distance p from the prop indefinitely, for what the magnitude of the product $P \times p$ loses by the diminution of P, it will gain by the increase of p.

There is another way in which the power which supports a given weight by means of a lever may be indefinitely diminished, and yet its distance from the prop may be preserved. Let the distance w of the weight from the prop be diminished until the product $W \times w$ becomes equal to $P \times p$.

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trical reasoning or algebraical notation. The student, however, will find his progress most materially facilitated by the acquisition even of a very small portion of the first elements of Geometry and Algebra. For students who only seek this limited knowledge of these sciences, there are perhaps no treatises which can be read with more advantage than Dar-LEY's *Popular Geometry and Algebra*.

Thus the mechanical efficacy of this machine increases as the distance of the power from the prop is increased, and as the distance of the weight from the prop is diminished.

(16.) It is evident on inspection, that in a lever of the *second kind*, the power must necessarily be less than the weight, since it must be farther from the fulcrum; and in a lever of the *third kind* it must be greater than the weight because it is nearer to the fulcrum.

It appears also, that in a lever of the first kind the power and weight act in the *same direction*, both acting downwards; while in those of the second and third kinds they act in opposite directions.

In the lever of the third kind there is a mechanical disadvantage, the power being greater than the weight, and therefore, this species of lever is never used except in cases in which velocity, and not power, is wanted; for it will be remembered that the velocities of the power and weight are as their distances from the prop (7).

(17.) If the centre of gravity of the bar itself be not over the prop, the weight of the bar must be taken into account. Let this be G, and let the distance of the centre of gravity from the prop be g. The moment of this is $G \times g$. If this force tend to turn the lever in the same direction with the power, the condition of equilibrium is

$$P \times p + G \times g = W \times w.$$

But if it conspire with the force of the weight, the condition is

$$P \times p = W \times w + G \times g.$$

If the lever be of uniform thickness, its centre of gravity will be at its middle point. In a lever of the first kind, the whole length is equal to $p + w$; and therefore, if H (*fig.* 4.) be the centre of gravity, C H is equal to $\frac{1}{2}p + \frac{1}{2}w$; but H G or g is equal to C G − H C = $p - \frac{1}{2}p - \frac{1}{2}w = \frac{1}{2}p - \frac{1}{2}w$. Hence, $g = \frac{1}{2}(p - w)$. That is, the distance of the centre of gravity from the prop is equal to half the difference of the arms.

In levers of the second and third kinds, when they are of uniform thickness, the distance of the centre of gravity from the prop is half the length of the arm, the lever being supposed to extend only on one side of the prop. If it extend on both sides, the distance is the same as in the last case.

(18.) If the arms of the lever be not straight but curved, as in *fig.* 7, the distances p and w are the perpendicu-



Fig. 7.

lars G B, G C, drawn from the prop upon the directions of the power and weight. But still the condition of equilibrium remains the same, $P \times p = W \times w$. (7.)

(19.) Also, if the power and weight be not parallel, as in *fig.* 8, the dis-

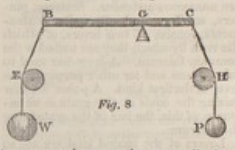


Fig. 8

tances p and w are the perpendiculars drawn from the prop upon the directions of the strings which act upon the lever, and which are drawn by the power and weight.

(20.) If several weights act upon different sides of the prop, as in *fig.* 9,

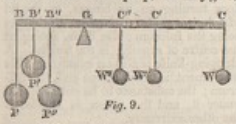
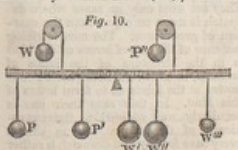


Fig. 9.

or in different directions on the same side, the condition of equilibrium is immediately derived from (10.); viz. the

Fig. 10.



sum of the moments of those which tend to turn the machine round in one direction is equal to the sum of mo-

ments of those which tend to turn it round in the other.

Thus, if the several weights which tend to turn the lever round in one way be P, P′, P″, and their distances from the prop be p, p', p''; and those which tend to turn it in the opposite way be W, W′, W″, W‴, and their distances from the prop be w, w', w'', w'''; the condition of equilibrium is

$$P \times p + P' \times p' + P'' \times p'' = W \times w + W' \times w' + W'' \times w'' + W''' \times w'''.$$

If the centre of gravity be not over the prop, the moment $G \times g$ must be added to whichever of these the weight of the machine conspires with.

(21.) Of levers of the first kind there are numerous instances. Scissars, pincers, snuffers, and all similar instruments, consist of two levers, of which the rivet by which they are united is the common fulcrum. A crow-bar used to raise stones and for other purposes, is a lever of the first kind. A poker used for raising the coals in the grate is an instance of this, the bar of the grate being the fulcrum.

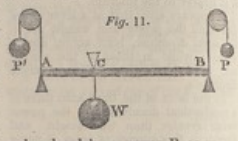
Levers of the second kind are not so frequent, yet several instances of them occur. The oar of a boat is an instance. In this case, the water against which the blade presses is the fulcrum, the boat is the weight, and the hand of the rower is the power. The rudder is another instance of the same kind. A door turning on its hinges, or the lid of a desk, are also examples; the hinges being the fulcrum; the door, acting at the centre of gravity, is the weight. A chipping-knife is also an example. This instrument is fixed at one end, the fulcrum; the substance to be cut is placed under it, and the power is applied at the other extremity.

Levers of the third kind, having a mechanical disadvantage, as we have already proved, are the least common. They are used only in cases where despatch is more an object than the exertion of great force. The most striking instance of the use of levers of this kind is in the structure of the limbs of animals, in which the bones are so connected at the joints as to form levers of this kind. In this case their use is peculiarly well adapted to the convenience of the animal, for in almost every case facility and despatch is rather an object than the exertion of intense force. Tongs are also an instance of this species of lever; and shears for shearing sheep.

In elevating a ladder, it is first a lever of the second and afterwards of the third kind. While the centre of gravity is between the hands that raise it and the end on which it rests, it is a lever of the second kind, and when the hands pass the centre of gravity it becomes a lever of the third kind.

(22.) A bar supporting a weight by two props acts on the principles of a lever. Suppose the prop B removed

Fig. 11.



and replaced by a power P, as represented in the figure; that power will evidently represent the pressure of the weight W on the prop B. Now, by the principles already established are

$$P \times A\,B = W \times A\,C,$$

and therefore,

$$P = W \times \frac{AC}{AB};$$

and in exactly the same manner, if P′ represent the pressure on the prop A, we find

$$P' = W \times \frac{BC}{AB}.$$

The pressure on each prop is therefore a certain fractional part of the weight, viz. that fraction whose numerator is the distance of the weight from the other prop, and whose denominator is the distance between the props.

It follows from this that the sum of the pressures is equal to the weight, and that the weight is distributed between the props in the *inverse* proportion of its distances from them.

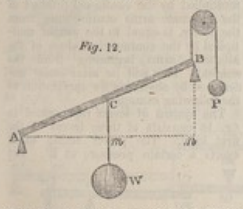
(23.) It easily follows from this, that the pressure upon the fulcrum of a lever of the second or third kind is equal to the *difference* between the power and weight. For if A be considered as the fulcrum, W the weight, and P the power; the lever will be of the second kind, and P′ will be the pressure on the fulcrum; and by what we have already proved, P′ is the difference between W and P. If P be considered as the weight, and W as the power, it is a lever of the third kind, and the same observation applies.

If at C a fulcrum be placed presented downwards, and the weight W be removed, and in place of the props A and

B, the weights P′ and P act at those points, the pressure on the fulcrum C will evidently be equal to the weight W which was removed. But W is equal to the sum of P′ and P, and in this case the lever is one of the first kind. Hence, in a lever of the first kind, the pressure on the fulcrum is equal to the sum of the power and weight.

(24.) In (22) we supposed that the bar which sustains the weight rests on the props in a horizontal position. But the conclusions which we have deduced are equally true if the bar be inclined to the horizon and the weight is distributed between the props precisely in the same proportion. For let A B (*fig.* 12.) be the beam, and, as before, let the prop B be replaced by a weight P acting over a wheel, and let the vertical line in which the string

Fig. 12.



from B acts be B n, and let C W be the direction of the weight. This is a lever of the second kind, and by (14) it follows that

$$P : W :: A\,m : A\,n.$$

But since C m and B n are parallel, it follows by the principles of geometry that $A\,m : A\,n :: A\,C : A\,B$. Hence

$$P : W :: A\,C : A\,B$$

or $$P = W \times \frac{AC}{AB}$$

which is the same value as we obtained for the pressure on the prop B when we supposed the beam A B to be horizontal.

Hence it appears that, whether the beam be horizontal or inclined, the weight is distributed between the props in the same proportion.

From what we have established in (22) it follows, that when the weight is placed at the middle point of the beam, it is equally distributed between the props, each prop bearing half of it.

(25.) When two men bear a weight on poles, the proportion sustained by each is to be determined on the principles which we have just established, and when it is, as is usual, placed in the centre between them, each bearer carries half the load. If the centre of gravity of the load be in the plane of the poles which support it, this equal distribution of the load continues whether the bearers move on a level plane or on a declivity. If, however, the centre of gravity be above or below the poles, the load is not equally distributed if the bearers are on an ascent or descent. In this case let G (*fig.* 13.) be the centre of

Fig. 13.

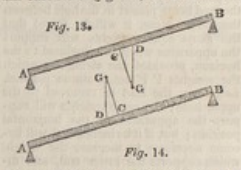


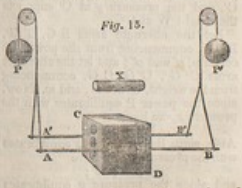
Fig. 14.

gravity of the load below the poles A B, and through G draw the vertical line G D. Since the weight acts as if it were collected at the centre of gravity, it must produce the same effect as if it were suspended from D, and consequently is distributed between the bearers A and B in the proportion of B D to A D, and consequently it presses more severely on the upper bearer B.

But if, on the other hand, the centre of gravity be *above* the beam, the weight, acting as if it were placed at D (*fig.* 14.), is distributed between the bearers A B in the proportion B D to A D, and therefore presses more severely on the lower bearer A.

This may be proved experimentally by providing two straight bars, A B, A′B′, (*fig.* 15.) and attaching them to the sides

Fig. 15.



of a block of wood C D, which is pierced with three holes, in any of which may

be placed a cylindrical piece of lead X. Let the apparatus be so adjusted that when the lead is put into the hole between the bars, the centre of gravity will be between them, and that the centre of gravity will be below or above them when the lead is put into the hole which is below or above the bars. Let strings be attached to the extremities of the bars, and passing them over wheels as represented in the figure, let the whole apparatus be supported in the horizontal position by equal weights, P and P′, the lead being placed in the hole between the bars. Now, it will be found that the same equal weights will support the apparatus when it is inclined to the horizon, provided the strings by which the weights P P′ act continue parallel. Let, then, the lead be removed to the upper hole; the same weights will support the apparatus in the horizontal position; but if it be inclined, it will become necessary to increase the weight which supports the lower end, and diminish that which supports the upper end. On the other hand, if the lead be placed in the lower hole, when the apparatus is inclined, it will be necessary to increase the weight which supports the upper end, and to diminish that which supports the lower end.

Throughout these experiments the strings which support the weights should be kept parallel.

Mechanical writers have sometimes investigated this problem erroneously.

CHAPTER IV.—*Compound Levers—Rectangular Lever—Weighing Machine—All simple and complex Machines reducible to equivalent Levers.*

(26.) THE power may act upon the weight through the intervention of a series of levers, in which case the apparatus is called a *composition of levers*, or a *compound lever*. There is one general condition which applies to every combination of levers, *viz.* that "When the system is in equilibrium, the power multiplied by the continued product of the alternate arms commencing from the power, is equal to the weight multiplied by the continued product of the alternate arms beginning from the weight." This will be more easily understood by observing its application to the following examples.

The system of levers represented in *fig.* 16 consists of three levers of the first kind. The power acting at B exerts a certain pressure at B′. Let

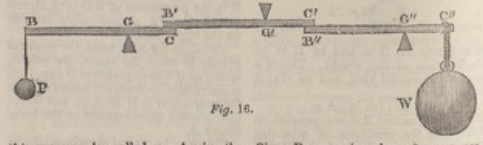


Fig. 16.

this pressure be called x. Again, the pressure x by means of the lever B′ C′ produces a pressure, which we call y, at G′, and the pressure y at C′ supports the weight W at C″.

Let the alternate arms B G, B′ G′, B″ G″, commencing from the power, be called p, p' and p''; and let the alternate arms C″ G″, C′ G′, C G, commencing from the weight, be w'', w', and w. Now, since the power P equilibrates with the pressure x, we have

$$P\,p = x\,.\,w.$$

Also, since the pressure x equilibrates with the pressure y, we have

$$x\,p' = y\,w';$$

and since the pressure y equilibrates with the weight W, we have

$$y\,p'' = W\,.\,w''.$$

Since P p, x p', and y p'' are respectively equal to x w, y w', and W w'', it follows that, if the former be multiplied together, they will be equal to the latter multiplied together. Hence we have

$$P\,p\,x\,p'\,y\,p'' = x\,w\,y\,w'\,W\,w''.$$

In these equal products, by omitting the common multipliers x and y, we obtain

$$P\,.\,p\,p'\,p'' = W\,w\,w'\,w'';^*$$

that is, *the power multiplied by the continued product of the alternate arms commencing from the power, is equal to the weight multiplied by the continued product of the alternate arms commencing from the weight.*

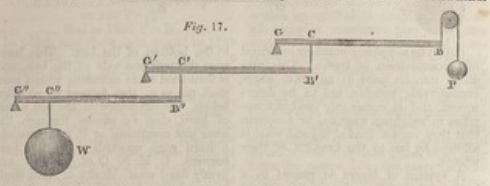
Those students who are not sufficiently masters of the signification of the algebraic notation to follow the preceding very simple proof, may easily be satisfied of the truth of the result by actual experiment.

* See DARLEY'S *Algebra*, p. 61.

Let us suppose that the arms p, p', p'', are 4, 6 and 8 inches respectively, and that w, w', w'' are 1, 2 and 3 inches; it will be found that a power of two ounces at B will sustain a weight of 64 ounces at C″. In this case we have the product $2 \times 4 \times 6 \times 8$ equal to 384, and the product $64 \times 1 \times 2 \times 3$ also equal to 384; and the same would be found to be true of any power and weight which would balance each other.

The demonstration which we have given above of the condition of equilibrium will be found to apply equally to any system of compound levers. *Fig.* 17 is a system of levers of the second kind.

Fig. 17.



The alternate arms, beginning from the power, and those beginning from the weight, are marked by the same letter as in *fig.* 16.

In *fig.* 18, we have represented a system of mixed levers, some of the first, and some of the second, kind. The same condition establishes the equilibrium.

(27.) A rectangular lever is a form

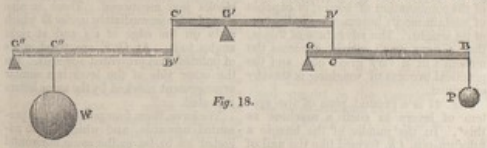
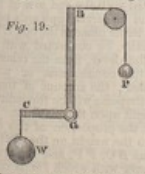


Fig. 18.

not unfrequently used, and is governed by the same condition of equilibrium as other levers. Such a lever is represented in *fig.* 19. The weight W is

Fig. 19.



suspended from the shorter arm G C or w, and the power P from the longer G B, or p: the condition of equilibrium is evidently

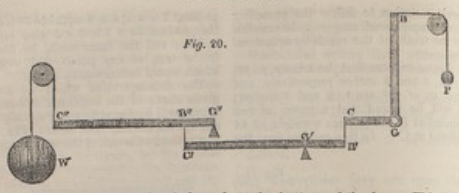
$$P\,p = W\cdot w.$$

When a hammer is used for drawing a nail it is a lever of this kind, G C being the claw and G B the handle. In this and all the other cases which we have now noticed, we consider the axis, or fulcrum, to pass through the centre of gravity of the lever, and therefore we have not attended to the effect of the weight of the bar itself.

The condition of equilibrium in the rectangular lever may be verified by experiment in a manner similar to the other cases, by suspending such weights as will produce equilibrium, and multiplying them by the lengths of the arms by which they respectively act, and showing that $P\,p = W\,w$.

(28.) The rectangular lever may form part of a compound system, as in *fig.* 20; but the general condition of equilibrium established in (7.) will still be applicable.

Fig. 20.

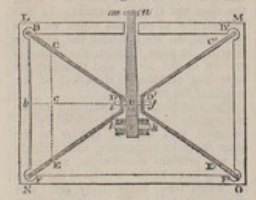


(29.) The *weighing-machine* is formed of a composition of levers. This machine may be used in any case where considerable weights are to be determined, and is commonly used at turnpikes in weighing wagons, to ascertain that they are not loaded beyond what is allowed by law to the breadth of their wheels.

A system of levers is placed in a horizontal position in a box about a foot deep, so that a platform supported by the levers shall be on a level with the road; the wagon to be weighed being rolled upon the platform, the power which, through the intervention of the combination of levers, is capable of sustaining it, becomes an indication of its weight. The advantage of this is, that a very small weight becomes the measure of a very great one, and the practical process of weighing is thereby expedited.

Fig. 21 is a ground plan of the system of levers in such a machine as this*. In the middle of the box is a fulcrum-pin, *l k*, formed like the nail of

Fig. 21.



a balance, which rests with its edge on arches of hardened steel firmly fastened to the bottom of the box. This lever goes through one side of the box, and is furnished at its extremity with a hard steel pin *m n*, also formed to an edge below. In the centre of the box a nail of hard steel *i j* passes through the lever just mentioned at P, and presents a hard edge upwards. In the four corners L M N O of the box are firmly fixed small blocks of hard steel, having hollow hemispherical cavities or cups in their upper surfaces. B C D E F represent the upper edge of a strong iron bar, having hard steel studs on its lower surface at B and F, which rest in the cups or cavities of the steel blocks just mentioned. There is also a hard edge immediately under D which rests on the edge of *i j* and at right angles to it. At C E are fixed studs of pointed steel presented upwards. On the other side of the lever is a similar arrangement marked by the same letters accented.

We have, then, four pointed studs presented upwards, and which are so adjusted as to be in the same horizontal plane. On these studs the platform rests on which the body to be weighed is placed.

Now, suppose that a wire or rod be connected with the end *m n* of the lever F P, and be carried upwards perpendicularly to the plane of the box L M O N, and finally, be connected with the end of another lever, from the other arm of which the counterpoise or power is suspended; the amount of that power or counterpoise will be the indication of the weight upon the platform. To determine the proportion of this counterpoise to the weight on the platform, let the arms B C, F P, and the arm of the final lever with which *l m* is connected be w, w' and w'' respectively, and let B D, F *m* and the arm of the final lever on which the power acts be p, p', and p'' respectively. The four levers B D', B D, F D, F' D', being perfectly equal and similar, the effect of the weight distributed amongst them is the same as if the whole weight rested upon any one. Hence the condition of equilibrium is

$$P \times p\, p'\, p'' = W \times w\, w'\, w''.$$

Thus, if w and w' be each one foot, and that p and p' be each 10 feet, and if w'' be one inch, and p'' be one foot; we have

$$P \times 10 \times 10 \times 1 = W \times 1 \times 1 \times \tfrac{1}{12}$$

$$\text{or } 100\,P = \tfrac{W}{12}$$

$$\text{that is } 1200\,P = W.$$

In which case the weight would be 1200 times the counterpoise, and thus a weight of one pound would balance 1200 lbs.

By a proper adjustment of the levers, the indicating weight might be made to have any convenient relation to the weight to be ascertained. Thus one ounce might correspond to one hundred weight. This would be effected if w and w' were each one foot, and p were 8 feet, p'' 16 feet, and w'' one inch, and p'' 14 inches: for then we should have

$$P \times 8 \times 16 \times \tfrac{1}{14} = W \times 1 \times 1 \times \tfrac{1}{12}$$

$$\text{or } 1792\,P = W;$$

that is, the weight is 1792 times the counterpoise; and since there are 1792 ounces in one hundred weight, it follows, that one ounce will balance an hundred weight.

(30.) The *mechanical efficacy* of a machine depends on the ratio of the weight to the power, and is said to be greater or less according as this ratio is greater or less. It might be well at once to define the mechanical efficacy to be the numerical quota arising from the division of the weight by the power. Thus, if the weight be ten times the power, the mechanical efficacy is ten. If three times the weight is equal to twenty times the power, the mechanical efficacy is $\frac{20}{3}$ or $6\frac{2}{3}$. It follows, therefore, that when this quantity is a proper fraction, what in ordinary cases is mechanical efficacy, becomes a mechanical disadvantage, as when the weight is half the power. We have already seen when the power on the lever is between the weight and prop, the machine acts in this way under a mechanical disadvantage.

(31.) The same lever admits of having its mechanical efficacy varied at pleasure, by changing the positions of the power and weight with respect to the prop, so that it may be made to act with any given mechanical efficacy, or even with any mechanical disadvantage. This is a property in which it is distinguished from most other simple machines, and one which renders it a convenient standard or modulus for representing all other machines. Whatever be the proportion of the power and weight in any machine, a lever may be assigned in which the power and weight will have the same proportion, and which, therefore, we call an *equivalent lever*.

As all simple machines may be represented by equivalent simple levers, so all complex machines may be represented by equivalent systems of compound levers. To effect this, it is only necessary to determine the proportion of the power to the weight in all the simple component machines, which, in the complex machine under consideration, are interposed between the weight and the power, and take a series of levers whose alternate arms, beginning from the power, bear the same proportions to the remaining arms respectively. Such a system of levers will be *mechanically equivalent* to the complex machine.

Hence, and from the result of (26) it follows, that in any complex machine, the proportion of the power to the weight may be easily assigned, provided the proportions of the power to the weight in the simple component machines are known. For let these proportions be $w : p$, $w' : p'$ and $w'' : p''$; then the proportion of the power and weight in the complex machine will be determined by

$$P.\, p\, p'\, p'' = W.\, w\, w'\, w''.$$

When we say that a lever or a system of levers can always be found which are *mechanically equivalent* to any given machine, we would be understood to mean only, that the same power will sustain the same weight in each, but by no means implying that all the mechanical functions of each species of machine can be discharged by a system of levers.

CHAPTER V.—*The Balance—common Balance with equal Arms—its requisites—sensibility—Method of detecting a fraudulent Balance—Steel-yard—Danish Balance—bent lever Balance—Brady's Balance.*

(32.) THE BALANCE is an instrument used for determining the weights of bodies, by showing their relation to the weights of some other bodies which are known, or which are assumed as general

* For a more detailed account of this machine, see GREGORY'S *Mechanics*, vol. ii. p. 553.

standards of weight. This is one of the most interesting and generally useful applications of the lever, and assumes various forms, according to the nature and magnitude of the substances whose weights are to be determined, and to the degree of accuracy which is required in the result.

The most usual form of the balance is that of a lever of *the first kind* with equal arms; so that the substance to be weighed being suspended from one arm, and the weights assumed as standards of comparison being suspended from the other, the equilibrium will necessarily be established when these weights are equal (14).

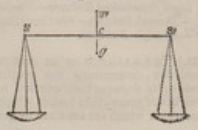
This, however, is only the general principle of the *common balance*. In its construction there are various circumstances to be attended to which are of considerable importance.

(33.) The lever which forms the balance, and which is called the *beam*, should be so constructed that its centre of gravity should be immediately *under* the axis or centre of motion. For if the centre of gravity were itself the centre of motion, the beam would rest indifferently in any position; whereas the equality of the weights is determined by its assuming the horizontal position. If the centre of gravity were above the centre of motion, the least disturbance would cause the beam to upset. (*Treatise I.* chap. iv.)

The centre of gravity being, by the construction of the beam, beneath the centre of motion, the line joining it with the centre of motion will, when the beam is unloaded, always settle itself so as to be in a vertical direction.

(34.) The substance to be weighed, and the weights with which it is compared, are placed in dishes suspended from points at the extremities of the beam, called the *points of suspension*. These points should be so placed, that a straight line drawn joining them shall be perpendicular to the straight line which is drawn joining the centres of

Fig. 22.



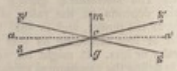
gravity and motion, and so that it shall be divided by that line into two equal parts.

That is, if S and S′ (*fig.* 22.) be the points of suspension, *m* the centre of motion, and *g* the centre of gravity of the beam; the lines S S′ and *m g* should intersect at *c* at right angles, and S *c* should be equal to S′ *c*.

The beam being thus constructed, the point *g* will, by the properties of the centre of gravity explained in *Treatise I.* settle itself vertically below *m*, so that *m g* shall be perpendicular to an horizontal plane. The line S S′, being perpendicular to *g m*, will in that case be horizontal.

(35.) In order to exhibit, in using the balance, the direction of the line *m g* (*fig.* 23.) a needle or index is attached to the beam, which sometimes plays upon a graduated arch; and when it is directed to that point of the arch which is in a vertical line passing through the centre of motion, the line S S′ will be horizontal, and the line *m g*, which is the direction of the index, will be vertical. This, as we shall presently see, is the position of the balance which indicates the equality of the weights suspended from S and S′.

Fig. 23.

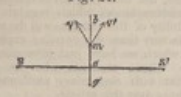


(36.) The practical determination of all these circumstances in a beam is not difficult. Under any circumstances, the line *m g*, when the beam is at rest, will be vertical. In order to determine whether S S′ is in that case horizontal or perpendicular to *m g*, let the beam be suspended against a vertical plane, and mark the points on the plane at which S and S′ are placed. Then lift the beam off its centre and reverse it. If it be found that S′ exactly takes the place of S, and S of S′, then the line S S′ is horizontal, and at right angles to *m g* but otherwise not. To explain this more clearly, let us suppose, that the line S S′ is, in the first instance, not perpendicular to *m g*, but that it deviates from the perpendicular *a c* by the angle S *c a*. Let the position of the points S and S′ on the vertical plane against which the beam is suspended be marked, and let the beam be reversed. When reversed,

it will assume the position represented by the faint line, the arm S′*c* being as much above the horizontal line *a c* as it was when on the other side above the horizontal line *a′c*; but that is evidently as much as the arm S *c* was below the horizontal line *a c*. Hence, it is quite apparent, that if the positions of the points S and S′ below and above the line *a c* before and after reversion be noted, half the angle S′ *c* S will be the deviation of the line S *c* or S S′ from the perpendicular *aa′*.

(37.) A process somewhat similar to this serves to determine the deviation of the index from the direction of the line *g m* (*fig.* 24.) Suppose that the previous adjustment has been made, and that the line S S′ is perpendicular to *g m*; but

Fig. 24.



still that the index *m v* deviates from the direction of *g m* by the angle *b m v*. It is necessary to determine practically whether any such deviation exists, and if so, to what amount.

As before, suppose the beam suspended against a vertical plane, and the position of the point *v* marked. Let the beam be reversed, and the index will assume the position *mv′*, deviating as much to the left side of the true direction *mb* as it before deviated to the right. The point *v′* being then marked, the angle *v′ m v* will be twice the deviation of the index from its true position.

The common commercial balance is usually sustained upon a loop of metal on which the beam rests by a knife edge. In this case, when the beam is unloaded, the index ought to settle exactly between the sides of the loop, and it should always be in this position when equal weights are suspended from S and S′.

(38.) The several adjustments which we have now described being made, it will be evident that, when equal weights are suspended from S S′, the beam will maintain its horizontal position. For the perpendicular distances of the vertical lines through S and S′, which are the directions in which the weights act are equal, being, in fact, S *c* and S *c′*. Hence these distances, when multiplied by the equal weights, will give equal products, and therefore the weights will have equal tendencies to turn the machine in opposite directions round the centre of motion *m*, and, consequently, they will mutually destroy each other's effects, and the instrument will maintain the position it had when unloaded.

But let us consider what would be the consequence if unequal weights were suspended from S and S′. Let W be suspended from S, and W′ from S′, and let W be the greater. Let the common length of the arms S *c* and S′ *c* be *a*.

The tendency of the weight W to depress the arm S *c* is measured by the product of this weight, and the length *a* of the arm S *c* or W × *a*; and the tendency of the weight W′ to resist this is the product of the weight W′ and the arm S′*c*, or W′ × *a*. Now, as W is greater than W′, the product of W and *a* must be greater than the product of W′ and *a*, and therefore the tendency of W to depress the arm S *c* is greater than the tendency of W′ to resist that, and therefore the arm S *c* will fall and S′ *c* will rise.

It appears, therefore, that if the balance be properly constructed, and the several adjustments which we have pointed out be attended to, it will only maintain that position in which the beam is horizontal, and the index vertical, when loaded with equal weights; but that if either weight be greater than the other, it will always incline in the direction of the greater weight.

The *sensibility* of a balance is measured by the smallness of the difference of weights which turns the index from its unloaded position *m o*, and by the greatness of the deviation *v m o* from the unloaded position which that difference produces. To explain this more fully, let us suppose that, W being greater than W′, the beam rests in equilibrium in the position represented in *fig.* 25.

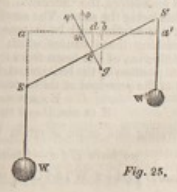


Fig. 25.

Let the weight of the entire beam be G. Through m let a line $a\,m\,a'$ be conceived to be drawn perpendicular to the directions of the weights, and therefore horizontal. Through c draw $c\,d$ perpendicular to $a\,a'$, and therefore parallel to S a and S′ a', and parallel to the same lines let $g\,b$ be drawn. The machine is thus maintained in equilibrium on its centre m by three weights, viz. W in the direction a S, W′ in the direction S′ a', and G acting at the centre of gravity (*Treatise I.* chap. iv.) of the beam, and in the direction $b\,g$. The weight W tends to turn the system round in one direction, and the weights G and W′ tend to turn it round in the other direction; and since these tendencies mutually counteract each other, the product $W \times a\,m$, of the weight W and its leverage $a\,m$ must be equal to $(W' \times a'\,m + G \times b\,m)$ the sum of the products of the weights W′ and G multiplied into their respective leverages $a'\,m$ and $b\,m$.

Since c is the middle point of the line S S′, and since S a, $c\,d$, and S′ a' are parallel, d must be the middle point of the line $a\,a'$, and therefore $a\,m$ will be obviously less than $a'\,m$, and therefore, in the present position of the beam, W acts with a less leverage than W′. A little attention to the figure will show that, as the weight W depresses the beam, it continually loses its leverage, and that, on the other hand, W′ is continually gaining leverage on W. Besides this, the weight of the beam G, which, in the unloaded position, had no leverage, gains leverage continually as W depresses S, and conspires with W′ in resisting the descent of S by the force of the heavier weight W. This being the state of the forces, they must come to equilibrium after the beam has turned from its unloaded position. Now, the greater the deviation of the beam from its unloaded position, when it attains the state of equilibrium, the greater will be its *sensibility*, the difference of the weights being the same. The sensibility then, it is evident, will be increased by diminishing those causes which resist the deflection of the beam from its unloaded position by the heavier weight W. One of the principal of these causes is the weight of the beam G acting with the leverage $b\,m$. Hence it follows, that, all other things being the same, the sensibility of a balance will be increased by diminishing the weight of the beam, and by diminishing also the distance $m\,g$ between the centres of gravity and motion, for that will evidently diminish the leverage $m\,b$.

Another cause which resists the effect of W is the relatively increased leverage of W′. This will be diminished by diminishing $m\,d$ (d being the middle point of $a\,a'$) or $c\,m$, that is, by diminishing the distance of the line which joins the points of suspension from the centre of motion.

(40.) To those students who have attained a slight knowledge of the most elementary parts of mathematical science, the following investigation of the circumstances which regulate the sensibility of the balance will be more satisfactory than the popular explanation which we have just attempted to give. Those students who are not familiar with elementary mathematics will pass over this article.

Let the angle $o\,m\,v$, by which the index is deflected from the vertical position, be D. Let $g\,m = d$, $c\,m = b$, and S c or S′ $c = a$. Since the angles $m\,c\,d$ and $m\,g\,b$ are each equal to D, by the parallels, and the angles d and b are right, we have $d\,m = b \sin D$, and $b\,m = d \sin D$. Also, since the angles formed by the lines S S′ and $a\,a'$ are equal to that formed by $m\,v$ and $m\,o$, which are respectively perpendicular to the former, that angle is equal to D, and since the angles at $a\,a'$ are right, we have S S′, $\times \cos D = a\,a'$, or $a\,a' = 2\,a \cos D$, and therefore $a\,d = a \cos D$. But $a\,m = a\,d - m\,d = a \cos D - b \sin D$, and $a'\,m = a\,d + m\,d = a \cos D + b \sin d$.

Now, suppose that the weight W consists of two parts, one equal to W′, and therefore the other E to the difference between W and W′: the combined effect of that part of W which is equal to W′, and of W′ itself, will be the same as if 2 W′ acted at the middle point c of the beam, and with the leverage $m\,d$. Hence the condition of equilibrium will be

$$E \times a\,m = 2\,W' \times m\,d + G \times m\,b, \text{ or}$$

$$E\,(a \cos D - b \sin D) = 2\,W'\,b \sin D + G\,d \sin D.$$

Dividing this entire equation by $\cos D$, observing that $\frac{\sin D}{\cos D} = \tan D$

we have $E\,(a - b \tan D) = 2\,W'\,b \tan D + G\,d \tan D$.

$\because \tan D \left\{ (E + 2\,W)\,b + G\,d \right\} = E\,a.$ $\quad \therefore \frac{\tan D}{E} = \frac{a}{G\,d + (2\,W' + E)\,b}$

The first member of this equation may be taken as the measure of the sensibility.

(41.) From the result of this investigation, the student will find no difficulty in drawing the following conclusions:—

1. That all other things being the same, the sensibility of a balance is increased by increasing the lengths of its arms.
2. That all other things being the same, the sensibility is increased, diminishing the weight of the beam.
3. That the sensibility is increased by diminishing the distance between the centres of gravity and motion.
4. That the sensibility is increased by diminishing the distance of the line, joining the points of suspension from the centre of motion.
5. That the sensibility is greater when the load is smaller.

We cannot here pursue this subject further, although numerous other interesting consequences might be deduced. We have supposed that the line joining the points of suspension is below the centre of motion. This is not always the case, and when it is above it, the formula which we have obtained for the sensibility becomes

$$\frac{\tan D}{E} = \frac{a}{G\,d - (2\,W' + E)\,b}.$$

We leave the mathematical student to pursue the effects of this modification on the sensibility.

(42.) In the practical construction of a balance of a high degree of sensibility for philosophical purposes, there are many circumstances to be attended to, which are properly enough neglected in balances used for commercial purposes.

Fig. 26.



Fig. 26. is a representation of a very sensible philosophical balance, by which very minute differences of weight may be determined. The beam S S′ has arms of equal length, and of perfectly equal and similar figures. It is very accurately placed upon knife-edges at m, which rest upon highly-polished plates of hardened steel. The beam is only allowed to rest upon the plates when in use. Two forks are placed under its arms at G G′, supported by vertical pillars, which when raised by screws which are represented at the foot of each pillar, will lift the beam from the plates on which the knife-edges rest. By this, the wear arising from the continued pressure of the edges on the plates is avoided. A needle or index is attached to the centre m and plays upon a graduated arch below, and points to zero on the arch when there is exact equilibrium. A balance such as this is generally inclosed in a glass case, and only opened sufficiently to introduce into the dishes the weights and substances to be weighed.

(43.) Commercial balances are frequently misconstructed for fraudulent purposes, by making the arm, from which the substance to be weighed is suspended, longer than that from which the counterpoise is hung, thereby giving the substance to be weighed a greater leverage and enabling it to support a counterpoise proportionally greater than itself. The end to be attained by the use of such a balance may be defeated in several ways. If the object be merely to detect the fraud, it will be sufficient, after equilibrium has been established between the substance to be weighed and the weights, to transpose them, and put the substance to be weighed in the dish in which the weights were, and *vice versâ*. If the balance be honestly constructed, the equilibrium will be undisturbed; but if it be fraudulent, the substance to be weighed will preponderate, since, after the transposition, it will have the greater leverage. But if the object be not alone to detect the fraud, but to ascertain the true weight of the substance, let the counterpoise which will produce equilibrium after transposition be found, and let this and the former counterpoise be reduced to the same denomination of weight, and let the two counterpoises thus expressed be multiplied together, and the square root of the product ex-

tracted; that square root will be the true weight. Thus, for example, if one counterpoise be 7lbs., and the other 9¼lbs., the product $7 \times 9\frac{1}{4}$lbs. is 64, the square root of which is 8. Hence 8lbs. is the true weight.

To prove this, let a and b be the arms, A and B the two counterpoises, and x the true weight. We have

$$x : A :: a : b.$$
$$B : x :: a : b.$$

Hence we may infer, that

$$x : A :: B : x.$$
$$\therefore x^2 = A\,B, x = \sqrt{A\,B}.$$

Independently of finding the true weight, or detecting the fact of a balance being fraudulent, there are several ways in which the design of the vender may be defeated.

Let the substance to be purchased be bought in two quantities nominally equal, and let these be weighed in different dishes; the resut will be, that the buyer will always get more than the just quantity, in proportion as the balance is more fraudulent. Thus, suppose that the arms of the balance were in the proportion of 11 to 12, and that two pounds of any substance be weighed in different dishes, the counterpoise in each case being just a pound: in the one case the buyer will receive eleven-twelfths of a pound, and in the other twelve-elevenths; so that in one portion he will receive one-twelfth less than one pound, and in the other he will receive one-eleventh more than a pound. Now, one-eleventh being more than one-twelfth, he will, on the whole, receive more than the just quantity, by the difference between an eleventh and a twelfth, or by $\frac{1}{11 \times 12}$ of a pound.

In general, let $a\ b$ be the arms, W the counterpoise, and x and y the two portions, nominally equal,

$$x : W :: a : b \therefore x = W.\tfrac{a}{b}$$
$$y : W :: b : a \therefore y = W.\tfrac{b}{a}$$

Hence we find,

$$x + y = W\left(\tfrac{a}{b} + \tfrac{b}{a}\right)$$

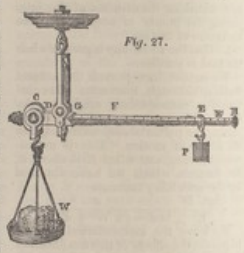
Now, the sum of a number and its reciprocal is always greater than 2, and therefore $x + y$ is greater than 2 W.

But the best way of ascertaining the true weight of a substance with a fraudulent balance, or indeed with any common balance, is to place the substance in one dish, and accurately counterpoise it with fine sand in the other. Then take out the substance to be weighed, and replace it by the weights with which it is to be compared; and the equilibrium being produced by them, the true weight will thus be determined, independent of all imperfection of the instrument.

(44.) Besides the common balance with equal arms, there are various other modifications of the lever used for determining the weights of bodies. We have already described one (the *Weighing Machine*,) for ascertaining very great weights. Those which we shall now describe are suited to ascertain the weights of smaller quantities.

The *Roman balance*, or the *common steel-yard* (*fig.* 27.) consists of a beam or a bar of iron resting upon knife-edges or

Fig. 27.



a pivot, and having one arm much longer than the other. We shall first suppose, that the shorter arm is rendered so heavy as to balance the longer arm when the instrument is unloaded, and that in that state the beam is horizontal. A hook is fixed upon the shorter arm, from which the substance to be weighed is to be suspended, and a determinate and moveable weight P slides on the longer arm. Equilibrium is established by moving the sliding-weight P from the centre G until it acquires such a leverage that it supports the weight W. The arm G B is graduated, so that it indicates the amount of the weight W at the point where the sliding-weight supports it.

The principle of this machine, and the method of graduating it, are very simple. By the general property of the lever, the condition of equilibrium is, that the weight W multiplied by its distance w from the fulcrum, is equal to the counterpoise P multiplied into its distance p from the fulcrum, or $W \times w = P \times p$. Now, since the distance w of the weight from the fulcrum always remains the same, and since the counterpoise P is not changed, it follows, that in whatever proportion W is increased or diminished, p must be increased or diminished in exactly the same proportion, in order to sustain the equality of the products we have just mentioned; that is, if W be doubled or trebled, p must be likewise doubled or trebled, and so on.

If, then, it be required to graduate the steel-yard so as to indicate to the exactness of ounces, let one ounce be suspended from C, and let the counterpoise P be moved towards G until the beam rests in the horizontal position. Then let two ounces be suspended from C, and move the counterpoise P from G until the beam rests as before. Having marked two divisions at the two positions of the counterpoise thus obtained, let the whole length of the arm G B be divided into equal divisions at the same distance, and the number of any division, beginning from that which is nearest to G, will give the number of ounces which the counterpoise P placed at that division will sustain.

If the centre of gravity of the beam be not at or under the fulcrum, the graduation must be effected differently. First, let us suppose that the centre of gravity of the beam is at D at the same side of the fulcrum with the weight. In that case the end C of the beam will preponderate when unloaded. Let F be the place at which the counterpoise P must be suspended in order to keep the unloaded beam horizontal, and let G F be called f. As before, let the steel-yard be graduated to ounces. The counterpoise P being placed at F, let one ounce be suspended from C, and a division having been marked at F, let the counterpoise be moved from G until equilibrium is established. Let the second division be marked at that position. After this, let the divisions towards B be continued at equal distances, and the number of any division beginning from F will be the number of ounces which the counterpoise P placed at that division will sustain: for let the distance D G be d, and let g be the weight of the steel-yard: the whole weight acting at D, its effort to depress the arm C G is measured by the product $g \times d$. Also, the effort of W to depress the arm is measured by the product $W \times w$. These two efforts are counteracted by the effort of P to depress the arm G B, which effort is measured by the product of P, and the distance of P from G. Let the distance of P from F be p, and its distance from G will be $p + f$, and the product just mentioned is $P \times (p + f)$ or the sum of the products $P \times p$ and $P \times f$. Thus, we have

$$W \times w + g \times d = P \times p + P \times f.$$

But it was before stated, that P, at the distance f, balanced the unloaded beam; and therefore $P \times f$, which measures the effort of P to depress the arm G B, is equal to $g \times d$, which measures the effort of the weight of the beam to depress the arm C G. Hence the equals $g \times d$ and $P \times f$ being taken from the former equals, we have remaining

$$W \times w = P \times p.$$

Hence, in whatever proportion W is increased or diminished, p must be increased or diminished; but p is the distance of the counterpoise P from F, that position in which it balances the unloaded beam. From that point F, therefore, the graduation must commence.

If the centre of gravity be in the longer arm, the graduation will commence from that point in the shorter arm at which the counterpoise will balance the unloaded beam. For, suppose this position to be D, and the centre of gravity of the beam to be F, the distances G D and G F being denominated as before, suppose the counterpoise first suspended at D; a weight W being suspended from C, let the counterpoise be moved towards G until equilibrium is established. First let this take place, when P is between D and G, and let the distance of P from D be p. Then we have

$$W \times w + P \times (d - p) = g \times f,$$
$$\text{or } W \times w + P \times d - P \times p = g \times f;$$

adding to both these equals $P \times p$, we obtain

$$W \times w + P \times d + P \times p - P \times p = g \times f + P \times p,$$
$$\text{or } W \times w + P \times d = g \times f + P \times p.$$

But, since the product $P \times d$ represents the effort of the counterpoise at D to depress the arm C G, and $G \times f$ represents the effort of the weight of the beam to depress the arm G B, and these efforts are equal, it follows that the products $P \times d$ and $g \times f$ are equal. These then being taken from the last equals, there remains

$$W \times w = P \times p.$$

Hence, in whatever proportion W is increased, p must be increased in the same

proportion; and since p is measured from D, the graduation must commence from that point.

The same will be true if the counterpoise be on the longer arm; but our limits compel us to leave the further investigation to the student.

It is evident that there is a limit to the weight which can be determined by this machine. When the counterpoise has been brought to that division which is nearest to B, it sustains the greatest weight which it is capable of determining. There are two ways of estimating greater weights than this, either by using a heavier counterpoise, or by having another point of suspension on the shorter arm nearer to the fulcrum. It is evident that either will have the desired effect.

(45.) The *Danish balance* is a steelyard, in which the counterpoise is fixed in one position, but the fulcrum is moveable. It is represented in *fig.* 28.

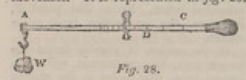


Fig. 28.

Let C be the centre of gravity of the unloaded beam, and let the distance C G be x. The effort of the weight g of the beam to depress the arm is then $g \times x$. The effort of W to depress the other arm is W × A G, or W × (A C − G C). Now, let A C be called a, and the condition of equilibrium will be

$$g\,x = \mathrm{W}\,a - \mathrm{W}\,x$$
$$\text{or}\quad g\,x + \mathrm{W}\,x = \mathrm{W}\,a$$
$$\therefore\ x = \frac{\mathrm{W}\,a}{g + \mathrm{W}}$$

(46.) Hence may be deduced the method of graduation. The divisions must obviously commence from C, since when the loop is there it poises the unloaded beam. If it be required to be graduated for pounds, let the weight of the instrument g be expressed in pounds, and let a, the distance C A, be expressed in inches. First, suppose W to be one pound, and we have

$$x = \frac{a}{g + 1}$$

If we suppose W to be successively 2, 3, 4, &c. pounds, we have

$$x = \frac{2\,a}{g + 2}$$
$$x = \frac{3\,a}{g + 3}$$
$$x = \frac{4\,a}{g + 4}\ \text{&c.}$$

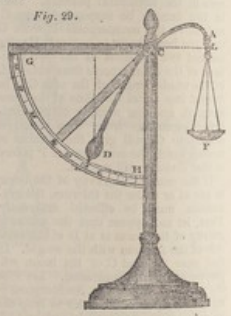
For example, let a be 18 inches, and g be 6 lbs.—the distances of the divisions corresponding to 1, 2, 3, and 4 lbs. from x, will be

$$x = \frac{18}{6+1} = \frac{18}{7} = 2\tfrac{4}{7} \qquad x = \frac{36}{8} = 4\tfrac{4}{8}$$
$$x = \frac{54}{9} = 6 \qquad x = \frac{72}{10} = 7\tfrac{2}{10};$$

these several numbers expressing in inches the distances of the several divisions from C.

This instrument may be graduated experimentally by suspending from A successively 1, 2, 3, &c. pounds, and finding by trial the position of the fulcrum which will produce equilibrium.

Fig. 29.



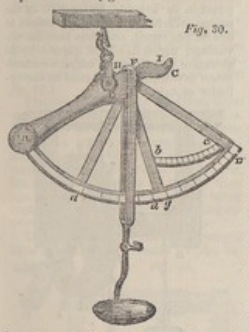
(47.) The *bent lever balance* is represented in *fig.* 29. The substance to be weighed is placed in a dish F, suspended from the arm of a bent lever at L. The other arm C D is terminated in a heavy knob, which plays upon a graduated arch G H. As the weight depresses the arm C A, it is so constructed, that the leverage of W is constantly diminished; and since D is moved up the arch, its leverage is constantly increased. When D acquires such a position that it counterpoises the weight, the division to which the index points on the graduated arch expresses the amount of the weight.

To graduate this instrument, let the first division be placed at the position which the index assumes when the dish F is unloaded. Then let the dish be successively loaded with 1, 2, 3, &c. pounds or ounces, or whatever denomination of weight it is designed that the divisions should indicate; and the successive positions of the index will determine the divisions.

A method of graduating the arch may be derived from mathematical investigation, independently of experiment, but we cannot introduce it here.

(48.) We shall conclude this chapter with the description of a more modern instrument, somewhat similar to the bent lever balance. Brady's balance is represented in *fig.* 30. B C D is an

Fig. 30.



iron frame, being much thicker and heavier towards B than in the other parts. It is supported upon a fulcrum G, and F is a moveable suspender to which a scale or hook is attached to receive the substance to be weighed. There are three distinct positions, H F I, in which this suspender may be placed, and for which there are three distinct graduated scales. When a weight is suspended from the hook, or placed in the dish, the machine is turned round the fulcrum G, and the side C descends until equilibrium is established, and the weight is read off from that scale which corresponds to the position of the suspender.

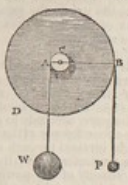
One scale shows the weights of bodies not exceeding two pounds, and is graduated to ounces; another determines weights not exceeding eleven pounds, and is graduated to two ounces; and the third determines weights not exceeding thirty pounds, and is graduated also to four ounces.

CHAPTER VI. *The Axle in the Wheel—Methods of applying the Power—Windlass—Capstan—Pressure on the Pivots—Defects of this Machine—Methods of removing them—Method of Regulating the Variation of a Power or Resistance.*

(49.) WHEN a very severe force, acting through a small space, is required to be produced by a comparatively small power, the common lever, whether simple or complex, is a machine well adapted to produce the effect. But the defect of this engine is, that, under all circumstances, it works through a very limited space, and that the action of the power is almost necessarily intermitting. Thus if a weight is to be raised by a lever, the prop or fulcrum is generally placed somewhat above the point at which the working end of the lever is to be applied to the weight. The end to which the power is applied is, therefore, above the fulcrum. On depressing that extremity, the weight is raised until the end at which the power is applied is a little below, and that which sustains the weight a little above the fulcrum. The weight must then be supported by some other means until the fulcrum be raised above it, and another similar exertion of the power be made.

(50.) To remove this inconvenience a modification of the lever, called *the axle in the wheel*, is used. This ma-

Fig. 31.

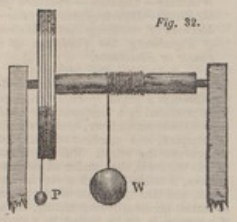


chine consists of a cylinder A C, and a wheel B D, having the same axis, at the extremities of which are points on which the whole may turn.

Fig. 31 is a section of this machine, taken in the plane of the wheel; and *fig.* 32 is a projection on a plane at right angles to the wheel. The power P is applied at the circumference of the wheel, and generally in the direction B P of the tangent. A cord is wrapped

about the cylinder, and is the means by which the weight is to be raised, or the resistance overcome.

Fig. 32.



It is evidently only a modification of the lever, as will appear by reference to (7,) and the condition of its equilibrium immediately follows from the general principle there established. Let R be the radius of the wheel, and *r* that of the axle, and the condition of equilibrium is $P \times R = W \times r$; that is, *the power multiplied by the radius of the wheel is equal to the weight multiplied by the radius of the axle.*

Thus, if the power be two pounds, and the radius of the wheel 12 inches, and the weight 8 pounds, and the radius of the axle 3 inches, there will be equilibrium, each product being 24.

This condition is sometimes expressed otherwise; thus, that the power must have to the weight the same ratio as the radius of the wheel has to the radius of the axle, or

$$P : W :: r : R.$$

(51.) It is easy to perceive that this machine furnishes an instance of the *principle of virtual velocities* already alluded to (5.) In one revolution of the wheel, the power descends to a space equal to the circumference of the wheel, and the weight is raised through a space equal to the circumference of the axle. Hence, the velocity of the power is to the velocity of the weight, as the circumference of the wheel is to the circumference of the axle. But the circumferences of circles are as their radii, and therefore the velocity (V) of the power is to the velocity (*v*) of the weight as the radius of the wheel is to that of the axle, that is

$$\therefore V : v :: R : r.$$

By what has been already proved, the weight is to the power in the same proportion, and therefore we have

$$W : P :: V : v.$$

or $P \times V = W \times v$;

that is, *the power multiplied by the velocity of the power is equal to the weight multiplied by the velocity of the weight.*

(52.) The axle in the wheel has been not improperly called the continual or perpetual lever, because the motion which it communicates to the weight is constant and not intermitting, as we have explained to be the case in the common lever. In order that it may be possible to suspend the action of the power without suffering the weight to descend or recoil, and thus lose the advantage which has been gained by its elevation, a contrivance called a *ratchet-wheel* is sometimes annexed to the cylinder or axle.

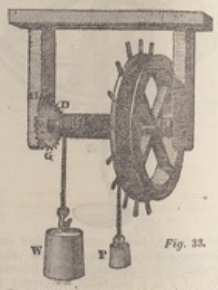


Fig. 33.

In *fig.* 33, this apparatus is represented at G D. It is a wheel furnished with teeth upon its edge. The teeth are not presented directly from the centre, but are curved and all bent in one direction, which is that direction in which the rope is coiled upon the cylinder. A curved bolt or catch working on a pivot at H, falls by its weight between the teeth of the wheel; and the effect is, that the wheel and cylinder to which it is attached, are suffered to revolve in that direction in which the weight is raised, but are not permitted to revolve in the other direction. So that the weight can never descend unless the bolt H be prevented from acting on the wheel G D. By such an apparatus the action of the power may be suspended at pleasure, and yet the effects of its past action maintained.

(53.) There are various ways in which the power is applied to the wheel; and the weight suspended by the rope which we have used is only to be understood as a general representation of the mechanical effect of the power, however it be applied.

Sometimes pins are placed at equal distances round the circumference of the wheel, by which the hand may be applied as the power. (See *fig.* 33.) An instance of this manner of applying the power will be seen in the wheel used to work the rudder of a ship.

Sometimes there is no wheel, but a number of long levers are inserted in the axle, and diverge from it like spokes from the box of a wheel, and the operator moves the axle by these levers. (See *fig.* 35.)

Frequently, as in the windlass, there is not either a wheel or diverging spokes, but simply holes, in which the workman inserts the end of a strong bar of considerable length, by which, as a lever, he turns the axle and raises the weight. He removes the bar as he works, from one hole to another, the weight being sustained by the action of the ratchet-wheel in the interim.

The windlass is frequently wrought by a winch, as represented in *fig.* 34.

Fig. 34.



The cylinder is fixed upon the axle A B, and at right angles to this axle a lever B O is fixed, and from O another arm O D extends, to which the hands of the operator are applied. By means of this simple contrivance, the operator can work upon the machine through the entire of each revolution, although not in every part with equal effect. In this case the ratchet-wheel is less necessary than in any of the former.

(54.) The axle is sometimes horizontal and sometimes vertical. In the *windlass* it is horizontal, also in most kinds of *cranes.* In the *capstan* (*fig.* 35.) it is vertical. The advantage of its vertical position in the capstan is very evident. The

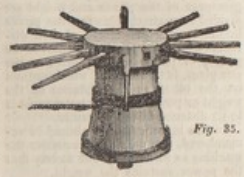


Fig. 35.

workmen insert levers in holes made to receive them, and walk round the axle, pushing the levers before them. In this manner a great number of men may work together, and there is no intermission of the power even when different men succeed each other.

(55.) When several forces act at the same time at different parts of the circumference of the same wheel, and all perpendicular to the radii, their combined effect is to be estimated in the same manner as if they all acted at the same point.

But if they act with different levers, each power is to be multiplied by the lever by which it acts, and the sum of these products is to be taken as the total effect. (10.)

(56.) In estimating the effect of the resistance or weight when the rope by which it acts has any considerable thickness, half the thickness of the rope is to be considered as a part of the radius of the cylinder, as the force is considered to be transmitted through the centre or axis of the rope.

The same may be said of the power, when it acts by a rope of any considerable thickness.

(57.) In order to determine the strength necessary to be given to the pivots which support the wheel and axle, it is necessary to determine the pressures to which they are liable.

If the axle be horizontal, the weight of the machine will press upon the pivots; and if its centre of gravity be equally distant from the pivots, its pressure will be equally distributed between them, half the weight of the machine pressing upon each pivot. If, however, the axis be vertical, the whole weight will rest on the point of the lower pivot.

The manner in which the pressures of the power and weight are divided between the pivots, may be determined by the principles established in Chap. iii. By these principles it appears, that the pressures of the power and weight are divided respectively between the pivots in the inverse proportion of their distances from them; that is, the part of the weight or power which presses on the one pivot, is to the part which presses on the other as the distance of the weight or power from the latter pivot is to its distance from the former.

In this investigation it should be remembered, that we do not consider the machine as in motion, but merely that the power sustains the weight.

(58.) In the simple wheel and axle, whatever be its form or peculiarity, its *mechanical efficacy* depends on the ratio of the radius of the wheel to the radius of the axle, or, to speak more generally, the length of the lever by which the power acts, to the radius of the cylinder on which the rope which raises the weight is coiled. There are then two, and only two, ways, in which this efficacy may be increased; viz. by increasing the leverage of the power, or by diminishing the radius of the cylinder which supports the weight. Now, although, in a theoretical view, there is no limit to our power of increasing this efficacy, since we can conceive the leverage of the power increased without limit, or the thickness of the cylinder diminished without limit, yet there is a practical limit to the increase of the mechanical efficacy of this engine.

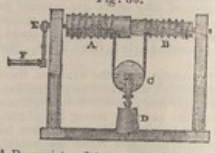
If we attempt to increase this efficacy by giving to the power a considerable leverage, the machine will become unwieldy; the power will work through a most inconveniently great space, and the practical disadvantages which will arise, will more than counterbalance any thing which can be gained by the increased power.

If, on the other hand, we attempt to increase the efficacy by diminishing the thickness of the axle, we diminish the strength of that part of the machine which must support the weight; and the cases in which this great efficacy is required are precisely those cases in which the greatest weights are to be raised, or resistances to be overcome, and, therefore, where the greatest strength in those parts of the machine on which the weight or resistance acts are indispensably necessary.

In cases, therefore, where great resistances are to be overcome, it is a problem of considerable importance to assign a method, by which, without rendering the machine more complex, sufficient strength may be preserved by preserving the thickness of the axle, the machine may not be rendered unwieldy by increasing very much the leverage of the power, and a high degree of power may be gained.

(59.) All these ends are attained by the simple modification of the wheel and axle in *fig.* 36. The axle or cylinder

Fig. 36.



A B consists of two parts, the diameter of one part being less than that of the other. A wheel and block C is attached to the weight, and round the wheel the rope which elevates the weight is passed, and is coiled in the *same direction* on the thicker and thinner parts of the axle. The elevation of the weight is thus effected: upon turning the axle in such a direction that the rope shall be coiled upon the thicker part, it will necessarily be rolled off the thinner part. Upon every revolution of the wheel, therefore, a portion of the rope equal to the circumference of the thicker part will be *drawn up*; but, at the same time, a portion, equal to the circumference of the thinner part, will be *let down*. On the whole, therefore, the effect of one revolution will be to shorten the entire length of that part of the rope, by which the weight is suspended, by a length equal to the difference between the circumferences of the thicker and thinner parts of the axle; consequently, half that portion of the rope will be shortened by half the difference between these circumferences. But half that part of the rope by which the weight is suspended, is evidently equal to the distance of the wheel to which the weight is attached from the cylinder. Hence, we perceive that every revolution of the cylinder raises the weight through a space equal to half the difference between the circumferences of the thicker and thinner parts of the axle.

To determine the conditions of equilibrium in this engine, we shall refer to

Fig. 37.

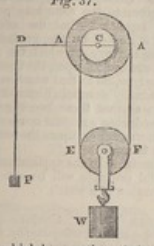


fig. 37, which is a section of the apparatus taken perpendicular to the cylinder, of which C is the centre, C B the radius of the thinner and C A of the thicker part, and C D the lever by which the power P acts. As the weight W hangs from the rope, which passes round the wheel E F, the parts E B and F A of the string are equally concerned in supporting the weight; and, consequently, half the weight is the force which hangs from each part of the string. If, then, the lever by which the power acts be R, and that r be the radius C A, and r' be C B, the condition of equilibrium, conformably to the principle laid down in (10), is

$$P \times R + \tfrac{1}{2} W \times r' = \tfrac{1}{2} W \times r;$$

that is, if the power be multiplied by its leverage, and half the weight by the radius of the thinner part of the cylinder, and these two products be added together, their sum will be equal to the product found by multiplying half the weight by the radius of the thicker part of the cylinder. Or, what amounts to the same thing, we have,

$$P \times R = \tfrac{1}{2} W \times r - \tfrac{1}{2} W \times r',$$

or $$P \times R = W \times \tfrac{1}{2} (r - r');$$

that is, *the power multiplied by the lever by which it works is equal to the weight multiplied by half the difference of the radii of the thicker and thinner parts of the cylinder.*

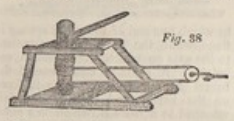
This condition may also be expressed thus: *the weight is to the power, as the lever by which the power works is to half the difference of the radii of the cylinder*; i. e.

$$W : P :: R : \tfrac{1}{2} (r - r').$$

From considering this condition, it is plain that, where the mechanical efficacy depends on the proportion of the lever of the power to half the difference of the radii of the cylinder, this efficacy may be increased, without any limit, by merely diminishing the difference of the radii of the cylinder, without either increasing the leverage of the power or diminishing the thickness of the cylinder. Thus, by this contrivance, the power will act through a convenient space; there will be nothing unwieldy in the construction of the apparatus; and all the requisite thickness and strength may be given to the cylinder.

A capstan, constructed upon the same principle, is represented in *fig.* 38.

Fig. 38



A great advantage attending this machine is, that there is no recoil upon the weight upon the remission of the power, and, therefore, the use of the *ratchet-wheel* and *catch* (54) is superfluous.

Almost the only disadvantage attending it is, that a considerable quantity of rope is requisite to raise the weight through a very small height; but still much less than what is requisite in any machine of the same power in which rope is employed.

Dr. Gregory states, that although this invention is generally ascribed to *George Eckhardt*, who probably invented it without being aware that it had been previously used; yet that there is a figure of it in some Chinese drawings, more than a century old, from which Dr. Gregory took the sketch, *fig.* 36. See *Gregory's Mechanics*, vol. ii. *p.* 3.

(60.) The principle of varying the diameter of the cylinder while the leverage of the power remains unvaried, is sometimes used to accommodate an uniform power to a varying resistance. We may state this principle still more generally. If a power, varying under any given conditions, be required to overcome a resistance which varies according to some other given conditions, the one may always be accommodated to the other by producing a variation in the leverage by which one or both acts,

which will modify the effect of the power so as to make it conformable to the variation in the resistance to be overcome.

This will probably be better understood by an example. Suppose that the power is a spiral spring of tempered steel, (*fig.* 39.) placed in a barrel A, (*fig.* 40.)

Fig. 39



Fig. 40.



to which one end of the spiral spring is fixed, while the other end is attached to the axis on which the barrel A revolves. A chain is coiled round the barrel A, one end of which is fixed on the barrel, and the other end is attached to a *fusee* B, which is a conical figure, also capable of turning on an axle, and on which a spiral channel or thread is cut to receive the chain after it has been rolled off from the barrel A. Let us suppose that the resistance, whatever it be, is uniform, and that it is applied to the axle of the fusee, or to a wheel connected with that axle; and that when the chain is rolled upon the spiral thread of the fusee, the spring within the barrel A is stretched to its utmost intensity. It is this which gives the barrel A a tendency to recoil, which tendency is communicated by the chain to the fusee B, and acts in turning the fusee by the leverage of the highest part of the conical figure. With this leverage the tension of the chain acts upon the resistance, and its effect is to be estimated by multiplying the tension of the chain, or, what is the same, the intensity of the spring, by the radius of that part of the cone on which the chain acts. As the fusee revolves, and the chain rolls *off* the fusee B and *on* the barrel A, the spring gradually loses its intensity; and consequently the tension by which the chain acts upon the fusee is gradually diminished, while the resistance to be overcome by that tension remains the same. It is, however, to be considered, that as the chain is rolled off the fusee, the part on which it acts, coming nearer to the base of the cone, becomes constantly thicker. The tension of the string, therefore, acts by a constantly increasing leverage, and therefore with a constantly increasing *mechanical efficacy*. Now, the tapering form given to the cone may evidently be so regulated, that the advantage which is *gained* by the gradually increasing leverage, by which the tension of the string acts upon the fusee, shall be exactly equal to that which is *lost* by the gradually decreasing intensity of the spring; so that these two opposite effects producing a mutual compensation, an uniform action upon the resistance will be the result.

An instance of the application of this beautiful principle will be seen in the construction of a watch.

CHAPTER VII. — *Complex Wheel-work—Force transmitted by Friction—Straps—Tooth and Pinion—Shape of Teeth — their number — Lantern and Trundles—Spur, Crown, and bevelled Gear.*

(61.) IT does not always happen that the end to be accomplished can be attained with convenience by the simple wheel and axle; and it frequently becomes necessary to transmit the effect of the power to the resistance, through a system of wheels and axles mutually acting upon each other. As the wheel and axle is only a modification of the lever, so a system of such machines acting one upon another is only another form of the compound lever, and the conditions of equilibrium are exactly the same in both.

In complex wheel-work, the power is applied to the circumference of the first wheel, which transmits its effect to the circumference of the first axle. This circumference is made to act, by various means, which we shall presently explain, upon the circumference of the second wheel, which again transfers the effect to the circumference of the second axle, which acts upon the circumference of the third wheel, and this in the same way transmits the effect to the circumference of the third axle; and thus the transmission of the force is continued, until it has arrived at the circumference of the last axle to which the weight or resistance is applied.

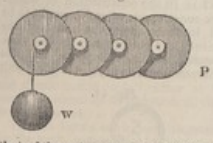
Each separate wheel and axle being a lever, the effect of such a combination as we have described is the same as that of a series of levers, whose longer arms

are respectively equal to the radii of the several wheels, and whose shorter arms are equal to the radii of the several axles, and therefore the condition of equilibrium is that the power multiplied by the product of the radii of all the wheels is equal to the weight multiplied by the radii of all the axles. Thus if R, R′, R″ be the radii of the wheels, and *r*, *r*′, *r*″ those of the axles, we have

$$P \times R\,R'\,R'' = W \times r\,r'\,r''.$$

(62.) The force of these observations will more readily appear, by considering the combination of wheels and axles in *fig.* 41. The radius of the wheel on which the power acts being R, and

Fig. 41.



that of the axle *r*, it is equivalent to a lever of the first kind, whose fulcrum is its centre. The first axle acts on the circumference of the second wheel with the leverage of its radius *r*, and the second wheel is also a lever of the first kind, the fulcrum being the centre. The radius *r* of the first acts upon the radius R′ of the second wheel, which depresses the radius *r*′ of the second axle, and thereby depresses the radius R″ of the third wheel, which raises the radius *r*″ of the third axle, and thereby raises the weight.

(63.) In this case the wheels and axles are supposed to work by the friction of their surfaces. In light work, where the pressure on the machinery is not very considerable, this method of connecting the wheel-work is often adopted with advantage. The friction of the surfaces is increased by cutting the wood so that the grains of the surfaces in contact shall run in opposite directions. Also by glueing upon the surfaces of the wheels and axles buffed leather. A saw-mill in which the wheels act by friction has been used at Mr. Taylor's, of Southampton, for nearly twenty years, and is found to work well.

(64.) There are, however, other ways of transmitting the force of each axle to the circumference of the succeeding wheel. A very common method is by ropes or straps passing round the circumferences of the wheel and axle, which act one upon the other. The action is in this manner transmitted by the tension of the rope or strap, and rendered effective by friction with the circumferences on which it is rolled. This

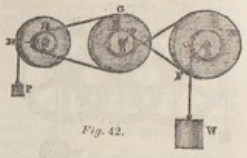


Fig. 42.

method of connecting wheels and axles is represented in *fig.* 42. When the wheel and the axle from which it receives motion are intended to revolve in the same direction, the strap is not crossed, but applied as between the axle R and the wheel G. But when the wheel is to revolve in a direction contrary to the revolution of the axle, the strap is crossed as between the axle D and the wheel F. This latter method of applying the strap has the advantage of having more surface to act upon, and therefore having more friction.

(65.) But by far the most usual way of transmitting the action of the axles to the succeeding wheels, is by means of teeth or cogs raised on their surfaces. When this is the case, the cogs on the surface of the wheel, are generally called *teeth*, and those on the surface of the axle are called *leaves*; the axle itself is in this case called a *pinion*.

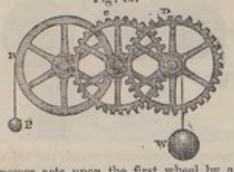
As the *leaves* of the pinion successively pass between the *teeth* of the wheel, they are perfectly equal and similar to them. Hence the circumferences of the wheels and pinions are proportional to their respective numbers of *teeth* and *leaves*; and since the circumferences are as the radii, it follows, that the numbers of teeth or leaves are proportional to the radii. Hence, in the condition of equilibrium determined in (61.), we substitute the number of teeth and leaves for the radii of the wheels and axles. Thus, then, the condition of equilibrium is, that the power multiplied by the product of the numbers of teeth in all the wheels is equal

to the weight multiplied by the product of the number of leaves in all the pinions. Or, if N, N′, N″ be the numbers of teeth in the several wheels, and n, n', n'' the numbers of leaves in all the pinions, the condition of equilibrium is

$$P \times N\,N'\,N'' = W \times n\,n'\,n''.$$

A system of tooth and pinion-work is represented in *fig.* 43. In this case the

Fig. 43.



power acts upon the first wheel by a rope; but in submitting it to the above condition of equilibrium, it is only necessary to calculate how many teeth the circumference would contain, and use that number in the condition.

(66.) It will be easy to show, that complex wheel-work obeys the law of virtual velocities (5); for since the teeth are equal, the circumference of each wheel moves with the same velocity as that of the circumference of the pinion by which it is driven, which is equally evident if they be connected by straps or work by friction. Now, since each wheel revolves in the same time with its axle, the velocities of their circumferences are as their circumferences, or, what is the same, as their radii or number of teeth. Hence, the velocity of the power, or the velocity of the circumference of the first wheel, is to that of the first axle as their radii. But the velocity of the circumference of the first axle is equal to the velocity of the circumference of the second wheel, which is to that of the second axle as their radii; and by continuing this reasoning, we shall find that the velocity of the power is to that of the weight, as the product of the radii of the wheels to the product of the radii of all the axles; and, therefore, that the power multiplied by the velocity of the power is equal to the weight multiplied by the velocity of the weight.

This will be better understood by an example. Let the number of teeth in the first wheel be 100, and the leaves in the first pinion 9; and let the teeth in the second and third wheels be 120 and 130, and the leaves in the respective pinions be 7 and 11. The velocity of the circumference of the first wheel being expressed by 1, that of the circumference of the second wheel will be $\frac{9}{100}$. This velocity is to that of the circumference of the second pinion or third wheel, as 120 is to 7; and therefore the velocity of the circumference of the third wheel is $\frac{9 \times 7}{100 \times 120}$. Again, this velocity is to that of the circumference of the last axle as 130 to 11. This velocity is therefore $\frac{9 \times 7 \times 11}{100 \times 120 \times 13}$, which verifies what we have just advanced.

(67.) In the construction of wheel-work considerable attention ought to be paid to their shape, as much of the efficiency and permanency of the work depends on this. Suppose that the teeth were found as in *fig.* 44. The tooth

Fig. 44.



$a\,b$ in driving $a'\,b'$ would be moved round the centre C, in a direction perpendicular to C $a\,b$, and would therefore press on the tooth $a'\,b'$ obliquely to the radius C′ $a'\,b'$; whereas, to produce the best effect, the pressure should be directed perpendicularly to that radius. Besides this, the whole pressure of the wheel is thrown upon one tooth, by which the chances of fracture are much increased, and the wear materially augmented. Another defect which appears manifest is, that during the motion the direction of the pressure of $a\,b$ on $a'\,b'$ is constantly changing while the teeth are in contact; and since the leverage by which the wheel C′ is turned by $a\,b$ is therefore variable, it is turned with an unequable force. In the motion, the corner of the tooth $a\,b$ scrapes or rubs the surface of the tooth $a'\,b'$; and the machine suffers a jolt when the tooth $a\,b$, finally slipping from the tooth $a'\,b'$, falls into the angle formed at the point where the tooth $a'\,b'$ springs from the circumference of the wheel.

The teeth should, therefore, be so formed as to remove these defects; for which purpose it would be necessary that they should act in such a manner, that,

1*st.* The teeth of one wheel should press in a direction perpendicular to the radius of the other wheel; or, in other words, the pressure should be *tangential* to the wheel which is driven.

2*d.* As many teeth as possible should be in contact at the same time, in order to distribute the pressure amongst them, and thereby to diminish the pressure upon each tooth. This arrangement will diminish the wear, and the chances of fracture.

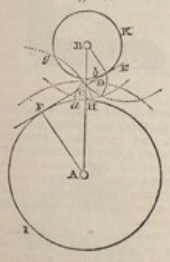
3*rd.* During the entire action of one tooth upon another, the direction of the pressure should be the same, in order that, acting with the same leverage, the effect may be uniform.

4*th.* The surfaces of the teeth in working should not rub one upon another, and should suffer no jolt either at the commencement or termination of their mutual contact.

Various forms have been suggested for the teeth, with a view to the accomplishment of some or all of these advantages; but that which seems best calculated to attain the desired ends is the following:

Suppose that F H I, *fig.* 45, is the circumference of the wheel on which it is proposed to raise teeth, and let H

Fig. 45.



be one of the points from which the side of a tooth is to spring. Suppose a string is attached to the circumference of the wheel as at I, and applied to the circumference I F, and terminated at H carrying a pencil at its extremity. Let the string, being constantly stretched tight, be rolled off, so that that part of it, F C, which has been at any time disengaged from the circumference of the wheel shall be in a straight line, touching the circumference at F, and in this way let the pencil describe the curve* H C g. Let a H be the breadth of the tooth at the circumference of the wheel; and attaching a string in like manner to the other side of the wheel, and rolling it on in the opposite direction, so that its extremity bearing the pencil shall be at a, let a similar curve be described. These two curves will include a space which will represent the form of a tooth which will accomplish all the purposes and possess all the advantages we have mentioned.

The teeth of the pinion, of course, are to be formed in the same manner.

It is a remarkable property of these curves that a line F E which touches both circles will pass through the point of contact of the teeth, and not only of one pair of teeth, but of every pair which are in contact: and this line will be perpendicular to the direction of the surfaces of the teeth at the point of their mutual contact. Thus the pressure of the pinion on the wheel is exerted tangentially to both, and therefore acts always with the same leverage and to the greatest advantage.

Further, during the whole period of the contact of any two teeth, the pressure acts in the same direction and with the same force, and therefore when it is uniform, it necessarily produces an uniform effect.

During the motion, the surface of one tooth does not *rub* or *scrape* against the surface of the other, but the one *rolls* upon the other, thereby removing nearly all the effects of friction, and diminishing considerably the wear of the machinery, and the waste of the power.

Several teeth are in contact at the same time, and all working with equal power, so that the stress is equally distributed among them, and the chances of fracture are greatly diminished.

Thus this form of tooth has all the advantages which can be desired.

(68.) In regulating the number of teeth in the wheel and the pinion which works it, it should be so contrived that the same teeth should be engaged as

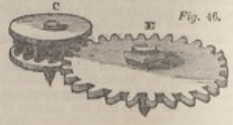
* This curve is called the *involute of the circle*.

seldom as possible, in order to avoid inequality of wear. For example, let us suppose that the number of teeth in a wheel were exactly ten times the number of leaves in the pinion; each leaf in the pinion would engage every tenth tooth of the wheel, and would work inevitably on the same ten teeth every revolution of the wheel. If it were possible that all the teeth and leaves could be constructed with mathematical precision, and perfect and absolute similitude, and that no accidental difference, owing to any want of uniformity in the material of which they are formed, could exist, this would be a matter of no consequence, and the wear would still be even and equable. But as these perfections never can exist, the inevitable inequalities incident, as well to the nature of the material of which wheels are constructed as to the forms they derive even from the most perfect mechanical construction, must be compensated by making the teeth and leaves work, so that each leaf shall successively engage with all the other teeth of the wheel before it engages a second time with any one of them.

This is accomplished by making the number of teeth and the number of leaves *prime* to each other, that is, such that no integer divides both exactly. The manner in which this is commonly done, is by making the number of teeth such, that it is just one more than a number which is exactly divisible by the number of leaves. This is what millwrights call making a *hunting cog*. Thus, suppose that there are ten leaves, and that the diameter of the wheel is about six times that of the pinion. If this were the exact ratio, there would be just sixty teeth, and after each revolution of the wheel the same teeth and leaves would be continually engaged, each leaf taking every sixth tooth. But if the diameter of the wheel be made somewhat greater than six times that of the pinion, so as to admit sixty-one teeth; then, after six revolutions of the pinion, the first leaf will be engaged with the tooth immediately before that in which it had worked at the commencement, and after six more revolutions it will be engaged with the tooth before that, or the second tooth from that at which the motion commenced. Thus, it is evident, that the wheel must revolve 61 times, and the pinion 6×61, or 366 times before the same teeth will be again engaged. By these means, the inequalities of wear arising from inequalities of form and material will compensate each other.

(69.) The teeth of the wheel, instead of working in the leaves of a pinion, are made to act upon a form of wheel called a *lantern*, as represented at *fig.* 46. The

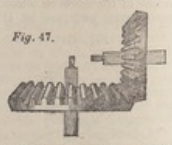
Fig. 46.



cylindrical teeth or bars of the lantern are called *trundles* or *spindles*. However, notwithstanding the various forms of wheel-work, the principles which we have already explained will always determine the relation between the power and resistance.

(70.) Wheels are denominated *spur*, *crown*, or *bevel gear*, according to the position or direction of the teeth. If the teeth be perpendicular to the axis of the wheel, and in the direction of radii, as in the wheel E, *fig.* 46. it is called a *spur-wheel*. If the teeth be parallel to the axis of the wheel, and therefore perpendicular to its plane, it is called a *crown-wheel*. Two spur-wheels, or a

Fig. 47.



spur-wheel and pinion which work in one another, are always in the same plane, and have their axis parallel. But when a spur and crown-wheel are in connection, their planes and axis are at right angles. By this means, therefore, rotatory motion may be transferred from a horizontal to a vertical plane, or *vice versâ*.

When the teeth are oblique to the plane or axis wheel, it is called a bevelled-wheel. Two wheels of this kind are represented in *fig.* 48. In this case, the surfaces on which the teeth are raised are parts of the surfaces of two cones. The manner in which these wheels act, and the principles on which

Fig. 48.



their formation depends, may be conceived by imagining two cones to be applied side to side, as in *fig.* 49. If their surfaces have sufficient friction,

Fig. 49.



and one of them be turned upon its axis by a mechanical force, it will compel the other to revolve; and if the bases of the cones be equal, each will revolve in the same time; as in *fig.* 49. But if the diameter of the base of one be equal to any number of times the diameter of the base of the other, as in *figs.* 48 and 50, then the lesser cone will

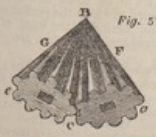
Fig. 50.



revolve as many times in one revolution of the greater. It is evident that what we have observed of the entire cones, will be equally true of any parts of them, *a*, *b*, *c*, &c. equally distant from their common vertex, and therefore would be true of wheels, the edges of which are parts, *c d*, of the conical surfaces.

If the friction of the conical surfaces be insufficient to transmit the force, the surfaces may be fluted, as in *fig.* 51;

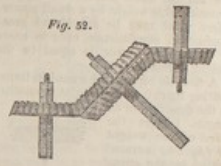
Fig. 51.



and if the conical surfaces be incomplete, the breadth being F *c*, they will become *bevelled-wheels*.

It will be easily perceived that the use of bevelled-wheels is to produce a rotatory motion round one axis by means of a rotatory motion round another which is oblique to it; and, provided that the two axes are in the same plane, this may always be accomplished by two bevelled-wheels. A system of wheels of this kind is represented in *fig.* 52.

Fig. 52.



CHAPTER VIII. — *Of the Pulley—Fixed Pulley—Single moveable Pulley — Spanish Burtons — Systems with a single Rope—their defects—White's Pulley — Systems with several Ropes.*

(71.) THE machines, the theory of which has been explained in the preceding chapters, derive their whole efficacy from the supposed inflexibility of the materials of which they are constructed. The effect of weights acting on a lever is to bend it over the fulcrum, and if the lever yields to this, and suffers itself to be bent, it loses its mechanical efficacy. The same observation may be applied to all the machines which we have hitherto described. It may be said that there are no materials of which such machines can be constructed which are perfectly inflexible. This is true; but we have before observed, that the most easy method of teaching the science, is to suppose, in the first instance, this perfect inflexibility, and subsequently to apply to the results *corrections* which will adapt them to cases where small degrees of flexibility are found, at least to those cases where the flexibility produces any effect sufficiently great to affect the practical accuracy of the result.

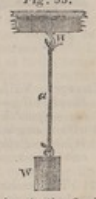
On the other hand, the machine to whose properties we are now to call the attention of the student, is one whose efficacy depends on the perfect flexibility of the material. On this supposition our theory will necessarily be founded, and

in cases where this supposed flexibility is not found, it will be necessary to apply *corrections* to our results to render them practically applicable.

(72.) A perfectly flexible rope, or thread, is a machine which, independently of the usual advantage attending the use of machines, of enabling us, by the aid of fixed points, to support a considerable weight by a small power, offers what may be considered great mechanical convenience, even in cases in which the power is equal to the weight or resistance.

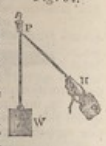
A flexible rope may be used in transmitting force from one point to another in the direction of its length. Thus the force of the weight W (*fig.* 53.) is transmitted by the string *a* to the hook H, and presses on the hook in the same manner as if it were immediately suspended from it without the intervention of the rope *a*. This power of transmitting pressure in the direction of its length, is not owing to the flexibility of the rope, but to its *inextensibility*. This quality the rope enjoys in common with an inflexible bar, which would also transmit the force of the weight to the hook in the same way. An inflexible bar, however, has the advantage of the flexible rope in transmitting force in the direction of its length; for, although a flexible rope will transmit a force applied at one end to the other end when that force is directed *from* the end to which it is to be transmitted, it will totally fail if the force be directed *towards* the other, in which case the inflexible bar will be effectual. Thus, if the weight acted towards the hook H, which would be the case if it were below W, the string *a* will fail to transmit the force, but if it were an inflexible bar it would do so.

Fig. 53.



(73.) One of the greatest conveniences attending the use of a flexible rope, is that by its means a force in any one direction may be made to balance an equal force in any other direction. Thus, if it be necessary to sustain the weight W, (*fig.* 54.) acting vertically downwards, by a power which acts in the direction P H, let a point P be assumed directly over the weight, and in the line P H, and let a flexible string be attached to the weight, passed through a ring at P, and connected with the power at H, and the object will be evidently accomplished. For if the rope be supposed to be perfectly flexible and smooth, it will suffer no resistance either from rigidity or friction, in passing through the ring at P, and the string will be stretched by the same force in its entire length, that tension being equal to the weight W.

Fig. 54.



But since it is impossible in practice to obtain ropes which are perfectly smooth and flexible, nor to construct rings whose surfaces are free from all asperities, it is usual, instead of passing the rope through a ring, to pass it over a grooved wheel which turns freely on an axle, or on pivots, as in *Fig.* 55

Fig. 55.



The substitution of the wheel for the ring is attended in practice with two obvious advantages: first, it removes in a great degree the effects of the friction of the rope with the surface of the ring, for instead of the surface of the rope sliding on the surface of the wheel, that surface turns with it. Secondly, it diminishes very much the effects of the imperfect flexibility of the rope, which instead of being suddenly and sharply bent, as over the ring, is gradually deflected upon the curvature of the rim of the wheel.

The wheel, therefore, is not used to impart any *mechanical advantage* properly speaking to the machine, nor is it at all necessary to be taken into account in the theory in which the perfect smoothness and flexibility, the want of which it is introduced to remedy, are pre-supposed.

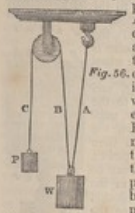
The wheel thus used is called a *pulley*, and hence that name has been given to the machine itself, and its various modifications. Some writers have even ascribed to the wheel thus used, the whole mechanical virtue of the machine, and have established the conditions of equilibrium by considering it as a lever. That such investigations are founded on wrong principles, although their results

happen to be true, appears from this, that if we suppose the wheels and blocks abandoned, and the ropes merely to pass through rings, but to be perfectly flexible and to act without friction, all the properties of the pulley may be established.

In our diagrams of pulleys, we shall always represent the cords as acting in the usual way over wheels; but our demonstrations will be founded only on the supposed flexibility of the string, and its perfect power of transmitting force by its tension.

(74.) The mechanical efficacy of every system of pullies may be immediately derived from this single principle, that the same flexible string must always suffer the same tension in every part of its length. Thus, if the weight W (*fig.* 56) be supported by the string A B, the parts of the string A and B will be equally stretched, and consequently the two hooks are equally engaged in sustaining the weight. Hence, each part A and B of the string must sustain half the weight. In this case we suppose the string to be perfectly free in passing through the ring, and the parts A and B to be parallel.

Fig. 56.

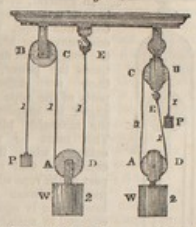


(75.) Pulleys are *fixed* and *moveable*. A fixed pulley has no *mechanical advantage*, since the power and weight are equal. This apparatus is represented in *fig.* 55. It is, however, very convenient in accommodating the direction of the power to that of the resistance. Thus, by *pulling downwards*, we are able to draw a weight *upwards*. It has been already observed, that by means of this simple machine, a power in any direction whatever may be opposed to a resistance in any other direction.

(76.) The *single moveable pulley*, sometimes called a *runner*, is represented in *fig.* 57. In this machine the same rope extends from the power P to the fixed point E, and has the same tension throughout its whole length.
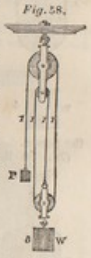
It is evident that this tension is equal to the power, for in that part P B of the rope, between the power and the fixed pulley, the power is supported by this tension. The weight W is supported by the parts C A and D E of the string, and must be equal to the sum of the tensions, that is, to twice the tension of the rope, or to twice the power. In this machine, therefore, a power is capable of opposing a resistance of twice its own amount.

Fig. 57.



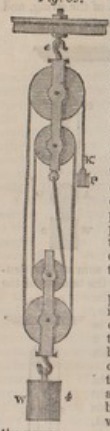
We have not noticed the effect of the weight of the pulley A. If this be taken into account, it is only necessary to add it to the weight. The single moveable pulley may also be so constructed that the weight will be three times the power. This is evidently the case in the arrangement in *fig.* 58.

Fig. 58.



(77.) There are several systems of pullies worked by a single rope. In all these there is one moveable block, in which *wheels* or *sheaves* are fixed, over which the rope runs, and to which the weight is attached. In estimating the mechanical effect, the moveable block is to be considered as a part of the weight. Since the same rope is successively passed over all the wheels, it must have in every part the same tension; and since the part K sustains the power, this tension must be equal to the power. The weight (including the weight of the block to which it is attached) is supported equally by each part of the rope, which passes between it and the fixed block. In *fig.* 59, the weight is distributed equally among four ropes, each of which is stretched by the force of the power.

Fig. 59.



Hence, in this case, the weight is four times the power.

In general, in systems of pullies having only one rope, and one moveable block, the weight is as many times the power, as there are different parts of the rope engaged in supporting the moveable block. This must be very evident, when it is considered that each part of the rope which passes between the two blocks is equally engaged in sustaining the weight.

In the system represented in *fig.* 59, if the rope, instead of being finally attached to the fixed block, were passed over a third wheel in that block, and finally attached to the lower block, the weight would be five times the power.

(78.) In these systems the wheels move on separate axles. They are sometimes placed side by side on the same axle, as represented in *fig.* 60. But the proportion of the power to the weight is the same in all.

Fig. 60.



Fig. 61.



In this arrangement of the sheaves it is difficult to keep the strings parallel, and to prevent the effect of the power and weight deranging the position of the blocks in the manner represented in *fig.* 61.

Fig. 62.



To remedy this inconvenience the ingenious and powerful arrangement represented in *fig.* 62, has been suggested. To prevent confusion in the figure, the rope has been omitted, but its course may be easily traced. Suppose one extremity attached to the hook at the bottom of the upper block: the rope from this point is brought under the wheel *a*, over *b*, under *c*, over *d*, under *e*, over *f*, and so on according to the order of the letters, until it finally passes over the wheel *u*, and is then attached to the power. In this case there can be no derangement in the position of the blocks, as in *fig.* 61, since the power acts immediately over the weight. The weight is here sustained by the ropes, which pass over *ten* wheels, and therefore is distributed between twenty parts of the rope, so that the weight is twenty times the power.

(79.) All systems of pullies of this kind, however, have still great defects. The great number of wheels requisite when much power is required increases the quantity of friction prodigiously for each wheel has not only the friction on its axle, but also the friction against the side of the block in which it revolves. Besides this, they are liable to great inequality of wear, owing to the circumstance of revolving on their axles with different velocities. Suppose that, by the action of the power, the lower block in *fig.* 62 is moved one foot towards the upper block; it is evident that the several parts of the rope between the blocks will be each shortened by one foot. Hence it appears that one foot of

that part of the rope which extended from the hook in the upper block to the wheel *a* must pass over that wheel: this foot of rope must evidently also pass over the wheels *b*, *c*, and all the succeeding wheels. But the part of the rope which extended from the wheel *a* to the wheel *b* is also shortened by one foot. This foot of rope must therefore pass over the wheel *b* and all the succeeding wheels *c*, *d*, *&c.* Hence one foot of rope passes the wheel *a* in the ascent, and two feet pass *b*. By continuing this reasoning, we shall find that three feet of rope pass *c*, four pass *d*, and so on. Now the velocities with which the wheels revolve (their diameters being the same) is justly measured by the quantity of rope which passes over them in the same time. Hence, while the wheel *a* revolves once, *b* revolves twice, *c* three times, *d* four times, and so on. Hence arises that inequality of wear which we have already mentioned.

If we attempt to remove this defect by fixing all the wheels on the same pivots so as to compel them to turn with the same velocity, we shall introduce another source of friction and cause of wear much greater than the former; for since the rope passes over the wheels with different velocities, while they revolve with the same velocity, it must necessarily scrape or slide more or less on the grooves of all of them, one excepted.

The great object, therefore, in the construction of such a system of pullies would be to make them all revolve on their axles in the same time, so as to avoid unequal wear; and yet that their grooves or circumferences should have different velocities equal to those of the rope in passing over them.

(80.) These ends were all attained by a pulley invented by Mr. *James White*. In order that the successive wheels should revolve in the same time, he constructed them of different magnitudes; and so that their several circumferences would be equal to the length of rope which passes over them in the same time. This will be easily understood by recurring to *fig.* 62. Suppose the circumference of the wheel *a* to be one foot: it makes one revolution, while the lower block is raised through one foot towards the upper block. In this time three feet of rope pass over the circumference of the wheel *c*. If then the circumference of this wheel be three feet, it will revolve once during the supposed ascent of the weight. In like manner, the wheel *e* will revolve once if its circumference be five feet, and so on. Thus, then, in general it follows, that the several wheels will revolve in the same time, if their circumferences be as the numbers 1, 3, 5, &c.; and in the same way it may be proved, that the wheels in the upper block will revolve in the same time with each other, and with the wheels in the lower block, if their circumferences be as the numbers 2, 4, 6, &c., or, what is the same, as the successive integers 1, 2, 3, &c.

The circumferences of circles are proportional to their diameters, and, therefore, by constructing the several wheels *a*, *b*, *c*, *d*, &c. with diameters proportional to the successive integers 1, 2, 3, &c., equality of wear would be obtained.

But still the multiplied friction of a at number of different wheels would

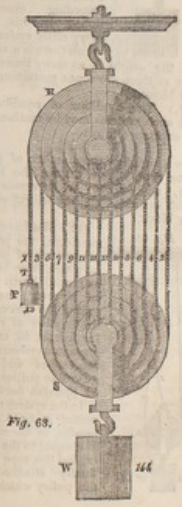


Fig. 63.

Fig. 64.



remain, as well the friction on their axles or pivots, as the lateral friction of their surfaces with the blocks. To remove this defect, Mr. White conceived the notion of reducing all the wheels in the same block to one; or rather, instead of using separate wheels, to cut several circular grooves, with the diameters we have already described upon the *same wheel*. Thus, all the friction was reduced to that of the pivots, and the lateral friction of *one wheel*.

This pulley is represented in *figs.* 63, 64, and it will be easily understood from the preceding observations. In this, like every other system in which there is a single rope, the weight is as many times the power as there are ropes sustaining the lower block.

(81.) The condition of equilibrium in all such systems may be mathematically expressed thus:—

$$W = n P;$$

where n signifies the number of parts of the rope which sustain the lower block, and where W expresses the weight sustained and the weight of the lower block.

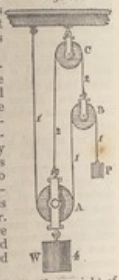
Fig. 65.



(82.) We have now mentioned the principal systems of pullies in which there is but one rope. Much power, however, may be gained by increasing the number of ropes. In *figs.* 65, 66, are represented systems with two ropes and two moveable pullies, called *Spanish burtons*.

In the system represented in *fig.* 65, the tension of the rope P B is equal to the power, and this rope being finally attached to the pulley which sustains the weight, supports a part of the weight equal to the power. The rope from C to B balances the united tensions of both parts of the rope extending from B to the weight and power, and therefore its tension is twice the power, and being brought under the pulley which sustains the weight, and finally attached to the fixed point, it sustains a part of the weight equal to four times the power. Thus, the whole weight must be equal to five times the power. The power being taken as the unit, the number placed at each rope expresses the part of the weight which it sustains.

Fig. 66.



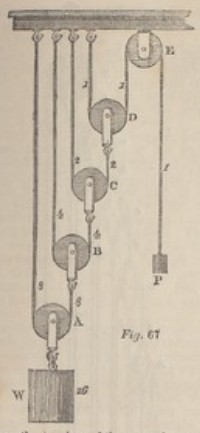
The system represented in *fig.* 66 has also two ropes, but is not so powerful as the former. The tension of the rope extending from the power to the fixed point is equal to the power, and the tension of that extending from the pulley B to the weight is obviously equal to twice the power.—Thus, the weight is four times the power. The tensions are here, also, expressed by the figures placed at the ropes.

In both these systems the weight of the pulley B assists the power, and that of A opposes it. In the system represented in *Fig.* 65, if the weight of the pulley B be half that of A, the weights of the two pullies will balance one another; but if the weight of B be more than half of A, the power will be assisted, and a less power than the fifth part of the weight will sustain equilibrium. If the weight of B be less than half of A, a contrary effect will take place.

In the system represented in *Fig.* 66, if the weight of B be equal to that of A, it will exactly balance it. If it be greater or less, it will assist or oppose the power.

(83.) In *fig.* 67, a system of pullies is represented with four ropes, in which the weight is sixteen times the power; for the tension of the rope D E is evidently equal to the power, because it sustains it. D, being a moveable pulley, must sustain a weight equal to twice the power; but the weight which it sustains is the tension of the second rope D C.

Fig. 67



Hence the tension of the second rope is twice that of the first: in like manner, the tension of the third rope is twice that of the second, and so on, the weight being equal to twice the tension of the last rope. If then, as in the present instance, there be four ropes, the tension of the first is P, that of the second 2 P, that of the third 2×2 P or 4 P, that of the fourth $2 \times 2 \times 2$ P or 8 P, and therefore the weight W will be 16 P.

It is obvious that each rope, which is added to such a system, will double its effect, and that the condition of equilibrium expressed mathematically will be

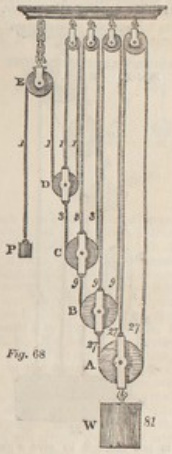
$$W = 2^n P;$$

n expressing the number of distinct ropes.

In this case the effect of the weights of the pullies themselves is neglected; but it is evident that they act against the power, and therefore that it requires a certain power to sustain them, even when unloaded.

(84.) The power of this system may be greatly increased without increasing the number of ropes, by substituting fixed pulleys for the hooks to which each rope is finally attached. This method was applied to a single moveable pulley in *fig.* 58, and *fig.* 68 exhibits a series of such pulleys. By *fig.* 58, it follows that the tension of the second rope is three times that of the first, which is equal to the power. The tension of the third is three times that of the second, or nine times that of the first, and so on, the weight being three times the tension of the last rope.

Fig. 68



In the present example there are but four ropes, and the weight is 81 times the power. The relation between the power and weight in such a system may be expressed mathematically thus:

$$W = 3^n P;$$

n being the number of distinct ropes.

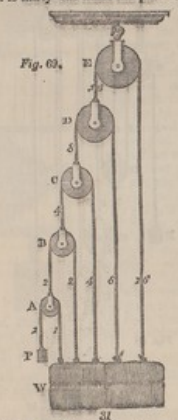
The effect of the weights of the pulleys themselves in this case is also in opposition to the power, and robs the machine of part of its efficacy.

(85.) A powerful system is represented in *fig.* 69. In this system each rope is finally attached to the weight. The first rope sustains a part of the weight which is equal to the power. The tension of the second rope is twice that of the first, and therefore it sustains a part of the weight equal to twice the

power. In like manner the third sustains a part equal to four times the power, and so on, the part sustained by each rope being double that which is sustained by the preceding one.

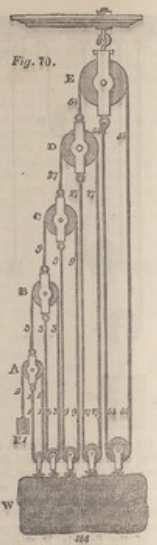
In this case the weight is equal to the sum of the tensions of all the strings, and in the example represented in *fig.* 69, it is thirty-one times the power.

Fig. 69.



31

Fig. 70.



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It is not difficult to give a general mathematical investigation of the relation between the power and weight. The tensions of the several ropes by which the weight is sustained are P, 2 P, 2^2 P, 2^3 P, &c. and if n be the number of ropes, the tension of the last is 2^{n-1} P. So that we have

$$W = P.\ (1+2+2^2+2^3+ \ldots . 2^{n-1})$$

But the series within the parentheses being in geometrical progression *, its sum is 2^n-1. Hence we have

$$W = (2^n-1)\ P.$$

(86.) Such a system may be rendered much more powerful without increasing the number of ropes, by passing each rope round a pulley, and finally attaching it to the moveable pulley over which it first passed, as in *fig.* 70. The numbers placed upon the several ropes express the parts of the weight which they respectively support, the power being the unit. In the system in the figure the weight is 188 times the power.

The general mathematical investigation of the relation between the power and weight is similar to that in (85.) The parts of the weight supported by each successive rope is 2 P, 6 P, 18 P, 54 P, &c. and that which is supported by the last rope, the number being n, is 2.3^{n-1} P. Hence we have

$$\therefore W = 2\ P\ (1+3+3^2+3^3+ \ldots . 3^{n-1}).$$

Summing the geometric series within the parentheses, we have

$$W = (3^n-1.)\ P.$$

(87.) The various systems of pullies which we have here described are not offered to the student as machines which he will frequently find adopted in practice, but rather as an exercise in the combination of these engines, and as the best means of impressing upon

* See DARLEY'S *Popular Algebra*, p. 97.

the memory the general principles upon which the mechanical agency of pullies is to be investigated.

Like all other machines, the pulley obeys the principle of *virtual velocities*; that is, the ascent of the weight is as many times less than the simultaneous descent of the power as the weight itself is greater than the power.

Thus in the single moveable pulley represented in *fig.* 57, if the power descend through two feet, two feet of the rope C A D E will pass over the fixed pulley B C. Hence, that part of the rope will be shortened by two feet, and therefore, each of the parts C A and D E will be shortened by one foot. Thus the weight ascends through one foot while the power descends through two feet, that is, the velocity of the power is twice that of the weight. But by (76) it appears that the weight is equal to twice the power.

In the same manner it may be proved that in *fig.* 58, while the power descends through three feet, the rope extending from the fixed pulley to that end which is attached to the pulley which supports the weight is shortened by three feet, and therefore, each of the three parts engaged in supporting the weight is shortened by one foot. Hence, it appears, that the velocity of the power is three times that of the weight; by (76) it was proved that the weight is three times the power.

In general, in all systems of pullies in which there is but one rope, the space through which the power descends is equal to the entire length by which the rope extending from the pulley next the power to its extremity is shortened. But this length is distributed equally between all the parts of the rope which are engaged in supporting the weight. Hence each part will be shortened by a quantity as many times less than the descent of the power as there are parts of the rope engaged in supporting the weight. But the number of these parts expresses the proportion of the weight to the power.

This reasoning will be easily applied to the systems represented in *figs.* 59, 60, 63, &c. We shall not pursue this investigation to the other systems. By adopting a similar method of reasoning, the student will find no difficulty in perceiving that it is applicable to all of them, and that universally as we gain great mechanical efficacy, that is, raise a very great weight with a very small power, we invariably lose just as much in velocity as we gain in force.

(88.) We have hitherto supposed that the ropes by which the pulleys are sustained are all in the vertical direction. When this is not the case, the several results which we have obtained are not applicable. In *fig.* 71 the power sustains the weight by the tension of a rope, in which the parts are not parallel. Let E F (*fig.* 71.) be the vertical line

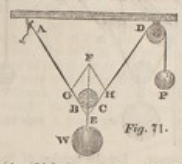


Fig. 71.

through which the centre of gravity of the weight passes, and from F draw F G and F H parallel to D C and A B. At the point E three forces may be considered as acting, which are in equilibrium, viz. the tensions in the directions E H and E G, and the weight W. Hence, by Treatise I. (9), these forces must be represented by the lines E H, E G, and E F. But, since the tension of every part of the rope is the same, and equal to the power P, the sides E H and E G of the parallelogram must be equal, and therefore the diagonal E F must divide the angle G E H into two equal parts. Hence, it follows that the weight will always settle itself into that position in which the two parts A B, D C of the rope will be equally inclined to the vertical line, and it will have to the power the same ratio as E F to E H.

Those who are conversant with trigonometry will perceive, that if the angle A E D, at which the parts of the suspending rope are inclined, be called E, we have

E F : E H : : Sin. E : Sin. $\frac{1}{2}$ E.

But Sin. E = 2 Sin. $\frac{1}{2}$ E Cos. $\frac{1}{2}$ E. Hence

E F : E H : : 2 Sin. $\frac{1}{2}$ E Cos. $\frac{1}{2}$ E : Sin. $\frac{1}{2}$ E.

E F : E H : : 2 Cos. $\frac{1}{2}$ E : 1

$\therefore$ W : P : : 2 Cos. $\frac{1}{2}$ E : 1

$$W = 2\ P \cos. \tfrac{1}{2} E;$$

that is, twice the power, multiplied by the cosine of half the angle under the ropes, is equal to the weight.

(89.) In the same way the effect of the obliquity of the ropes may be de-

termined, whatever be the system of pulleys. In *fig.* 72, the system of pulleys described in (83) is represented with the ropes oblique. The tension of the first rope, P A″, (*fig.* 72.) is equal to

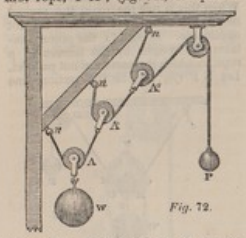


Fig. 72.

the power. Let the tension of the second rope be *t*. Then by (88) we have

$$t = 2\ \mathrm{P}\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}'',$$

A″ being the angle under the parts of the first rope.

In like manner, if *t′* be the tension of the rope A A′, we have

$$t' = 2\ t\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}',$$

and in the same way

$$\mathrm{W} = 2\ t'\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}.$$

Multiplying these three equations together, we have

$$\mathrm{W}\ t'\ t = \mathrm{P}\ t'\ t\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}'\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}''.$$

Omitting the common multipliers *t′ t*, we have

$$\mathrm{W} = 8\ \mathrm{P}\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}'\ \mathrm{Cos.}\ \tfrac{1}{2}\ \mathrm{A}''.$$

It is easy to see how a similar investigation may be extended to any case in which the ropes are oblique.

(90.) Friction has always been a great source of waste of power in pullies. This, however, has been in a great degree removed by an ingenious contrivance of Mr. Garnet, called *friction-rollers*. They not only save expense and labour, but also considerably diminish the wear of the machine. The principle is this: between the axis on which the wheel turns, and the concave cylinder or box in which that axis is placed, a hollow space is left to be filled by solid equal rollers, nearly touching each other. These are furnished with axles, inserted in a circular ring at each end, by which their relative distances are preserved, and they are kept parallel by means of wires fastened to the rings between the rollers, and which are rivetted to them.

Chapter IX.—*On the Inclined Plane.*

(91.) The Inclined Plane is a machine formed, as the name imports, by a plane surface, supposed to be perfectly hard and inflexible, and which is always inclined obliquely to the weight or the resistance to be overcome.

Let the line L H (*fig.* 73.) be horizontal, and let L M be a perfectly hard and smooth plane, forming, with the horizontal plane, the angle M L H, called the *elevation* of the plane. The line L M is called its *length*, M H its *height*, and L H its *base*.

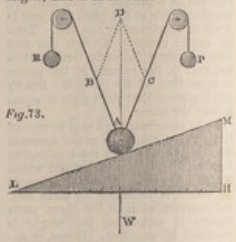


Fig. 73.

Let A be a weight placed upon this plane, and sustained by a power in any direction, as A C. The body A is kept at rest by three forces acting at its centre of gravity: 1°, the force of gravity, W acting in the vertical direction, A W; 2°, the power P acting in the direction A C; and 3°, the resistance R of the plane acting in the direction A B perpendicular to the plane. Now, since the weight W, in the direction A W, resists the forces P and R, in the directions A C and A B, it must be equal and opposite to the resultant of these two forces. (Treatise I. Chap. II.) Suppose A D drawn directly upward, in the direction W A, and from any point D draw D C and D B, parallel to A B and A C respectively, and it follows that the weight, the power, and the resistance of the plane will be proportional to the lines A D, A C, and A B. This may easily be verified by experiment. On a vertical plane behind the power and weight, draw the line A D vertical, and from any point D in it draw D C in a direction at right angles to the plane. Upon measuring the lines A D and A C, they will be found to have

exactly the same proportion as the weight W and the power P. The quantity of the resistance may be determined, experimentally, in the same manner. Let a string be attached to the weight, and brought in a direction A B, over a fixed pulley, and let a weight R be suspended from it, which will bear the same ratio to W and P, as the line A B or D C bears to the lines A D and A C. Upon removing the plane, it will be found that the weight A will remain suspended, undisturbed in its position. Hence, it appears that the tension of the string A C, which is a force equal to the weight R, supplies the place of the plane, and produces the same mechanical effect. The force R, therefore, is the amount of the pressure of the weight upon the plane*.

Since all equiangular triangles have their sides proportional†, it follows that if any triangle be drawn, whose angles are equal to those of a triangle, one side of which is vertical, another perpendicular to the plane, and the third in the direction of the power, the sides of that triangle will always be proportional to the power, the weight, and the pressure upon the plane. This relation between the power, weight, and pressure may be very simply expressed mathematically. Let the angle formed by the vertical line A D, (*fig.* 73.) and the perpendicular A B to the plane be A, and let the angle B D A, formed by the vertical line A D, and the direction A C of the power be D; and the angle under the direction of the power A C, and the perpendicular to the plane, viz. D B A be B. Since the sides of triangles are proportional to the sides of the opposite angles, we have

$$\frac{\mathrm{P}}{\mathrm{W}} = \frac{\mathrm{Sin.\ A}}{\mathrm{Sin.\ B}} \qquad \frac{\mathrm{R}}{\mathrm{W}} = \frac{\mathrm{Sin.\ D}}{\mathrm{Sin.\ B}}$$

(92.) In the preceding investigation of the proportion of the power, weight, and pressure, we have conceived the power to act in any direction whatever. If it act in the direction of the plane, the triangle whose sides will determine its proportion to the weight, will be A C B, (*fig.* 74.) in which B C is the direction of the power, A B of the weight, and A C of the pressure. This triangle

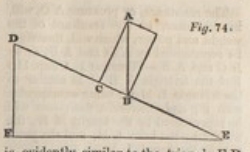


Fig. 74.

is evidently similar to the triangle F D E, formed by the height, length, and base of the plane. Hence, in this case, the height D F of the plane represents the power, the length, the weight, and the base of the pressure.

This may be verified experimentally. Let a thread, attached to the weight A, be brought parallel to the plane, and passed over a fixed pulley at D; let

Fig. 75.



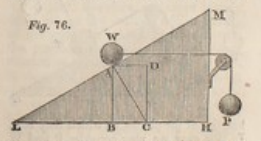
such a weight P be suspended from it, as will bear the same proportion to A as the height D E bears to the length D C, and it will be found to sustain the weight. The amount of the pressure may be shewn to be represented by the base C E in a manner exactly similar to that explained in *fig.* 73.

This may be expressed mathematically thus: let E be the elevation of the plane

$$\frac{\mathrm{P}}{\mathrm{W}} = \frac{\mathrm{D\ E}}{\mathrm{D\ C}} = \mathrm{Sin.\ E} \qquad \frac{\mathrm{R}}{\mathrm{W}} = \frac{\mathrm{C\ E}}{\mathrm{C\ D}} = \mathrm{Cos.\ E}.$$

(93.) If the power act in a horizontal direction, or parallel to the base of the plane, its proportion to the weight will be that of the height of the plane to the base. For, in *fig.* 76, let A B be ver

Fig. 76.



tical, and, therefore, in the direction of the weight; and let A D, parallel to the base, be in the direction of the power, and A C, perpendicular to the plane, will be in the direction of the resistance.

* The experiments which we have thought it advisable to describe, in verification of the theory, are not those which are the most easily executed, but those which we conceive to be best adapted to render the theory intelligible, independent of such mathematical reasoning.

† See Darley's *Popular Geometry*, Art. 112.

The resistance, or pressure A C, will, in this case, be the resultant of the weight and power, which will, therefore, be represented by A D and A B, or by B C and A B.—(Treatise I. Chap. II.) But the triangle A B C is similar to the triangle L M H, being equiangular with it; and, therefore, the power will be represented by the height M H, the weight by the base L H, and the pressure by the length L M.

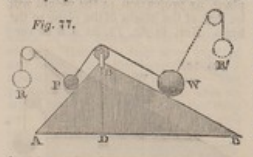
To express this mathematically, we have

$$\frac{P}{W} = \frac{M\,H}{L\,H} = tan.\ E. \qquad \frac{R}{W} = \frac{L\,M}{L\,H} = \frac{1}{Cos.\ E} = Sec.\ E.$$

(94.) It is easy to see that the power acts to greatest advantage, when its direction is parallel to the plane. This may be established at once by mathematical reasoning; but it is sufficiently plain, from considering, that if the power be directed *above* the plane, as in *fig.* 73, it is partly spent in lifting the weight from the plane, or rather in diminishing the pressure, and only partly in drawing it *up* the plane. If, on the other hand, it be directed *below* the plane, as in *fig.* 76, it is spent partly in pressing the weight against the plane, and only partly in drawing the weight *up* the plane. This will be very evident to the student, who has attended to what has been said of the composition of force in Chap. II. of our first Treatise. But if, on the other hand, the power acts parallel to the plane, its whole effect will be spent in drawing the weight up the plane.

(95.) If a weight on one inclined plane be supported by a power on another, their proportion will be that of the

Fig. 77.



lengths of the planes on which they rest. In this case we may consider P and W (*fig.* 77.) as two weights, sustained on two inclined planes, A B and C B, by the tension of the string which unites them, and which is the common power which sustains both, and which supports each in a direction parallel to the planes on which they respectively rest. Considering only the inclined plane A B, the power, that is the tension of the string, the weight P and the pressure are represented by B D, B A, and A D, respectively (92). In like manner, considering only the plane B C, the power or tension of the string, the weight W and the pressure are represented by B D, B C, and C D, respectively. The power, or tension of the string, being the same for both planes, it follows that the weights P and W are as the lengths B A and B C, and that the pressures are as the lines A D and C D.

This may be submitted to the test of experiment, by ascertaining the power P, which supports any given weight W, and measuring the lengths of the planes. They will always be found to be in the same proportion. To determine the proportion of the pressures, let threads be attached to P and W, and brought in directions perpendicular to the planes over fixed pulleys, and let weights R' and R be suspended from them, which shall have the same proportion to P and W, as the lines A D and C D have to B A and B C, and upon removing the planes from beneath the weights, they will retain their positions undisturbed.

(96.) The principle of virtual velocities may be easily applied to the inclined plane. In *fig.* 75, suppose that at the commencement of the motion the weight is at the foot C of the plane, and the power is at the top D of the altitude. Let the power then descend until the weight shall arrive at the top of the plane. It will have descended through a space equal to the length of rope which has passed over the pulley, that is, equal to the length of the plane, and at the same time the weight will have ascended through a space equal to the height of the plane; so that the perpendicular spaces, through which the weight and power move in the same time, are the height and length of the plane, and these are, therefore, the proportion of their velocities. But the proportion of the weight to the power is that of the length to the height. Hence, the power and weight are reciprocally as their vertical velocities, which is conformable to the principle of virtual velocities.

It would not be difficult to show the application of this principle to the other modifications of the inclined plane; but this instance will serve our present purpose.

(97.) In the inclined plane, therefore, like every other mechanical power, we lose velocity in proportion as we increase the force. In some instances, however, this is an advantage. For instance, in an inclined plane constructed for launching a ship. Here the plane is slightly inclined, and the power which would sustain the vessel on the plane (allowing the effects of friction) is equal to the force with which the vessel descends, which, owing to the small elevation, is comparatively trifling.

Chapter X.—*On the Wedge.*

(98.) A Wedge is a solid figure, which is called in geometry a *triangular prism*. Its two ends are equal and similar triangles, and its three sides are rectangular parallelograms. This figure is represented in *figs.* 78, 79.

The wedge is very generally used in

Fig. 78.



cleaving timber, in which case its edge is introduced into a cleft already made to receive it, and it is urged at the

Fig. 79



back by percussion. The friction of the faces of the wedge with the timber ought to be sufficient to prevent its recoil.

The wedge may be considered as formed by two inclined planes placed base to base, their altitudes forming the back of the wedge. The power being generally applied perpendicularly to the back will be parallel to the common base. But it is a more difficult matter to say in what direction the resistance is to be considered as acting against the face of the wedge.

In the theory of the wedge, there are introduced so many conditions, which are perfectly inapplicable in practice, so many gratuitous assumptions and suppositions so inconsistent with practical truth, that the whole doctrine has little or no value.

One of the circumstances, which creates the greatest difficulty in the theory of the wedge, is the very heterogeneous nature of the resistance, and the force or power by which it is overcome. The resistance is generally that modification of force called *ressure*. The power, which is opposed to this resistance, is commonly that species of action called *percussion*. These are modifications of force so totally different as not even to admit of comparison. It has been generally thought that there is no *blow* or *impact*, however slight, which will not overcome a pressure or resistance however great. From which it would seem to follow, that an infinitely small impact is equivalent to an infinitely great pressure. Be this as it may, however, the great difference between these modifications of force, is sufficiently evident to demonstrate the total impossibility of establishing the condition of equilibrium of a machine in which the weight or resistance is a force of the one, and the power is a force of the other species.

Nothing, therefore, can more plainly demonstrate the inutility of the theory of the wedge than that, in this theory, the power is supposed to be a pressure exerted on the back of the wedge, which is supposed to be capable of balancing the effect of the resistance in producing the recoil of the wedge. In all cases, where the wedge is practically used, the friction of its faces with the resisting substance, is sufficient to prevent the recoil; so that, strictly speaking, no force whatever is necessary to sustain the machine in equilibrium, and to move it, pressure is never resorted to, inasmuch

as the slightest percussion is far more effective.

The only general theoretical principle respecting the wedge, which obtains always in practice is, that its power is increased by diminishing the angle.

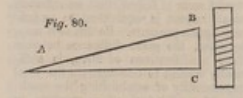
All cutting instruments, as knives, swords, hatchets, chisels, planes, &c. are wedges. In these cases, the harder, in general, the substance to be divided is, the greater will be the angle of the wedge. Thus, chisels for cutting soft woods are sharper than those used for the harder species, and these, again, are sharper than chisels used for cutting metals.

In the preceding observations on the wedge, we have not attempted to explain its theory, conceiving, that a theory, which is utterly inapplicable in practice, is better omitted in the "Library of Useful Knowledge."

Chapter XI.—*On the Screw—Hunter's Screw — Perpetual Screw — Micrometer Screw.*

(99.) The screw is a machine of great mechanical power, and is applied to various purposes; but is most generally used in cases where an intense pressure is to be exerted. This machine is a modification of the inclined plane. Let an inclined plane (*fig.* 80.) be placed with

Fig. 80.



its altitude B C parallel to the axis of a cylinder, and placing the altitude B C on the side of the cylinder, let the plane, supposed flexible, be rolled round it. The length A B of the plane will trace upon the cylinder a spiral thread, which is called the thread of the screw.

A perspective view of this machine is given in *fig.* 81. If any body be placed between two threads, and the screw be turned once round, the body so placed not being permitted to turn with it, it is plain that this body will be moved from its first position to a similar place on the thread next above that on which it was first placed. In fact, it will be elevated through an height equal to the distance between two contiguous threads. By this process the body is forced up the inclined plane, which is wrapped upon the cylinder, and the power being

Fig. 81.



supposed to be applied at the circumference of the screw acts parallel to the base of the plane.

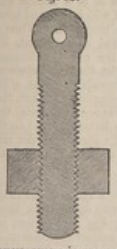
In this case, the proportion of the power to the weight is that of the height of the plane to its base (93). But in one revolution of the screw, the body, which is placed between the threads, is moved up an inclined plane, whose height is the interval between two contiguous threads, and whose base is the circumference of the screw. Hence, it follows that the power is to the weight or resistance as the interval between the threads is to the circumference of the cylinder on which the thread is raised.

The energy of the power on the screw is transmitted by means of a concave cylindrical screw, on the inner surface of which a spiral channel is cut, corresponding exactly to the thread raised upon the cylinder, so that by turning the one within the other the convex screw will pass through the concave screw, and will advance every revolution through a space equal to the distance between two contiguous threads.

A section of the convex and concave screw, by a plane through the axis, is represented in *fig.* 82. If the concave screw be fixed, so as to be incapable either of revolving or moving in the direction of its length, it is evident that the convex screw will gradually penetrate it, advancing through the space between two contiguous threads every revolution. If, on the other hand, the convex screw be incapable of moving in the direction of its length, it will, by its rotatory motion, force the concave

screw in the direction of its length, through a space equal to the interval between two contiguous threads, every revolution.

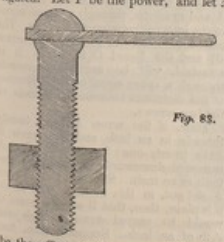
Fig. 82.



The convex screw is generally called the *screw*, and the concave screw is denominated the *nut*.

(100.) We have here considered the power to be applied at the circumference of the screw; and if we consider the screw as a simple machine, we must suppose it thus applied. But, in practice, the screw never is used as a simple machine, and the power is always applied to a lever at the head of the screw, in the same manner as it is applied in the wheel and axle, and as represented in *fig.* 83. In this case the machine is really complex, being composed of a lever and a screw. The proportion of the power to the weight is easily investigated. Let P be the power, and let x

Fig. 83.



be the effect of this power at the circumference of the screw. Let R be the arm of the lever by which the power acts, and let r be the radius of the section of the screw, at right angles to its length. By the principles established in Chap. III., we have

$$P \times R = x \times r,$$

or $$P : x :: r : R.$$

But the radii of circles are as their circumferences. Let C be the circumference described by the power, and whose radius is R, and c the circumference of the screw, whose radius is r.

$$r : R :: c : C$$

Hence, we have

$$P : x :: c : C,$$

or $$P \times C = x \times c.$$

But, by (99),

$$x : W :: D : c,$$

where D signifies the distance between the threads. Hence, we have

$$x \times c = W \times D \therefore P \times C = W \times D$$

or $$P : W :: D : C.$$

That is, "the power, multiplied by the circumference which it describes, is equal to the weight or resistance, multiplied by the distance between two contiguous threads;" or, "The power is to the weight, as the distance between two contiguous threads is to the circumference described by the power."

It frequently happens, that the lever by which the power acts is attached to the nut, and the screw is capable only of a longitudinal motion. Thus, in the press represented in *fig.* 84, the board

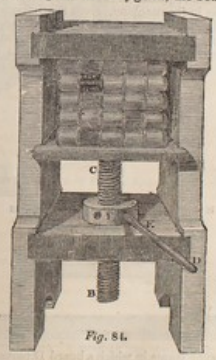


Fig. 84.

C, moveable between the sides of the frame, is urged by the screw CB, capa-

ble of moving directly upwards or downwards, but not of revolving. The nut F is worked by the lever D E. Every complete revolution of the nut urges the screw upward, through a space equal to the distance between two contiguous threads.

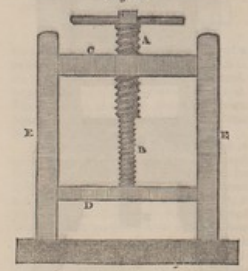
The proportion of the weight to the power, or the mechanical efficacy of the screw, depends on the proportion of the circumference described by the power, to the distance between two contiguous threads. Hence, it is evident that the efficacy of the screw may be increased, either by increasing the length of the lever by which the power acts, or by diminishing the distance between the threads. To both of these there are, however, practical limits, similar to those mentioned in the case of the wheel and axle (58.)

If the leverage of the power be very much increased, the power will work through an inconveniently great space, and the machine will become unwieldy. If, on the other hand, the thread of the screw be made very small and fine, it will be torn off by a great resistance in passing through the nut.

These inconveniences have been obviated by a contrivance of Mr. Hunter, the Surgeon, which, while it preserves all the requisite strength and compactness in the machine, gives it an almost unlimited degree of mechanical efficacy.

A perspective drawing of this contrivance is given in *fig.* 85: E E is a

Fig. 85.



strong frame in which a board D moves, so that when it is forced towards the bottom, it will exert a pressure on any substance placed between it and the bottom. To this moveable board D is attached a cylinder B, on which the thread of a screw is raised. C is a fixed nut through which a screw A plays. The screw A is a hollow cylinder, the interior of which is a nut adapted to receive the screw B. When the screw A is turned once round, it advances through the nut C, through a space equal to the distance between two contiguous threads; so that, if the screw B were not supposed to act, the board D would advance towards the bottom, through a distance equal to the distance between the threads of the screw A. But while the screw A advances through the nut C by its revolution, the very same cause makes the screw B move towards C through a space equal to the distance between two contiguous threads of B; or, by turning A, the nut contained in the inner concave surface of A is turned upon the screw B. Now, if the threads of the two screws A and B were perfectly equal, the effect of these two motions would be, that the board D would retain its position, inasmuch as the effect of one screw, in moving it *downwards*, would be exactly equal to the effect of the other screw in moving it *upwards*.

But if we suppose the interval between the threads of the screw B to be somewhat less than the interval between the threads of the screw A, the effect will be different. In this case, one revolution will move the screw A *downwards*, through a space equal to the interval between its threads, while the screw B will be moved within the screw A and *upwards*, through a space equal to the interval between *its* threads. The combined effect will be, that the screw B, and the board C to which it is attached, will be moved *downwards* through a space equal to the difference of the distances between the threads of the two screws.

Thus, if the screw A have twenty threads in an inch, and the screw B have twenty-one; in one revolution, A is moved downwards through the twentieth of an inch. Suppose that the nut A did not, in this motion, turn on B it is plain, then, that B and the board C would be moved down through the $\frac{1}{20}$th of an inch. Suppose, then, that the screw B was turned round once within the nut A, the screw B and the board C would be raised through the $\frac{1}{21}$th of an inch. Its position would then be below its original position by the

excess of $\frac{1}{20}$th of an inch above $\frac{1}{21}$th of an inch; that is, by $\frac{1}{420}$th of an inch.

To render the explanation clearer, we have here supposed things to happen in succession, which really happen together. The same motion which advances the screw A downwards, draws the screw B upwards; but the final effect is the same as if these two motions took place in succession.

It is plain, therefore, that the effect of this machine is the same as that of a simple screw in which the distance between the threads is equal to the difference of the distances between the threads of the two screws A and B; and, therefore, that the ratio of the power to the weight is the difference between the distances of the threads of the two screws to the circumference described by the power.

The mechanical efficacy is, therefore, increased by diminishing the difference of the distance between the threads of the screws. If the circumference described by the power be 20 inches, and one screw have twenty threads to an inch, and the other twenty-one, the power will be to the weight as the difference between $\frac{1}{20}$ and $\frac{1}{21}$, or $\frac{1}{420}$ to 20, or as 1 to 8400. If, however, one screw have 30 threads and the other 31 to an inch, then the power is to the weight as the difference between $\frac{1}{30}$ and $\frac{1}{31}$, or $\frac{1}{930}$ to 20, or as 1 to 18600.

The threads of each screw may be constructed of any size and strength which may be required, and yet so very nearly equal, that any degree of power may be imparted to the machine. Thus, by the preceding investigation, it appears that two screws, constructed with 30 and 31 threads in a foot, are equivalent to a single screw with 930 threads in a foot.

(101.) The thread of the screw, instead of urging forward the nut, sometimes is made to act upon the teeth of a wheel, as in *fig.* 86. In this case it is called a *perpetual screw*. The machine in this figure is complex, being composed of the screw and the axle in the wheel. The relation between the

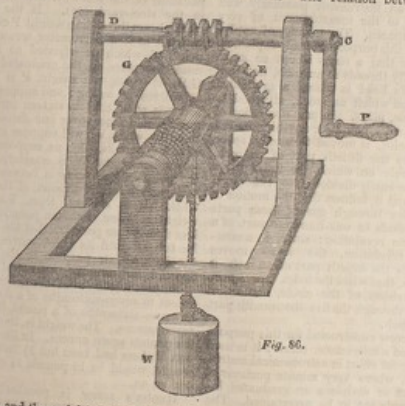


Fig. 86.

power, and the weight is easily investigated. Let P be the power, and let x be its effect on the wheel G E. Let R be the radius of the wheel, D the distance between the threads of the screw, r the radius of the axle, and W the weight or resistance; and let C be the circumference described by the power. By what we have established respecting the screw

$$P \times C = x \times D$$

and by the properties of the wheel and axle established in (50),

$$x \times R = W \times r$$

Multiplying these equalities, we have

$$P \times C \times x \times R = x \times D \times W \times r$$

Omitting the common multiplier x, we have

$$P \times C \times R = W \times D \times r$$

or $P : W :: D \times r : C \times R$;

that is, "the power is to the weight as the distance between the threads multiplied by the radius of the axle to the circumference described by the power, multiplied by the radius of the wheel."

The condition of equilibrium of this machine has been mistaken by some writers, and the error seems to have crept from one treatise to another. Instead of the circumference described by the power, the radius is used which gives the machine only about a sixth of its true efficacy.

(102.) The very slow motion which may be imparted to a screw by a very considerable motion in the power, renders it an instrument peculiarly well adapted to the measurement of very minute spaces. The manner of applying it to this purpose is easily explained. Suppose that a screw is cut so as to have fifty threads in an inch, and that round its head is placed a graduated circle, on which an index, attached to the screw, plays. In one revolution of the screw its point, or anything moved by its point, is moved through a space equal to the fiftieth part of an inch. The circle on which the index plays may be easily divided into 100 equal parts, and it follows that the motion of the index through one of these parts corresponds to one-hundredth part of a complete revolution: since, in a complete revolution, the screw moves through the fiftieth part of an inch, it follows, that when the index moves over one division of the circle, the screw moves through the five-thousandth part of an inch.

A screw constructed for this purpose is called a micrometer screw: it is used with great effect in astronomical instruments, where very minute portions of degrees or divisions on graduated instruments are to be ascertained. The limit of accuracy of any divided instrument adapted for measuring spaces or distances is primarily the magnitude of the smallest division on it. If it be required to determine the distance from any given division to a point which is placed somewhere between two divisions, it is easy to conclude that the distance sought is greater than a certain number of divisions, and less than a number greater than that by one. But how much greater than the one or less than the other, the mere graduation of the instrument does not indicate. Now, suppose that a micrometer screw is placed on the instrument, its length being parallel to the graduated face, and that the point of the screw, or rather, a wire which is moved by the point of the screw, is brought exactly opposite to one of those divisions between which the point, whose exact position is to be determined, lies. If the screw be turned until the wire is moved by its point from coincidence with the adjacent division till it coincides with the point, the number of turns of the screw, and parts of a turn, will indicate exactly the distance of the point from the adjacent division.

We may give an example of the application of the screw to this purpose in the steel-yard (44). If the loop which bears the sliding weight P carries inserted in it a micrometer screw, the point of which is adjusted so as to mark the place on the graduated arm G B, at which the weight P is to be considered as acting; and suppose the screw is such, that in sixteen turns its point would move over one division of the arm, which we will suppose graduated for pounds,—let us suppose that when the weight W is counterpoised, the point of the screw is between the tenth and eleventh division of the arm G B. It is evident, then, that the weight is more than ten pounds, and less than eleven pounds. Let the screw be turned until its point moves from the intermediate position to the tenth division, and note the number of turns —suppose it seven: that would be equivalent to seven-sixteenths of a division, or seven-sixteenths of a pound, that is, seven ounces. The weight is, therefore, ten pounds seven ounces. In like manner, if there had been but 5¼ turns, the weight would be 10 pounds 5¼ ounces, and so on.

Hunter's screw is peculiarly well adapted to micrometrical purposes, because it gives an indefinitely slow motion, without requiring a very exquisitely fine thread, which the simple screw would require in this case.

CHAPTER XII.—*Methods of regulating Machinery—Nature of a Fly-Wheel—its power of regulating force—its power of accumulating force—Instances—Nature and Properties of the Governor.*

(103.) IN applying force to impel machinery, for the purposes of manufacture, the mere transmission of the effect of the power to the working point is not the only end to be attained. It is most frequently necessary that the action of the working point should be steady and uniform, and not subject to irregular or desultory changes, occasioning jolts in the machinery, and sudden inequalities in the work. The want of uniformity, in the performance of a machine, may arise from either of three causes. *First*, a want of uniformity in the action of the power, or *first mover*, which impels the machine. Thus, for instance, in the single-acting steam-engine, where the elastic force of steam acts upon the piston during its descent, but which action is suspended during the ascent. *Secondly*, a want of uniformity in the resistance, or load upon the machine; and, *thirdly*, because the machine, in the different positions which its parts assume during the motion, transmits the impelling power to the working point with greater or less effect.

One of the most simple and effectual methods of equalizing these irregularities, is by the use of a FLY-WHEEL. A FLY-WHEEL is a heavy disc, or hoop balanced on its axis, and so connected with the machinery, as to turn rapidly round with it, and so as to receive its motion from the impelling power. Let us suppose a case in which the impelling power is perfectly uniform, but the resistance or load is irregular and intermitting. Thus, suppose an overshot water-wheel, (Treatise I. Chap. V.) urged by a regular and uniform fall of water, applied to work a common suction-pump. (PNEUMATICS, 40.) Here the impelling power is constant and uniform, but the resistance only acts during the ascent of the piston, and the machine is unloaded during its descent. As the impelling power during the descent of the piston has nothing to overcome except the inertia of the machine, and the friction of the parts, it will urge the piston down with a rapidly accelerated force, so that at the end of the stroke the piston will have acquired a considerable velocity. But, in the ascent of the piston, the impelling power is opposed by the column of water which the piston has to raise. (PNEUMATICS, 40.) This continually retards the wheel, and when the piston has reached the summit of the stroke, all its former acceleration is destroyed, and the same hobbling, irregular motion is continued. If a FLY-WHEEL be attached to such a machine, almost all this irregularity will be removed. When the heavy mass of the fly-wheel has been put in rapid motion by the impelling power, it will produce two very obvious effects: by virtue of its inertia, it will oppose a considerable resistance to any sudden acceleration, and also to any sudden retardation of its motion; that is, it has a disposition to continue the motion which has been imparted to it, and to resist the reception of more. By this, on the ascent of the piston, the weight of the column of water is dragged up, not alone by the energy of the prime mover as before, but by the moving force which has been imparted to the fly-wheel, and which that wheel endeavours to keep. On the other hand, when the piston descends unloaded, the action of the prime mover upon it, which before caused its sudden and rapid acceleration, is now intercepted by the fly-wheel, which, by its great inertia, refuses to receive that rapid degree of acceleration which had been before produced.

The power of a fly-wheel to resist acceleration is proportional to the square of its diameter, and, therefore, by sufficiently increasing its size and weight, we may be enabled to equalize the most desultory and irregular motions in the machinery.

In the example which we have just given, there was a variable resistance opposed by an uniform power. The reverse of this often happens, and a variable power is opposed to a constant resistance. Thus, in the single-acting steam-engine already alluded to, when the piston has been forced down by the pressure of steam, it is usually drawn up again by a weight suspended from the opposite end of the beam. In this case the mover is very unequal and desultory, and would never serve any purpose in which uniformity of action is necessary. But, if a fly-wheel be attached to the machine, the momentum which it acquires during the de

scent of the piston, it will retain, by virtue of its inertia, during the suspension of the power in the ascent; and this force will drive the machinery, or act against the resistance, whatever it be, in the intervals of the intermission of the power.

Even where both the impelling power and the resistance are uniform, the one may not be uniformly transmitted to the other. Suppose that piston P, working in a cylinder C, is connected with the end B of a beam, which works on the centre A. The other end, B', of the beam, is connected by a rod, B'D, with a crank F G H I K, which is turned

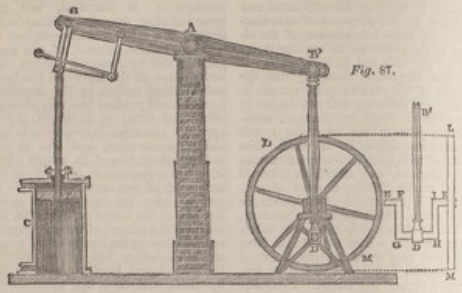


Fig. 87.

round the axis E F I K. The piston being supposed to be pressed both upwards and downwards by steam, suppose it at the top of the cylinder, as in *fig.* 87. The end B of the beam will then be in the highest position, and the end B' in the lowest, and therefore, the crank G H in the lowest position. In this position, let us suppose the pressure of steam to urge the piston P downwards. It is evident, that the piston and beam have no power whatever in turning the crank. The piston being pressed downwards, draws the connecting rod, B'D, directly upwards. But since, in the present position, the rods B'D, E F, F G, G H, H I, and I K, are all in the same vertical plane, the upward force of B D is resisted by the pivots E K, of the axis of the crank, and there is no leverage to enable the force of B'D to turn the crank. The machine is, therefore, placed in that mechanical dilemma in which the impelling power loses all influence in moving it. But if we suppose the crank moved a little out of this position, the rod B'D and crank cease to be in the same vertical plane, and the rod acquires a small leverage on the crank, by which it turns it. This leverage continues to increase until the plane of the crank F G H I becomes perpendicular to the connecting rod, as represented in *fig.* 88. In this case, the power of the connecting rod over the crank is at its maximum, and when the crank is further raised, the leverage constantly

Fig. 88.

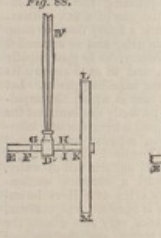
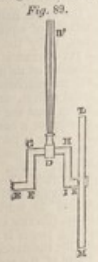


Fig. 89.



diminishes, until the piston reaches the bottom of the cylinder, and the crank attains its highest position, as in *fig.* 89. Here, again, the impelling power loses all influence on the crank. Suppose the pressure of steam to urge the

piston *upwards*; the connecting rod B'D would thereby be pressed downwards; but since the crank and rod are now in the same vertical plane, the pressure of the rod will be entirely spent on the pivots, and, having no leverage, cannot turn the crank. Thus, it appears that when a machine is constructed in this way, an uniform action of the first mover will be modified, and rendered desultory and variable, and at certain moments totally destroyed by the nature of the machinery by which it is transmitted to the working point. If, however, on the axis of the crank a FLY-WHEEL (L M, *fig.* 87) be fixed so as to turn with the crank, this inconvenience will be completely removed. The moving force of the fly-wheel will extricate the machine from the dilemmas in which it is involved at those moments at which the impelling force loses its power over the crank, and it will equalize the effects of the varying leverage by which the first mover acts on the crank.

A very remarkable instance of the use of a fly occurs in the engine constructed by Mr. Vauloue, for driving the piles of Westminster bridge. In this machine, a heavy mass is elevated by horse-power acting upon it through the intervention of a rope and wheel-work, and when it has reached a considerable height it is disengaged, and permitted to fall upon the pile which is to be driven. Now the moment this mass is disengaged, the machine having no resistance, and the horses being relieved from the weight they before encountered, would immediately fall forward. This is prevented by connecting the wheel-work with a heavy fly, the inertia of which opposes the strength of the animals when they are suddenly relieved from the weight of the elevated mass.

The advantages of a fly-wheel are sensibly perceptible when a man acts upon a *winch* (*fig.* 34). In this case the action of the power is very unequal: its effect is greatest when he pulls upwards from the height of his knee, and least when, the handle being in a vertical position, he thrusts from him in an horizontal direction. The force is increased when, pressing the handle downwards, he is assisted by his own weight. If a fly be placed upon the axis of the winch, all these unequal effects run into one another, and the force becomes uniform.

Besides the use of a fly, in regulating the action of machinery, it is employed for the purpose of accumulating or collecting together successive exertions of a power, so as to produce a much more forcible effect by their aggregation than could possibly be done by the separate and successive actions. In this respect a fly-wheel serves the same purpose as condensed air (Treatise I. 56). If a small force be repeatedly applied in giving rotation to a fly-wheel, and be continued until the wheel has acquired a very considerable velocity, such a quantity of force will be at length accumulated in its circumference as to overcome resistance and produce effects utterly disproportionate to the immediate action of the original force. Thus it would be very easy in a few seconds, by the mere action of a man's arm, to give to the circumference of a fly-wheel a force which would give an impulse to a musket ball equal to that which it receives from a full charge of powder.

The same principle explains the force with which a stone may be projected from a sling. The thong is swung several times round by the force of the arm, until a considerable portion of force is accumulated, and then it is projected with all the collected force.

If a heavy leaden ball be attached to the end of a strong piece of cane or whalebone, it may easily be driven through a board: by taking the end of the rod remote from the ball in the hand, and striking the board a smart blow with the end bearing the ball, such a velocity may easily be given to the ball as will drive it through the board.

Much of the efficacy of a fly depends on the position assigned to it in the machinery. If it be used as a regulator of force, it should be placed near the prime mover; but if, on the other hand, it be used as a magazine of power, it should be nearer to the working point. No general rules can, however, be given for its exact position.

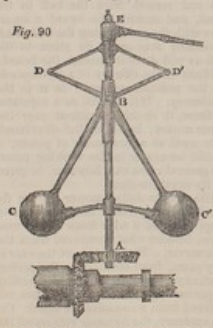
The accumulating power of the fly has led some persons into the error of supposing that it adds force to the machine, besides what is received from the first mover. That this is not the case is very plain, from considering the perfect inactivity of matter, and its incapability of possessing any force that it has not received from some effective agent. On the contrary, the fly never retains all the force communicated to it by the first mover, for the resistance of the air and

the effects of friction rob it of a certain part of this force.

A fly-wheel is not the only regulator of force, and, even in cases where it is used, we are sometimes obliged to have recourse also to other contrivances. In manufactures it generally happens that there is one certain and determinate velocity with which the machinery should be moved, and which, if increased or diminished, would render the machine unfit to perform the work it is designed to execute. The application of a perfectly-uniform power, aided by a fly, will not effect this. For suppose, as very frequently happens, the resistance is changed by some of the machines, which are worked, being thrown out of gear or an increased number put on, the moving power having the resistance thus diminished or increased, will impart a greater or a less velocity to the machinery, and all the fly-wheel can do in this case is to maintain the velocity uniform after it has been so increased or diminished.

To maintain an uniform velocity with a varying resistance, one of the most beautiful contrivances ever used is the *governor*, an instrument used in millwork, but the application of which is most conspicuous in the steam-engine, when that machine is applied to manufacturing purposes. The principle on which the efficacy of this instrument depends, is easily explained.

Fig. 90



Let A B be a vertical axis, which is made to revolve by the bevelled wheel A, acted on by the other parts of the machinery, and so that it always revolves with a velocity proportional to that of the fly-wheel. Two heavy balls C C′ are attached to metal rods, which work on a pivot at B, so that they are capable of receding from the axis A B. As they recede from the axis, the joints D D′ recede from one another, and the joint E is drawn down. This joint E is connected with the end of a lever or a system of levers, the action of which we shall presently explain.

Now, by the revolution of the spindle or axis A B, the balls C C′ acquire an obvious tendency to fly off from the axis, and this tendency is resisted by their weight, so that, when the instrument is revolving with a certain velocity, the balls will remain suspended. The property, from which this apparatus derives its whole efficacy, is, that at whatever distance or in whatever position the balls remain suspended, and neither move to or from the axis, the spindle A B must be revolving with the *same velocity*. A greater velocity would cause the balls to fly further off, and a lesser velocity would cause them to fall towards the axis*.

If the action of the levers with which the joint E is connected, be directed upon the first mover, in such a manner, that its energy is diminished when E is depressed, and increased when E is elevated, it is plain that the uniformity of velocity which is sought may be obtained. Let us suppose that the levers on which E works communicate with a valve which admits steam to the piston of a steam-engine to which this governor is applied; and suppose that, when E is raised, and the balls C C rest in their seats, the valve is fully open, so as to allow the steam to flow in a full stream to the piston; but that according as E is depressed the levers gradually close the valve, so as to admit the steam in a constantly diminished quantity. Now, suppose that the engine has been working twenty printing-presses, and that the action of ten of them is suddenly suspended. The engine thus loses half its load, and would, if the same power of steam continued to be admitted, move with about twice its former velocity. But the moment an increased velocity is perceived in the machine, the balls C C′ recede from the axis, draw down the joint E, partially close the valve, and check the supply of steam to the cylinder. The impelling power is thus diminished; and if it be diminished in exactly the same degree as the load, the machine will move with its former velocity; but if it should, at first, be more diminished, the velocity will be less than its former velocity, and the balls will again move towards the axis and open the valve, and will, at length, settle into that position in which the steam admitted to the cylinder is exactly proportioned to the load on the machine; and the proper velocity will thus be restored.

By this exquisite contrivance, therefore, however the load or resistance may from time to time be varied, the velocity will be constantly the same, the impelling power being varied in exactly the same proportion as the resistance.

There are various other contrivances for regulating the motion of machinery, amongst which the pendulum of a clock may be mentioned. Our limits preclude us from prosecuting this interesting subject further in this place. We may refer the reader to the second volume of Dr. Brewster's edition of Ferguson's Mechanics for some valuable information on this subject; as also to the second volume of Dr. Gregory's Mechanics, article "Scapements."

* This is strictly true only when the range of the balls is small compared with the length of the rods to which they are attached, which, however, is always the case in practice.

Chapter XIII.—*On Mechanical Contrivances for Modifying Motion.*

(104.) We have frequently stated, that one of the great ends to be attained by machinery is the change, or modification of motion. Our impelling power may be rectilinear when a circular motion may be required in the working point, or the impelling power may be alternate, or reciprocating, when the force required at the working point is continuous. In a word, the motion of the impelling power may be of any one species, and that required at the working point may be of any other species. It is, therefore, a very important problem to assign the nature of the machinery which should be interposed between a given impelling power and the working point, so as to produce at that point the effect required.

This problem, in its most general form, it is evidently impossible to solve; nor is it easy to enumerate all the different motions which the impelling power may have, nor the various motions which these may be required to produce at the working point. Generally speaking, however, the motions which we meet with in the use of machinery may be resolved into *rectilinear* and *circular*, that is, one in which the points of the moving part describe parallel straight lines, or one in which they move in circles round a common centre or axis. These, again, may be divided into *continued* and *alternate*, or *reciprocating*. That is, the point which moves in a straight line may move continually in the same direction, or it may move backwards and forwards, or upwards and downwards, its range being limited by two points on the straight line in which it moves. Again, if the point move in a circle, it may move constantly round the centre in the same direction with a continued rotatory motion; or, on the other hand, it may only move over an arc of the circle in one direction, and then return through that arc in the opposite direction, and so on alternately, having a vibrating or reciprocating motion in the circular arc.

The motions which we have to consider may then be resolved into the four following:—

1. Continued rectilinear motion.
2. Reciprocating rectilinear motion.
3. Continued circular motion.
4. Reciprocating circular motion.

We shall devote the present chapter to explain some of the contrivances by which each of these may be modified or converted one into another.

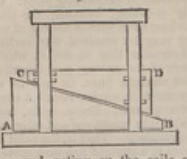
(105.) *To convert continued rectilinear motion in any one direction into continued rectilinear motion in any other direction.*

If the directions of the two motions be in the same plane, this may evidently be effected by a fixed pulley. But if the directions be in different planes, two fixed pulleys will be requisite, one being in the plane of the direction of one motion, and the other in the plane of the direction of the other motion.

In *fig.* 91, a contrivance is represented, by which a rectilinear motion in one direction is made to produce a rectilinear motion in a direction at right angles to the former. The inclined plane or wedge A B, is moved under C D, which is connected by *guides* with the pillars of the frame. It is evident, that as A B advances from A to-

wards B, C D rises in the vertical direction.

Fig. 91.

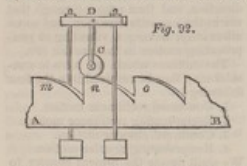


The wind acting on the sails of a ship in one direction gives the vessel a rectilinear motion in another direction.

(106.) *To convert continued rectilinear motion into reciprocating rectilinear motion.*

Let A B be a chain furnished with wipers *m*, *n*, *o*. Let B be a frame loaded with weights and furnished with a wheel C, and let the frame be so fixed

Fig. 92.



that it is incapable of any but a vertical motion. As the chain is moved continually in the direction A B, the wheel C running up the surfaces of the wipers will be elevated, and when it passes the point of each wiper it will fall into the space between that and the succeeding one, and thus the frame B will acquire a rectilinear motion upwards and downwards.

(107.) *To convert a continued rectilinear motion into a continued circular, or vice versâ.*

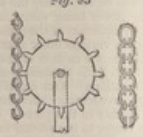
There are various methods of effecting this. The wheel and axle is an obvious instance where the continued rotation of the power produces the continued rectilinear ascent of the weight, or if the weight be permitted to descend, its continued rectilinear descent will give a continued rotation to the wheel.

This may also be effected by a toothed wheel working in a rack. A rack is a straight bar on which teeth are raised. If such a bar be placed in connexion with a wheel on which similar teeth are raised, the continued rectilinear motion of the rack will produce continued circular motion in the wheel, and *vice versâ*.

A strap, or belt, passing round a wheel, and turning it by its friction with the surface or groove in which it works, will attain the same end where the resistance is not very great. An endless strap may be used, in which case two wheels will be necessary.

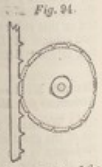
But in cases where much resistance is to be overcome, the friction of the strap with the surface of the wheel would not be sufficient to transmit the force. In this case, however, a chain and rag-wheel may be used. The chain sometimes lays hold of pins or hooks in the wheel, as represented in *fig.* 93, and

Fig. 93



sometimes carries pins upon it, which enter notches in the circumference of the wheel, as in *fig.* 94.

Fig. 94.



A common screw offers an instance of the conversion of continued circular motion into continued rectilinear.—The power applied to the head of the screw moves with continued circular motion, and the screw itself advances with continued rectilinear motion.

The paddle-wheels of a steam-boat and an undershot water-wheel are examples of a continued rectilinear motion produced by a continued circular, and of a continued circular produced by a continued rectilinear.

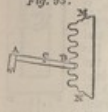
An overshot or breast-wheel is an instance of continued rectilinear motion producing continued circular; also the wind, acting on the arms of a windmill, is another example of the same effect.

The screw of Archimedes is an instance of a continued circular motion producing a continued rectilinear one. (See *Hydraulics*, chap. ii.)

Barker's mill is a remarkable instance of a continued rectilinear motion producing a continued circular one.

(108.) *To convert a continued rectilinear motion into a reciprocating circular motion, or vice versâ.*

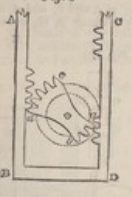
Fig. 95.



One method of effecting this is by a rack M N, (*fig.* 95.) in the teeth of which the end B of a lever A B works. As the rack M N descends, the end of the lever falls from one tooth to another, and the end A moves alternately up and down in a small circular arc.

A method of producing either a reciprocating circular motion from a continued rectilinear motion, or a continued rectilinear from a reciprocating circular motion, is represented in *fig.* 96. A B C D is a double rack, fur-

Fig. 9

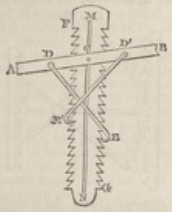


nished with teeth at intervals, the parts of A B, which bear teeth, being opposite to those parts of C D which are free from them; *a b c d* is a wheel bearing teeth, corresponding to those of the rack. Suppose the rack in its highest position, and the first tooth *b* of the wheel engaged with the lowest tooth on the rack C D. As the rack descends, the teeth *b a* are successively engaged with the corresponding teeth of the rack, and the wheel revolves until the last tooth *a* is passed by the last tooth of the first set on the rack C D. At this moment the lowest tooth *d* on the other side of the wheel is seized by the lowest tooth of the first set on the rack A B; and after this, the teeth *d c* are successively engaged by those of the rack, and the wheel is turned in the direction contrary to its former motion. As the rack continues to descend, the same reciprocating circular motion continues to be produced in the wheel.

The motion may be continued without limit by using two chains, bearing teeth at intervals, working on two pair of rag-wheels.

The *lever of La Garousse* is a contrivance by which a reciprocating circular motion produces a continued rectilinear one. M N (*fig.* 97.) is a fixed

Fig. 97.



shaft, in which a centre is placed at C, on which the lever A B works. F G is a rack, which is capable of being raised in the vertical direction. This is effected by two bars D E, D' E', placed on joints at D, D'. When the extremity A descends, the point D' rises, and the hook E', being engaged with a tooth of the rack, draws it up. The hook E in this process falls from one tooth of the rack to the tooth immediately under it. When B is depressed, and D rises, the same effects take place, but on different sides of the rack.

Thus, the reciprocating circular motion of the lever A B produces a continued rectilinear motion in the rack F G. The term *continued* rectilinear motion here means rectilinear motion which is always in the same direction; for, strictly speaking, the motion is not *continued*, since it is *intermitting*.

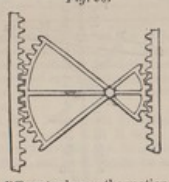
(109.) *To convert reciprocating rectilinear motion, in one direction and with one velocity, into reciprocating rectilinear motion in another direction and with another velocity.*

If the velocities of the two motions were equal, and the directions in the same plane, this might be effected by a strap passing over a wheel, the part of the strap on one side of the wheel being in one of the given directions, and that on the other side in the other given direction. If friction were insufficient, a

rag-wheel and chain might be used, and if the directions be in different planes two wheels will be necessary.

If, however, the velocities be different, other means must be resorted to. If the two directions be in the same plane, two racks may be worked by the sectors of two wheels moving on the same axle, the magnitudes of the sectors being proportional to the two velocities. Such an apparatus is represented in *fig.* 98. If, however, the two directions

Fig. 98.



be in different planes, the motion must be transmitted from the one rack to the other by the aid of bevelled wheels.

Rag-wheels and chains may evidently be used in these cases for racks.

(110.) *To convert a reciprocating rectilinear motion into a continued circular motion, and vice versâ.*

The methods of producing these effects are very numerous. A continuous circular motion will produce a reciprocating rectilinear one, if a wheel having wipers on its circumference be placed in connection with a vertical beam or stamper, on which a projecting shoulder or pin is raised, by which the beam is lifted by each wiper, and falls, when disengaged from it, by the revolution of the wheel: it is then lifted by the next wiper, and so on.

Also, if a vertical beam be terminated in a rack which is connected with a wheel which has teeth only on a part of its circumference. While the toothed part of the wheel is engaged with the rack, the beam will be raised, and the moment the last tooth of the wheel passes the rack, it will fall. It will be again raised when the teeth engage the rack, and so motion is continued.

In this case, the motion of the rack in one direction is produced by its weight, or that of the beam, or stamper, with which it is connected. It is easy to make the wheel itself produce both motions in the rack. In *fig.* 99 is represented a double rack, worked by a wheel partially furnished with teeth. As the wheel P is turned in the direction of the arrow, its teeth, being previously disengaged from those of the rack, B D, will commence to work in those of A C, and will evidently press the rack down. When the last tooth of the wheel has passed the rack A C, this downward motion will cease, and the teeth will become engaged with those of the rack B D, and the rack will accordingly be raised; and by continuing the rotation of the wheel P in the same direction, the rack will be alternately elevated and depressed.

Fig. 99.



This may also be effected by a simple method, represented in *fig.* 100, where M N is a beam moving in guides *c d* and *e f*: *a b* is a bar moving on joints, or pivots, at *a* and *b*, and A is a wheel turned by a winch A H, or otherwise.

Fig. 100.

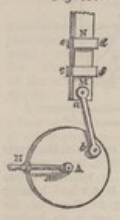


Fig. 101.



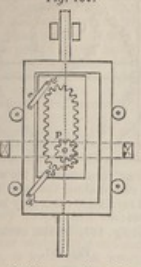
As the wheel revolves, the bar *a b* is evidently alternately pressed upwards, and drawn downwards, and by this the beam M N is moved alternately upwards and downwards between the guides.

In *fig.* 101 is represented a method similar to that shown in *fig.* 99, but each rack is furnished with but one tooth. In this case the pins or teeth of the wheel alternately raise and depress the rack, in the same manner as in *fig.* 99.

A very ingenious contrivance, for

producing the same effect is represented in *fig.* 102. When the pinion

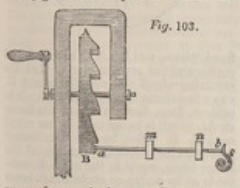
Fig. 102.



P has worked in one side of the rack, it acts upon the teeth in the semi-circular end, by which it gives the rack a slight lateral motion, which is permitted by the joints *a b* and *c d*. The pinion then engages the teeth of the rack on the contrary side, and moves it in the opposite direction, and so the process is continued.

In *fig.* 103 is represented a contri-

Fig. 103.

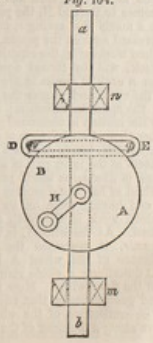


vance for producing an alternate rectilinear motion, by a continued circular. A B is a wheel turned by a winch or otherwise, and bearing, in the manner of a crown-wheel, teeth, the form of which may be adapted to the circumstances of the case. A rod, *a b*, plays in guides *m n*, and has one end bearing on the teeth of the wheel, while the other end presses against a spring *s*. As the wheel is turned, the rod is forced in the direction *a b* by the teeth; and as it passes the top of each tooth, it is forced back in the direction *b a* by the spring. Thus the rod *a b* has a reciprocating rectilinear motion. This machine has been applied by *M. Zureda* for pricking holes in leather, for making cards, and has also been employed in the manufacture of fishing nets.

M. Zureda has also contrived a very ingenious piece of mechanism for converting a continued circular into a reciprocating rectilinear motion. A cylinder rests in a fixed frame, on pivots, and is turned by a winch, or otherwise, round its axis. On the surface of this cylinder a spiral groove is cut, similar to the thread of a screw. This spiral groove, when it reaches the end of the cylinder, meets another similar groove, which traverses the cylinder in the opposite direction, and which runs into the first-mentioned groove at the opposite end of the cylinder. A pin is passed through a groove, cut through and through a straight beam, which is placed over the cylinder, and parallel to its length. The end of this pin falls into the spiral groove in the cylinder. As the cylinder is turned round its axis, the pin is moved along the spiral groove, so as to be urged from one end of the straight beam to the other, moving in the groove cut through that beam. When it arrives at the end of the cylinder, it passes from the spiral groove, in which it moved, into that which traverses the cylinder in the opposite direction; and the pin is thus moved back towards the opposite end of the straight beam, and so the process is continued.

In *fig.* 104, a very simple contrivance

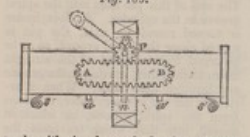
Fig. 104.



for attaining the same end is represented. A B is a wheel turned by a winch H or otherwise; *a b* is a beam, which moves through the guides *m n*. Attached to this beam is a cross-piece D E, having a groove *p q* cut in it. This groove receives a pin *c*, which projects from the wheel A B. As the wheel revolves, the pin *c* moves in the groove from *p* to *q* and from *q* to *p* alternately, and evidently raises and depresses the beam *a b* through the guides *m n*. The vertical action of the pin *c* on the sides of the groove *a b* is variable, and gives the beam *a b* an unequable motion. This defect may be removed by forming the sides of the groove into proper curves, so that the action of the pin may be rendered perfectly equable.

Another very ingenious contrivance is represented in *fig.* 105. A B is a double

Fig. 105.



rack, with circular ends fixed to a beam, capable of moving in the direction of its length. This rack is driven by a pinion P, which moves in a groove *m n* cut in the cross-piece. When the panion has moved the rack and beam until it comes to the end B, the projecting piece *a* meets the spring *s*, and the rack is pressed against the pinion. The pinion, then working in the circular end of the rack, will be forced down the groove *m n* until it works in the lower side of the rack, and moves the beam back in the opposite direction; and in this way the motion is continued.

Another elegant contrivance is represented in *fig.* 106, where A B is a wheel having teeth in the inner part of its rim. This wheel is fixed so as not to revolve; C is a wheel of half the diameter of the former, and having teeth on its outer edge, which work in the teeth of the fixed wheel. As the wheel C is turned on its axis, it traverses the inner circumference of the wheel A B, the centre C describing a circle round the centre of the fixed wheel. Now it may be proved geometrically, that any point on the circumference of the wheel C will move along a diameter of the wheel

Fig. 106.



A B in one revolution of the wheel C, and will return along the same diameter the next revolution: this may be proved as follows:—

Let C, *fig.* 107, be the centre of the

Fig. 107.



fixed wheel, and let A C be the initial position of the revolving one. Let the revolving wheel roll over the arc A B, so as to assume the position C B. It is evident, then, that an arc of the lesser circle, which is equal to A B, has rolled over A B. But by the established principles of geometry, an arc of the lesser circle, equal to the arc A B, subtends at its centre an angle which bears to the angle A C B the same proportion as the diameter of the greater circle bears to that of the lesser, that is, two to one. Hence, the arc of the lesser circle, which has rolled over A B, subtends at the centre of the lesser circle an angle equal to twice the angle ACB. To the point where the lesser circle in the position A B intersects C A, draw the line B E, and from the centre of the lesser circle draw D E. The angle B D E is equal to twice the angle B C A*, and therefore the arc B E of the lesser circle is equal to the arc B A of

* Dar AY's *Popular Geometry*, Art. 71.

the greater circle. Hence, the arc B E is that which has rolled over B A, and E is the point of the lesser circle, which at the beginning of the motion was at A, and it is now found on the line A B. In the same manner it may be proved that this point is found on the diameter A, F in every position of the lesser circle. When the lesser circle has rolled over a quadrant of the greater, the point is found at the centre C; and when it has rolled over a semicircle, it is found at the other extremity, F, of the diameter. While the lesser rolls over the other semicircle, the point returns along the diameter F A to A. Thus the point alternately moves from A to F, and from F to A.

A very simple and obvious contrivance for producing a reciprocating rectilinear motion by a continued circular one, is by a crank wrought by a winch. A rope attached to the crank, and passed over a fixed pulley, from which a weight is suspended, will attain the desired end. As the crank revolves, the weight will evidently ascend and descend in a straight line.

If a connecting rod be carried from the crank and connected by a joint with a straight bar or beam, which moves in guides, this bar will receive a reciprocating rectilinear motion. In this way the piston of any species of pump may be wrought by a continued circular motion. Such a contrivance as this is used in the apparatus for condensing gas, in the portable gas manufacture.

The common apparatus, called an eccentric, may be made to produce a similar effect. This contrivance consists of a circular metallic ring, the inner surface of which is perfectly smooth. This ring is connected by a shaft and a joint, with a straight rod or beam moving in guides. Within the ring is fitted a circular metallic plate, capable of turning freely within the ring, the surfaces in contact being perfectly smooth, and lubricated with oil or grease. This circular plate revolves, but not on its centre. It turns, in fact, on an axis at some distance from its centre, the effect of which is, that the ring within which it turns is moved alternately in opposite directions, and through a space equal to twice the distance of the axis from the common centre of the ring, or circular plate. Thus communicates, through the shaft and joint, an alternate rectilinear motion to the rod which works in the guides,

(111.) *To convert a reciprocating rectilinear motion into a reciprocating circular one, or vice versâ.*

This is one of the most useful and important changes of motion which can be effected by machinery, and merits the greatest attention.

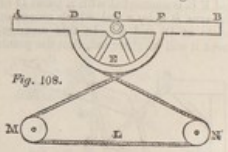
A beam, having an arched head at one end, bearing teeth, which work in a rack, the opposite end being moved alternately in a circular arc, will move the rack alternately in a straight line.

Also, if a weight be suspended by a chain which hangs on the arched head of a beam, the other end of the beam being alternately moved in a circular arch, the weight will alternately ascend and descend in a vertical straight line.

An example of this will be observed in the atmospheric steam-engine, and of the former contrivance in the earlier double-acting steam-engines of Watt.

A very neat method of accomplishing this change is represented in *fig.* 108. A B is a lever turning on the

Fig. 108.



centre C. D E F is a half-wheel, to which, at the extremities, D F, a rope or strap is attached, and is passed, as represented in the figure, round the wheels or sheaves M N. A reciprocating circular motion, in the ends A B of the lever, will produce a reciprocating rectilinear motion in any point L, on or connected with the rope, and *vice versâ*.

A common bow used by watchmakers and other artists for drilling holes, is another example of this. The bow-string is rolled once round a small sheaf or wheel carrying the piercer, and an alternate rectilinear motion in the bow produces an alternate circular motion in the wheel.

But by far the most remarkable method of converting an alternate rectilinear motion into an alternate circular one, is that known by the name of the *parallel motion*, and invented by Watt for his double-acting steam-engine.

In this machine the piston is urged

upwards and downwards, in a very exact straight line, and any force which deflects it from this straight line will injure or destroy the operation of the machine. The end of the beam, on the other hand, with which the piston-rod is to be connected, moves alternately in a circular arc. It became then a difficult problem to connect these in such a manner that a perfectly smooth motion, and free from strain, should be imparted from the one to the other. In the first instance, Watt placed a rack on the end of the piston-rod, which worked in teeth raised upon the circular head of the beam. It was found, however, that this gave an uneven jolting motion, and was liable to rapid wear. He soon substituted for it his *parallel motion*.

The beam turns on the centre C, and its end B moves alternately in a circular arc, of which C is the centre; a rod F E plays on fixed centre F, and the end E moves in a circular arc, with that point F as centre. The end E of the rod F E is connected with a point D on the arm B C by a rod which moves on joints at D and E. In this arrangement it will be observed, that the points

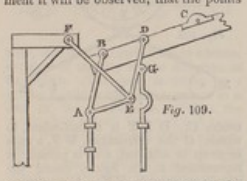


Fig. 109.

D and E each move alternately in circular arcs. Now, it is found that the middle point G of the bar D E moves alternately upwards and downwards in a straight line, and, therefore, a piston rod attached to the point G will be moved upwards and downwards in a straight line*.

Jointed at E is another rod, A E, equal to B D, and another, A B, equal to D E, jointed at A and B. The figure A B D E is evidently a parallelogram, and the point A moves in a line similar and parallel to that described by G, but longer than it, in the proportion of B C to D C.

It is usual, in the steam-engine, to attach the great piston of the cylinder to the point A, and the piston of the air-pump to the point G.

The most common proportion of the several rods forming the parallel motion is as follows: D is at the middle point of B C; F E is equal to D C, or half of B C. Great latitude is allowed in the length of D E. There are, however, various proportions which may be given to these rods, and for which we refer to works on the Steam-engine.

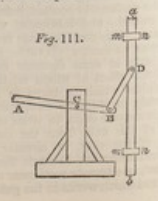
Another contrivance for this purpose is represented in *fig.* 110. A B is a wheel capable of moving round an axis or spindle, and also capable of moving

Fig. 110.



longitudinally on it. A rope is attached to A, and passing through a hole at the top, C, of the spindle, or axis, it is fastened at B, the opposite end of the diameter of the wheel which passes through A. By turning the wheel, the rope is twisted round the spindle, and the wheel drawn up towards C; and as the rope is again untwisted, the wheel descends to its former position. Or, if the wheel be incapable of a longitudinal motion, but the spindle C D be capable of moving longitudinally through it, a similar effect will be produced. This apparatus may be used for drilling or boring with the point D.

Fig. 111.



* Strictly speaking, the path of the point G is not a straight line, but is a curve of a high order. That part of the curve, however, which is included within the range of the piston-rod lies at equal distances on each side of a point of inflection. The radius of curvature is, therefore, infinite, and the curve differs imperceptibly from a straight line.

Another contrivance for the same purpose is exhibited in *fig.* 111. A B is a lever working on the centre C. B D is jointed at B to the extremity of this lever, and at D to a beam *a b*, which moves in guides *m n*. It is evident that a reciprocating circular motion at A will produce a reciprocating rectilinear motion in the beam *a b*, and *vice versâ*.

(112.) *To convert a continued circular motion into another continued circular motion.*

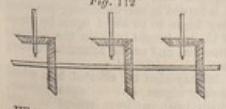
In a motion of continued rotation, two things are to be considered; the axis round which the rotation is made, and the velocity, or the number of revolutions performed in a given time.

If, by a rotation round one axis, it be required to produce a rotation round another axis parallel to it, the problem may be solved thus: place two wheels on the two axes, so that they shall be in the same plane at right angles to the given axes. Let these wheels act one upon the other either by the friction of their edges or by a strap, or chain, or, finally, by teeth. If they act either by friction or by teeth, the rotation round the two axes will be made in contrary directions; but if they act by a strap or chain, the rotation will be in the same direction if the strap be crossed; but otherwise in opposite directions.

The rotation may be produced in the same direction when the wheels act by teeth, or friction, by interposing a third wheel between those which are placed upon the given axes. There is an advantage in the use of a strap, in cases where the two axes are at a considerable distance one from the other; as it does not render the multiplication of wheels necessary.

In cases where the resistance is too great for the use of a strap, rotation may be transmitted to a number of parallel shafts by means of bevelled wheels on a shaft at right angles to them. This method of giving rotation to several parallel shafts is represented in *fig.* 112.

Fig. 112

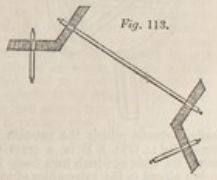


When the velocity of rotation is to be the same as that of the shaft from which it is received, the wheels by which it is transmitted, whether by friction, straps, or teeth, are to be of equal diameters; and in whatever proportion the velocity is to be increased or diminished, the diameter of the wheel must be diminished or increased exactly in the same proportion.

We have here supposed that the shafts through which the rotation is transmitted are parallel. Suppose they are not parallel, but their directions intersect; the rotation may then be transmitted by bevelled wheels placed upon the shafts, as represented in *fig.* 47 (70.); and if the velocity of rotation be required to be changed, the cones, from which the bevelled wheels are formed, must have different angles, as explained in (70.)

If the shafts be at a considerable distance one from the other, the bevelled wheels placed upon them cannot conveniently act one upon the other immediately. In this case a third shaft must be used, bearing two bevelled wheels, as represented in *fig.* 113, through which the motion is transmitted.

Fig. 113.



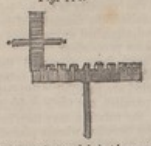
This method of connecting the shafts by a third shaft will also serve when the two given shafts are not in the same plane.

When the shafts, between which the motion is to be transmitted, are at right angles, two bevelled wheels, such as are represented in *fig.* 47, are most frequently used. A crown and spur wheel would, however, serve the same purpose, and are sometimes resorted to. This arrangement is represented in *fig.* 114.

Rotation round an axis may be transferred to an axis at right angles to it by means of a perpetual screw working in a toothed wheel, as represented in *fig.* 86. In this figure the axis of the wheel is represented parallel to the horizon; but it is plain that the same effect will

be produced at whatever angle it is inclined to the horizon, provided it be perpendicular to the axis of the screw.

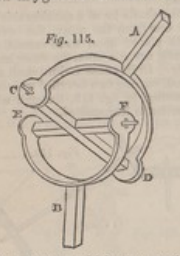
Fig. 114.



Hooke's universal joint is a very simple and effectual method of transferring rotation from one axis to another.

The *single universal joint* is represented in *fig.* 115. A and B are the

Fig. 115.



shafts, between which the rotation is transmitted; C D, E F is a cross of metal, the ends of which turn freely in bushes placed in the extremities of two diameters in which the shafts terminate.

From considering this arrangement, it is evident that, when the shaft A is turned round, the shaft B will receive a similar motion. If, however, the angle under the shafts A and B be less than 140°, this will fail to act.

In this case, the *double universal joint* must be resorted to. This is represented in *fig.* 116. There are here two crosses, the extremities of which move on pivots, like the former. This will serve when the angle contained by the shafts is less than 140°.

These joints may also be constructed with four pins, fastened at right angles upon the circumference of a hoop, or solid ball. They are of considerable use in cotton mills, where the tumbling shafts extend to a great distance from

Fig. 116.



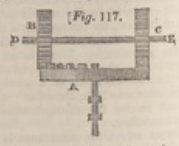
the impelling power; for, by applying an universal joint, the shaft may be cut into convenient lengths, and be thus enabled to overcome a greater resistance.

(113.) *To convert a continued circular motion into a reciprocating circular motion, or vice versâ.*

There are various methods of making this change. One of the most common is by a crank, connected by a rod with the end of a working beam, or lever, as represented in *fig.* 87. Here the end of the rod connected with the crank moves with a continued circular motion round the axis of the crank, while the other end, connected with the beam, moves alternately in a circular arc.

Another contrivance for this purpose is represented in *fig.* 117, where B and

Fig. 117.



C are two spur-wheels on the same shaft, and A is a crown-wheel, which is only partially furnished with teeth, and placed on a shaft at right angles to D E. The shaft D E, being turned constantly in the same direction, so long as the teeth of the wheel A are engaged with those of B, the shaft of A is turned in one direction; but when they begin to be acted upon by those of C, it is turned back in the opposite direction, and so the alternate rotatory motion is continued.

It may also be effected by a wheel having wipers on its circumference, which raise a lever placed at right angles to the plane of the wheel, the lever descending by its own gravity,

In *fig.* 118 the wipers are represented

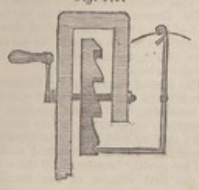
Fig. 118.



as lifting a forge hammer, which falls on the anvil by its own weight.

Another contrivance is represented in *fig.* 119, somewhat similar to that represented in *fig.* 103, but instead

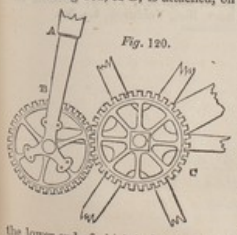
Fig. 119.



of the wipers acting on a rod moving in guides, they act on a lever working on a centre. The end of the lever is pressed against the wipers by a spring.

The *sun and planet wheel*, invented by Watt for his earlier double-acting steam-engines, is another example of this. To the end of a vibrating beam, a connecting rod, A B, is attached, on

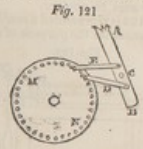
Fig. 120.



the lower end of which is fixed a toothed wheel, incapable of turning on its centre. This wheel works in the teeth of another, C, which turns freely on the centre, so that, as the one wheel is carried round the other by the connecting rod, it gives to the other a continued rotatory motion. The alternate circular motion of the end of the beam is thus made to communicate a continued rotatory motion to the wheel.

In *fig.* 121 is represented a contri-

Fig. 121



vance on nearly the same principle as the *lever of La Garousse*. M N is a wheel having teeth, or spindles, projecting from it in the manner of a crown-wheel: A B is a lever working on the centre C; D and E are two rods turning on pins in the lever, and the opposite ends of which are so formed, as to press against the spindles, and turn the wheel round. When the end B of the lever is pressed towards the wheel, the rod D presses the spindle, and urges the wheel round its centre. By the same motion, the rod E, and the spindle on which it rests, are separated, and the rod E falls upon the next spindle of the wheel. The end B being then moved from the wheel, the rod E presses upon the spindle, and urges the wheel round its centre; while the rod D, and the spindle on which it rests, are separated, and the rod D falls upon the next spindle. In this way the alternate circular motion of the lever A B produces a continued circular motion in the wheel M N.

The various kinds of escapements which are used in clock-work, are instances of the same effect. The pendulum has a reciprocating circular motion, and the wheel in connection with it, and which it regulates, has a continued circular motion.

(114.) *To convert a reciprocating circular motion into another reciprocating circular motion.*

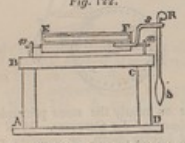
The means of accomplishing this are numerous and obvious. If the two vibrations be round the same axis, it is evident it may be done by fixing upon the axes two arms or levers, presented from the centre in the directions in

which the motions are to be made, and of lengths proportional to the circular arcs through which their extremities are to vibrate.

If the motions be not on the same axis, the two axes may be connected by almost any of the methods used in transferring continued circular motion from one axis to another.

In *fig.* 122 is represented a contrivance of *M. Camus*, for the purpose of moving

Fig. 122.



sieves. A B C D is a table, on which is a plank E F, capable of revolving on the pivots *m n*. To an arm, *s*, attached to one of the pivots, a pendulum, R S, is suspended. The first mover gives the pendulum an alternate circular motion, and this gives the plank a vibrating motion on the pivots.

There are numerous other contrivances for accomplishing this change, but our limits preclude us from prosecuting this subject further.

CHAP. XIV.—*Works on Mechanics.*

The treatises which have been published on this subject, not to mention innumerable detached pieces which have been printed in the transactions of learned societies, scientific periodicals, &c., &c., are so numerous, that we cannot pretend to insert here any catalogue of them. Nevertheless, we may refer the student, who is desirous of extending his inquiries on the subject, to sources where he may find ample materials for the extension and improvement of his mechanical knowedge.

To those who are not very familiar with mathematical science, we should recommend Dr. Brewster's edition of FERGUSON'S MECHANICS. In the second volume of this work, more especially, a vast quantity of valuable information is collected and explained with admirable clearness and simplicity. This volume is entirely from the pen of Dr. Brewster, and is by far the best part of the work. The student should be cautious not to consult the old editions of Ferguson, as they contain numerous errors.

The second volume of Dr. Gregory's MECHANICS contains a great quantity of interesting and useful practical information, explained in a very familiar style, and without much mathematical reasoning. The mathematical student will be greatly benefitted by the study of the first volume of this excellent work.

For those who seek an acquaintance with the mathematical theory of Mechanics, there is a very numerous class of English authors, amongst whom we may mention Bridge, Desaguliers, Emerson, Gravesande, Playfair, Robison, Whewell, Wood, Young, &c.

The foreign authors, on this subject, are also very numerous:—Laplace, Lagrange, Prony, Poisson, Belidor, Biot, Venturoli, &c. &c.

TRANSACTIONS

OF THE

CHINA BRANCH

OF

THE ROYAL ASIATIC SOCIETY.

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PRELIMINARY ADDRESS.

WITHOUT abusing the patience of the SOCIETY by any diffuse or trite generalities on the advantages of those enquiries which it is the object of this new institution at once to encourage and to prosecute, I shall save their time and my own by going at once into the question of what is likely to be acquired by the future labours of our members, and by taking a rapid view of the prospects before us.

It may be remarked incidentally that, on some points, the neighbourhood of Canton, as a field already gleaned, may probably afford less of novelty in research than the more northern localities, which have been open now for about five years,—"depuis" (to use the honest expression of a foreigner) "depuis que par un noble et généreux désintéressement la Grande Bretagne a ouvert le commerce de la Chine à toutes les nations."

I will just remark that if the cursory and imperfect sketch which is to be presented in this paper should prove to be very different from the productions of learned leisure, or the furniture of "academic bowers," it will be only just to explain its defects by the constant demands on my attention of two separate public offices, from whose graver and more imperative calls such digressions can occur only as chance recreations—as *impermissa raptim gaudia*, and I may add in the absence of my books, (though not exactly in the meaning of the poet) *luminibus remotis*. At the same time, the spontaneous proposition of the Society, that I should be its first President, was at once too flattering and too congenial to my own inclinations, to be declined on the ground of any other than insurmountable obstacles. I will, therefore, claim its indulgence to my imperfect services in the words of the Scottish Erasmus,—"*Accipe, sed facilis!*"

To commence with the language of China, as the key to a great deal that remains to be known. With regard to the intrinsic qualities of that very peculiar literature which constitutes the archives of this language, my own experience does not lead me to be very sanguine in expectations from the future. My old preceptor and friend, Mr

Malthus, who left behind him an European reputation, applied to some of it (judging of course from translations) a remark which is true of a great deal of Asiatic literature,—that it was "childish;" in fact a reflex of that general condition of society and intellect in which it originates. Some of the best specimens that could be discovered of their drama, their poetry, and their prose fictions, have long ago been translated, and the chief value of these has consisted, not so much in their own abstract merits, as in the light which they threw on a people so long self-insulated, and shut in from the reach of foreign influence or investigation. Their sacred and historical works, and more particularly the latter, which are bare chronicles of events little connected with the rest of the world, have hardly repaid the pains of translation.

Some lights might possibly be obtained as to Indian History from the Budhist books, if the records which they contain could be made out. Lord Auckland observes to me,—"I mention, as a particular object of enquiry, that Pali phrases expressed in the Chinese character, are said to be found in Chinese works, and that Pali works (or copies of them) taken from India to China between the second and tenth centuries of the Christian era by Budhist Priests, are supposed to exist in the libraries of China."

In its practical uses, however, the importance of the language has lately increased in proportion to the extension of the field for its exercise. The best proof of this lies in the great accession to the number of persons who make it their study, and who have gained an extensive knowledge of it. The importance of this knowledge in promoting and aiding all our relations with China is sufficiently obvious, and Sir Henry Pottinger informs me, in his last letter, that there is a growing impression at home to this effect.

On the other hand, in consequence of the unpliant nature of the Chinese medium, and the difficulty of conveying foreign ideas through it, we never shall be able effectually to impart *European* information to the *Chinese*, unless they learn our language. For this purpose, however, it is remarkable that there are no less than three separate institutions already in Victoria, while I am not aware of any express establishment for teaching Chinese to Europeans.

Abstractedly and apart from its positive uses, the Chinese, in a merely philological view, may be considered as a species of miracle. It is in fact the most ingenious and nearly the most perfect applica-

tion of the hieroglyphic principle that can be imagined. The classification and analysis of the characters afford a subject of endless metaphysical amusement, and a new or additional language might be constructed out of the infinite combinations of their distinct constituent portions.

I am able to hand to the Society a paper, drawn up by Sir George Staunton, of general hints as to various points of enquiry to be suggested to residents in China and at Victoria.* The Consuls at the five ports have been instructed by me to give every encouragement and assistance to pursuits of this nature, in conformity with the wishes of Her Majesty's Government.

Under the head of arts, we are already too much beholden to Chinese ingenuity to be altogether without hope of something from the future. The people who appear from the best accounts to have originated among themselves the inventions of gunpowder, printing, and the compass, as well as the manufactures of silk and porcelain,

* *Hints for Queries to be suggested to the Residents at the Five Ports open to British Commerce, and at the British Colony of Hongkong.*

1. What are the geographical features and geological characters of your district?
2. What are its chief productions and manufactures?
3. Are any of them likely to suit the British market?
4. What articles of European produce and manufacture are in demand amongst the natives?
5. Is opium consumed by the natives; by what classes; and in what proportion to the entire population?
6. What effect has this habit upon their moral and intellectual character, as well as on their bodily health?
7. What is the moral, intellectual, and physical character of the natives of your district, as compared with other parts of China?
8. Are robberies and thefts frequent?
9. Are murders and piracy frequent?
10. Is infanticide prevalent?
11. Is the population generally favourable to Europeans, and to European commerce?
12. Is the trade carried on by barter, or is credit frequently given:—and if so, to what extent; and what is the result?
13. Is there any social intercourse between foreigners and natives?
14. Are foreigners confined within certain limits by the established regulations:—and if so, do they practically submit to those regulations, or do they occasionally penetrate into the interior, and what is the consequence, when they do so?
15. Are the natives, generally speaking, obedient to the government, or are insurrections frequent?
16. How are the people affected to the reigning Tartar dynasty?
17. How are the laws administered in case of differences between foreigners; between foreigners and natives; and in cases in which the natives only are concerned?

must carry into the operations of their productive industry a constitution of mind rich in results, of which something still remains to be known. It was only a few days ago that I was shewn some white English porcelain, very well painted at Hongkong, with figures and flowers by Chinese workmen.

I have by me several letters from the Earl of Auckland, the noble President of the ROYAL ASIATIC SOCIETY, in which his Lordship suggests subjects on which information would be interesting. "I may premise," he observes, "that in our present state of knowledge regarding the government and people of China, and the arts, manufactures, and agriculture of that country, scarcely any information in detail could be given to us which would not be regarded as valuable. I observe that a Medical Society has been established at Hongkong, which it is proposed shall correspond with scientific societies in England. Might it not be of advantage to all parties if this society

18. Are the native tribunals in general purely administered, or does corruption prevail, and to what extent?
19. How are causes conducted in Chinese courts—have they any persons employed as counsel or attorneys for the plaintiffs and defendants?
20. Are there any very large proprietors of estates, or is the land very equally divided?
21. Are there any ancient families recognised and respected in the district?
22. Is there any special provision for the destitute poor; or if not, how are they relieved and supported?
23. Is mendicancy very prevalent?
24. What is the condition of the people as to education: can any considerable proportion of them read and write?
25. Is the population supposed to be on the increase, or the contrary?
26. Is the district supposed to be, generally, increasing in wealth and prosperity, or the contrary?
27. What is the prevalent religion or superstition in the district?
28. What are their favourite games and amusements?
29. Are there any ancient monuments, or antiquities of any kind to be met with?
30. In what language are commercial transactions with foreigners generally carried on;—in pure Chinese; in pure English; or, as in Canton, in a *jargon* partaking of both?
31. Have the Christian missionaries, Roman Catholic or Protestant, met with any success in your district, and are the works which they have printed and endeavoured to circulate, in any esteem amongst the natives?
32. Do they meet with any obstruction from the government, and do the priests of the prevailing superstitions evince any jealousy respecting them?
33. Has the increased intercourse with foreigners since the cession, made any perceptible alterations in the habits or usages of the people, or has it led to the adoption of any of the improvements and inventions of modern science; and, in general, has it conduced to more liberal views respecting the conduct and character of foreign nations, amongst the natives, either in the higher or lower classes?

Leigh Park, September, 1843.

were to place itself in direct communication with the Royal Asiatic Society of London?" The Medical Society seems, from what I hear, to have been the germ in which our new institution originated, and if we should hereafter desire to be admitted as a branch of the Royal Asiatic Society (of which I happened to be one of the seventeen or eighteen original members, in 1823) I cannot doubt of the accession being welcomed by that body.

It appears to myself that one of the most promising departments of knowledge which have been opened out to us since the war is that of natural science, and that the mineral, vegetable, and animal kingdoms (to take them in the ascending series) afford a comparatively unexhausted field for research.

Geology, indeed, considered as the ancient record of our Planet, "rich with the spoils of time," cannot be expected to unroll one of its most interesting or alluring pages in the east and south of China. The primary, unstratified, or non-fossiliferous rocks, which there seem almost exclusively to prevail, contain none of those remains of organised existence, vegetable and animal, in which the more recent formations of *our own Island* are so rich—having given birth indeed to that remarkable rule, "that the surest way of tracing the same formation in different countries or situations, is not by the identity of structure, but the identity of the fossil remains contained in it."

Of the secondary formations—the fossiliferous strata—in which the remains of organised existence shew themselves, the highest or most recent that we have yet heard of in our neighbourhood are the coal-beds, which Sir Thomas Cochrane's visits to Formosa have proved to exist near the northern extremity of that country, at Quilon or Kwei-loong. Some Formosan coal (of which a specimen is on the table) was lately brought to this Colony and sold at 15 rupees or about 27 shillings a ton, but will in all probability be obtained much cheaper. It is needless to insist on the importance of such resources for our steamers. Now here the *practical* value of Geology may come into play, by enabling persons to follow out those certain indications which are afforded by the strata that invariably lie in immediate contiguity to coal-beds, and which are a much more infallible guide to hypogene discovery than the divining wand of Dousterswivel in "The Antiquary."

If the primary rocks of China are in some respects deficient in Geological interest, they form a class that is rich in metallic treasures,

and for some time past the government of the country has evinced an extraordinary desire to discover and work additional silver mines. During my stay at Florence, in 1837, I spent some time in H. I. Highness the Grand Duke's Museum of Natural History, where, in the department of Minerals, there is an admirably arranged series of metallic substances. It so happens that I have by me the rough notes of observations which were made on the spot, and I will produce them here to shew that the sites in which metals are found, or what may be called their *habitats*, are principally the granitic and other primary rocks. The substances with which they are usually combined or alloyed, when not in a native state, are added :—

Platina—Found in granitic rocks—native or in company with iron.

Gold—The primitive rocks—native, and often mixed with the sands of rivers; of course a mechanical result.

Silver—The granitic rocks, and carbonate of lime—native, or combined with sulphur and antimony.

Mercury—In quartz, and in the primary calcareous rocks—native, or combined with sulphur and sulphuric acid.

Lead—The granite rocks, fluate of lime and carbonate of lime—combined with sulphuric acid, with crome, carbonic and phosphoric acid, and with molibdenum.

Nickel—Found in quartz and carbonate of lime—combined with arsenic.

Copper—In the granitic rocks, in carbonate of lime, and about volcanoes, in union with sulphuric acid—In the natural state, when pure, nothing can exceed the fine crimson colour. It is found as an oxyde, and also combined with pyrites, zinc, the arsenic, muriatic, and carbonic acids; and as a carbonate abounds in China, in the shape of *malachite*, which is found in lime rocks.

Tin—Exists in company with quartz and mica, two of the constituents of granite—almost always as an oxyde, for we learn from experience that tin rusts almost as readily as iron.

Iron—In the granitic rocks, and in carbonate of lime. It is found generally as an oxyde, but the Grand Duke's museum contained some fine crystals from the Isle of Elba in the neighbourhood. These the Italians call *oligisto*, I presume from their rarity.

Zinc—In the granitic rocks—found as an oxyde, and combined with carbonic and sulphuric acids.

Bismuth—In the primary rocks—exists native, as well as combined with sulphuric acid, and also as an oxyde.

Cobalt—Found in the granitic rocks, and in carbonate of lime—exists as an oxyde, and in combination with arsenic acid. With this substance the Chinese prepare the blue colour of their porcelain.

I may here remark, as a motive to the Society to collect a museum, the great use of such collections in concentrating, and thus subjecting to observation in a condensed view, the more rare or interesting productions of the natural world. Buffon himself is said to have commenced his career from the moment he became intendant of the Museum of Natural History at Paris. "Dès lors," (says his biographer) "l'ardeur de Buffon se fixa sur un seul objet—étudier, enrichir les dépôts d'histoire naturelle, et, a côté de ces échantillons toujours si incomplets de la nature, décrire la nature elle-méme, en raconter l'histoire, en expliquer les lois, en retracer les monuments." Such a depôt besides has the advantage of supplying a place of reception to many objects which would otherwise become lost or destroyed.

There is the same sort of use, as regards living plants, in a small Botanical garden, for which I should be willing to grant (and I feel persuaded H. M. Government would sanction it) a moderate piece of ground. Lord Auckland wrote to me when leaving England,—"Since I saw you I have had some communication with Lord Aberdeen, who seems to be most favourably disposed to the view which I have taken, and who will, I trust, give his official authority to the proceedings which I have in view. I wish that he may be led to sanction a moderate expense for a garden at Hongkong which may serve as a depôt for the introduction of plants to China, and for the transmission of plants to England." An official despatch was subsequently addressed to me by Lord Aberdeen conveying a general authority for the encouragement of scientific and literary pursuits in this country.

I have now in the ground attached to my house three flourishing plants of the European olive, brought out by Mr Fortune of the Horticultural Society. It is satisfactory to see them thrive so perfectly in this climate, for, according to the Grecian fable, the olive was deemed the best gift that Minerva was able to confer on mankind; and at the close of a war, whose object it was *armis exposcere pacem*, this was the most appropriate and auspicious symbol that England could send to China.

We may hope that Mr Fortune's last valuable collections reached home in safety with himself, as the supplement and completion of the previous consignments which he had made. But his stay was of course too brief to exhaust the boundless stores of Botany which must still remain to reward research, in a country to which we are already much beholden. With regard to what may now be called the old and new systems of botanical classification, every one will choose for himself; but the scheme of Linnæus seems for some years to have lost something of its authority in competition with that perfected by Jussieu. Indeed, in the botanical garden at Geneva I could not perceive any allusion to the Linnæan plan. By an amateur of the

science they may both be valued for their respective merits. The precision with which the Swedish naturalist divided the vegetable world into twenty-four classes, determined by the number, situation, or proportion of the stamens in flowers, still further subdividing these classes into orders, founded on the number of pistils, or their styles, is certainly highly ingenious and attractive; and what is perhaps most remarkable in this method, is the fact, that it has completely comprehended, not only the plants known to Linnæus, but all that have been discovered since.

At the same time, this system is so entirely artificial that plants which are nearly allied in nature, are sometimes widely separated in classification; while, on the other hand, many which are classed under the same head have not the remotest natural affinity. I may instance the sacred lotus of China, and the poppy,—they belong not only to the same *class*, but the same *order*, in the Linnæan system; yet the one has been regarded as something sacred by the Chinese, (being in fact a symbol of Budhism,) while the other is proscribed, and its cultivation prohibited. They have not the most distant affinity in nature.

The natural system of Jussieu is less of a mere *nomenclature*, and I may here give in a few words the outline of its principles, from his French biographer. There are among vegetables, certain natural families, as the *gramineous*, the *umbelliferous*, and the *leguminous*. It having been observed that in each of these families some of the distinctive organs are constant, while others are varied, the first, as the most important and useful, were made to serve as the heads of the principal divisions, and the others in their turn came in to form the subdivisions under them. By this natural procedure, one certainly arrives less easily at naming any new plant, than by the artificial nomenclature of Linnæus; but it has been found that the juices and substances of vegetables, naturally allied, have generally similar qualities, and hence the natural system is a great help in Materia Medica and œconomics; at the same time that great aids may be derived from it in gardening and agriculture, particularly with reference to grafting and the rotation of crops, on account of the similar organisation and habits of plants belonging to the same natural families.

The most valuable shape for transmitting home a new plant is of course in the living state, but there is much less difficulty, and some-

立永遠斷賣田契人黃貴隆今有祖父遺下經分名下民田壹坵，計稅肆畝參分坐落土名磨塘村枕涌第二段東至周界南至吳界西至何界北至王界四

趙德升

十八

至明白今因急用母子商議自愿將此田出賣與人每畝取定時價銀壹拾五兩正先召房親人等各不承買次托中人胡玉明執賬問到趙德升承買為業議定承盤價銀陸拾肆兩五錢司碼平兌三面言定二家允肯即日丈量明白立杙立契交易銀契兩相交訖並無少欠分厘其稅三升則載在左岡七十九圖六甲黃大成子戶內任從買主隨時挑歸本堡八十畝另趙允昌戶自行办納此田的係祖父遺下以前並無按當典揭等情倘有別人爭論賣主同中理明不干買主之事永陸二路照田道行此田一賣永休斷無收贖恐口無憑立明斷賣契一紙并上手田契二帋交執為據

欽加同知衔南海縣正堂梁 驗價陸拾肆兩伍錢

中人 胡玉明
胡元章

（當衆母子領足田價番銀陸拾肆兩五錢成貫司碼）

母陳氏指模

道光十九年三月十五日

立永遠斷賣田契人黃貴隆的筆

times equal utility, in sending the seeds. Dried specimens of plants answer the purposes of the Hortus Siccus; while fruits preserve their perfect shape, and sometimes their colour, in spirits. Some vegetable productions, as the nutmeg, are so highly antiseptic that fine specimens of the fruit and leaves of that spicy aromatic have been preserved in a bottle of plain water.

Lastly, as to the animal kingdom:—The greatest encouragements are afforded by the Zoological Society of London to the transmission home of living specimens, chiefly of rare mammalia and birds. I have letters from the Earl of Derby, the President of the Society, in which his Lordship suggests the promotion of their objects by transmitting home any really new or scarce animals from China in a living state, and offers to defray the charges on their being delivered at Liverpool, which is not far distant from Knowsley, the Earl's seat.

But in cases where the difficulty of transmission, or the mode of capture, renders living specimens impossible, the objects of physiology, at least, may be partially answered in other ways,—by the skin or the skeleton of quadrupeds or birds, or in the case of the smallest animals, (reptiles especially) by entire specimens in spirits. In this manner sporting may sometimes be made subsidiary to science, and the gun may occasionally serve as purveyor to the museum.

Keying sent me from Canton an adult male and female and a fawn of what I had hoped, before they arrived, might turn out a new species of deer; but they proved to be identical with the fallow deer which we have at home. Among the natural productions of this Island I have seen a small variety of the deer kind, a fox, and a civet cat, which last was caught among the rocks by the sea-side, a circumstance which may seem to imply that it preys occasionally upon fish. It is well that the snakes appear to be neither numerous nor of a malignantly poisonous character. A variety of the boa constrictor has been proved to exist here; but its size is fortunately not such as to render it formidable.

In the several departments of natural history, the Society may look especially for assistance from its Medical members, in addition to their professional contributions. In language and literature, the increased number and extended range of the new race of Chinese students ought to do something; while in arts and manufactures the ordinary

channels of commerce will hardly fail to supply much that is valuable. It is at once unnecessary and impossible to particularise every thing that may be comprised within the sphere of an association like this, whose objects are so general.

I have a note from Dr Buckland, at Oxford, addressed to Sir George Staunton, conveying the request of Professor Liebeg to be furnished with all possible information as to the details of Chinese agriculture, and especially the question of manures. The whole subject of field cultivation has become of momentous interest, since the failure of one of our main articles of food appears to have imposed the necessity of a sort of revolution in a long established system. It is not likely that the productions of the extreme south of China would be suited to our climate; but we know from experience that towards the north a great variety of the Cereal and other dry grains are produced in lieu of rice, and some of these might be profitably adopted as articles of food.

To trespass no longer on your attention, I will merely add, that the pursuits which it is the object of this Society to encourage and to cultivate, are a fertile source of amusement and occupation, and that they are respectable even when unattended with success. The useful and beneficial exercise of intellect is the main distinction between men and the brute creation, with which the former are so nearly allied in their animal organization, their animal wants, and their animal gratifications, as to have led an ancient philosopher to define man as a mere "bipes implumis," — a two-legged creature without feathers. But the best answer to this bad compliment is the practical one. In a sense allied to that of the popular saying, that "the boy is father to the man," youth and middle life may, by the improvement of time and opportunities, bequeath to age a species of inheritance which is no bad compensation for the loss of other advantages.

Φύσει, δίλπους, ἀπτιλλοι', ἰστοξόα,
Σοφοὺς σίδοις, κ' ἀγαθούς, ἰτῶν δὲ σὺ
Ἀμείμων εἰδεῖς ἄλλο πλὴν γέρας πτυῶ.

The insulated exertions of individuals, however strenuous, must be weak in comparison with the union and co-operation of an associated body like this Institution, which I hope will assume a sort of adventitious maturity by being incorporated with, or grafted on, the Royal Asiatic Society.

契 字號

道光 年

廣東等處承宣布政使司爲遵

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TRANSACTIONS

OF THE

CHINA BRANCH

OF

THE ROYAL ASIATIC SOCIETY.

ARTICLE I.

LAND TENURE IN CHINA.

REMARKS ON THE ACQUISITION, COMMON-TENURE, AND ALIENATION OF REAL PROPERTY IN CHINA, ACCOMPANIED BY A FACSIMILE AND TRANSLATION OF A DEED OF SALE: BY THOMAS TAYLOR MEADOWS, *Interpreter to H. M.'s Consulate at Canton.*

LEST those who have any acquaintance with the voluminous and bewildering English law concerning Real Property, should be surprised at my venturing to engage a similar subject in a paper or two intended to be read before a Society, I would premise, that the Chinese laws influencing real property are *comparatively* few and concise, and that conveyancing, in particular, is extremely simple. There is notwithstanding, little or nothing known on the subject among foreigners, while it is one now likely to become practically interesting to them. The cause of the comparative scantiness of Chinese law regarding Real Property is in some measure indirectly explained by the circumstance, that the Chinese have no written *Commercial* Law. The main object of their laws respecting lands and houses is evidently the certain and easy levying of the Imperial Revenue, derived from the Ground-tax; while *the quick and certain disposal of their property by the people* is so much a secondary consideration that I am inclined to think it has never been the object of special legislation, and that the few enactments which at first sight seem intended to ensure such disposal, are quite incidental. It is a fact worthy of attention, that under these circumstances landholders in China can sell or mortgage their property with comparative ease.

I have said that the Chinese have no written Commercial Law; and it may not be wholly out of place to mention here, that all disputes concerning commercial matters, as well as many others of those legal contests which would in England be called civil actions, and could only be commenced as such, are here decided according to what we would call common law, and in equity, *i. e.* according to the customs of the place, either as defined by the decisions of the courts in old cases, or as acknowledged to be existing by respectable natives, and according to common reason. Such is at least the case where no bribery takes place, and even then it must be so in appearance.

On the Acquisition of Real Property.

In China real property can at present only be acquired in three ways: first by cultivation of unoccupied land; secondly by purchase (in which I include the acquisition of unredeemed mortgaged property;) and thirdly, by inheritance.

I shall here consider only the first mode of acquisition, and give the remarks I have to make on the second and third when I come to treat of Alienation.

Any Chinese, whether a native of the district in question or from a different province, may obtain legal possession of unoccupied land simply by bringing it into a state of cultivation and fulfilling the usual conditions of the common tenure,—mandarins, who cannot possess real property where they hold office, being of course excepted. When any person is desirous of cultivating a piece of unoccupied land, he must present a statement of its situation, extent, boundaries, and the name by which it is known in the locality, to the district magistrate, who has it surveyed, and issues a proclamation calling on all persons having claims to the land in question to prefer the same within five months. If no one answers the call within that period, the district magistrate fills up one of those blank deeds, of which a supply ready sealed is always furnished him by the Superintendent of Finances for the province (A.D. 1753*), and after attaching his own official seal, delivers it to the cultivator. The latter is thereby placed in full and permanent possession of the property; for this

* The years in the text enclosed by brackets are those in which the laws embodied in the passages preceding were enacted, as given in the Imperial work entitled "Collected Statutes of the Great Pure Dynasty."

deed, granted after five months' notice to the public, bars all subsequent claims in perpetuity (A.D. 1734.)

No taxes are demanded from the cultivator until after he has enjoyed the profits derived from the soil for the following periods from the time of granting the deed, viz: ten years for Dry, and six years for Wet Lands (A.D. 1723), which latter are of course the most productive in a rice-growing country. On the expiration of the respective periods, the lands are again surveyed by the authorities, in order that if any change has in the meantime taken place in their nature or extent,—either in consequence of those lying near rivers having been diminished by the action of the water, covered with sand by floods, or increased in size by the addition of productive alluvial deposits; or from those on high grounds having been partly swept away by torrents,—the assessment may be made in conformity with their actual state. And if the cultivator should, during the above periods, find that, either from the original badness of the soil, or from deteriorating natural causes that have intervened, it will be impossible for him to continue the cultivation of his grant with advantage, he can give up his right of possession and free himself of the liability to the tax by petitioning the authorities to inspect the land and cancel the deed.

By an edict of the Emperor Yung-ching promulgated in the 7th year of his reign (A.D. 1729), it was ordained that poor people who are ready to undertake the cultivation of waste lands, shall receive loans of money from the government treasuries, to be repaid in three years after the land has been reclaimed; and by later rescripts this term has been extended for particular localities where the nature of the ground renders cultivation difficult.

Persons who bring waste government lands into cultivation without the cognizance of the authorities, but who themselves subsequently give information of the fact to the latter, shall commence paying the tax from the time they give such information, but shall not be subjected to any punishment.

As might be expected, land which, though not under cultivation, is otherwise employed for the common good, cannot be acquired in the above manner. Among such ground may be instanced the beds of those creeks that wind through the rice fields, which could themselves easily be converted into rice ground, but may not be interfered with, because useful for irrigation. And although alluvial banks that are gradually formed along the sides of broad rivers may be

diked in for cultivation, still it is forbidden under severe penalties to do this to such an extent as to impede the free passage of the water (A.D. 1746.) Totally unoccupied land, if lying within four chang (about sixteen yards) of graves, shall also not be cultivated (A.D. 1734.)

Every five years at about the end of winter and the beginning of spring, when the waters are low, the Governors-General and the Governors of the provinces are to depute Intendants of Circuit to make, with the assistance of the respective District Magistrates, complete surveys of all lands in each province gained from rivers, as well as of those which, lying along the latter, are liable to be affected by the action of the water. These surveys are then made the basis upon which are grounded the alterations in the fixed assessment, which must by law follow all variations in the extent or in the quality of the lands (A.D. 1728.)

The preceding is the substance of the general law on the subject, as laid down in the "Collected Statutes of the Great Pure (the present) dynasty," the "Code of the Fiscal Board," and other works published by Imperial authority. It is applicable in all the eighteen provinces of China Proper, but is in some of them in a slight degree modified by more detailed laws and regulations having only a local force. Several of these local laws are entered in the above works published by the central Government; but the following translated extract from "The provincial laws and regulations of the province of Kwangtung," as published in 1846 by the Governor-General Keying and the then Governor Hwang-an-tung, will best shew the usual extent of the modifications, and will at the same time form for the Society a specimen of the nature and style of a work, interesting as well for the light it throws on the state of this important province, as on account of the position the two eminent editors hold towards foreigners.

Regulations for the Cultivation of Alluvial Levels.

1. The states of the Alluvial Levels along the rivers and estuaries of Kwangtung are various. Those on which the floating sand has just commenced to collect are called Profitless Levels; those on which mud has been collecting for a long period, and on which weeds and grass have grown up, are called Grassy Levels; and Grassy Levels which have been enclosed with dikes, are called Reclaimed Levels.

Those among the latter which have been reclaimed but a short time, and which suffer diminutions or are increased by the ebb and flow of the tides; or which, though reclaimed for a long time, are nevertheless partly covered by the tides, and which therefore cannot be uniformly planted with paddy; shall, whether they have been duly reported previous to cultivation, or the cultivator have informed on himself after having taken possession without the cognizance of Government, pay for each mow* a tax of 0.00464 of a tael, in all respects in accordance with the scale of taxes for the unproductive Salt Lands of the Heang-shan and other districts,† and shall have the periods respectively fixed when they are to commence paying.

Those Reclaimed Levels of which the dikes are already strong, and of which there is no fear of being covered by the tides, shall, as they constitute taxable Levels, reclaimed for a length of years, pay for each mow the higher tax of 0.03119 of a tael in money, and 1 shing, 2 ho, 2 keu, and 8 chaou of rice, in accordance with the high schedule for land held by common tenure in the district of Pwan-yu.

A list of all such lands must be drawn up and sent in for the inspection of the Fiscal Board.

2. With reference to Alluvial Lands by rivers and estuaries, the cultivation of which has been undertaken without the cognizance of Government, and of which no report has been made with the intention of evading the taxes, it must be ascertained at the time of the quintennial general measurement whether such are reclaimed or unreclaimed, and the proper amount of profits recovered accordingly. They must with this view be divided into two classes—those which have been long reclaimed, and those which have been but a short time reclaimed. Upon the former 8 or 6 taels per mow shall be recovered as profits; upon the latter 6 or 4 taels, according as they are respectively placed on the High or the Low schedule.‡ On Grassy Levels 3 taels per mow shall be paid, and on Profitless Levels 2 taels.

All such Alluvial Levels cultivated without the cognizance of the Government, shall be assessed in the year in which the fact is discovered, in the same manner as, according to the law on self-informing in cases of lands having been cultivated without the knowledge of Government, the payment of the taxes commences with the year in which the cultivator gives the information.

Those which have not been clandestinely cultivated, but which were previously reported, shall be assessed after a period of six years, in accordance with the law for Wet Lands; but nothing shall be recovered on them as profits.

It must also be ascertained whether or not the cultivation of the Levels cause any obstruction to the water courses, and their cultivation respectively prohibited or permitted accordingly.

Whoever passes fertile Levels for barren, or evades the payment of an increased tax on Levels capable of rendering it, shall, as soon as the fact is

* According to a measure furnished from the district magistracy of Nan-hae, a mow contains 8042.6 square English feet, or about 1-5th of an acre. *(Note of translator.)*

† Proposed in a memorial and sanctioned in the 1st year of Kien-lung (A.D. 1736.) *(Note of the original Chinese.)*

‡ Lands paying the regular taxes are entered according to their quality, in one of three schedules: the High, the Middling, and the Low, for each of which a different rate is fixed. *(Note of translator.)*

discovered, be punished in accordance with the law on Fraudulent Evasion of the Land-tax, and if the authorites connive at the offence, they shall also be denounced and prosecuted.*

3.† With reference to undertaking the cultivation of newly formed Alluvial Levels by rivers and estuaries, the people are enjoined to send in a circumstantial report of the same, as soon as the least appearance of a Level discovers itself. The local authority will then cause their extent in all directions to be marked with stakes, and also issue a proclamation on the subject, fixing a period of one month, at the expiration of which they will repair in person to the locality of the Alluvial Levels, and after summoning to them the informing officer, (ti pau) of the neighbourhood, hold a public survey of them. If their cultivation be undertaken on false grounds, a representation of the facts must be presented when the survey is made, to the local authority, who will examine the parties and deal with the case as may be necessary, on the spot. Should it be found that the authority to cultivate the Levels has not been obtained on false grounds, and that wrongful possession has not been taken of such as were already the property of others, boundary marks shall be forthwith set up and descriptions of the grounds, together with bonds taken from the cultivators, forwarded to the higher authorities. Deeds will at the same time be given to the (cultivators as) proprietors, and after the Levels have been diked in, and at the proper periods been reported to the Fiscal Board and assessed, they shall become their property for ever. Should any persons avail themselves of circumstances to raise deceitful litigations about the Levels subsequent to the survey, they shall be punished in accordance with the law on Taking wrongful Possession of the Lands of others.

4. No person who is sole proprietor of land to the extent of 1000 mow or upwards, shall, in addition to this, cultivate Alluvial Levels, even if contiguous to his own property; and members of the lower classes shall likewise not dike in more than 500 mow of Alluvial banks.

Should any fraudulent individual take forcible possession of lands, or commit any similar malpractices, by coming forward as proprietor under cover of a false name, he shall be punished in accordance with the law.

Those, however, who are willing to advance funds to assist poor people to enclose Alluvial Levels, shall be at liberty to assist in that way, but they shall

* The preceding two articles are not laws expressly enacted for the assessment of new grants, but are among the regulations proposed and sanctioned in the 22d year of Kea-king (A.D. 1817), on the settlement of certain cases regarding the allotment of funds to supply deficiencies in the revenue derived from lands held by military tenure. The profits, amounting to upwards of 170,000 taels, recovered in the 16th year of Kea-king (A.D. 1811) on Alluvial Levels for evasion of the tax, were appropriated to the purchase of grain to make up the deficiencies in the public granaries; and those recovered for the same offence in the 20th year of Kea-king (1815), amounting to upwards of 160,000 taels, were employed to supply the accumulated deficiencies in the payment of the land-tax in the two districts Nan-heung and Jin-hwa, as also to cover the expenses of the general quintennial measurements; such uses of the said moneys having in both cases been sanctioned by His Imperial Majesty, as is on record. *(Note of the original Chinese.)*

† The following five articles were all reported to His Imperial Majesty Kien-lung, and sanctioned by him in the 5th year of his reign (A.D. 1740), but have not yet been entered into the Code of the Fiscal Board. *(Note of the original Chinese.)*

only be allowed to receive such a rent as interest on their advances, as may be agreed on; and the Levels shall belong, as in other cases, to the poor people, the cultivators.

If, previous to this law being made, the cultivation of a greater quantity of Alluvial Levels should have been undertaken than 1000 mow or 500 mow (by wealthy and poor people respectively), it is provided, for the purpose of preventing annoyance, that fraudulent individuals shall not be permitted to avail themselves of the circumstances to commence litigation.

5. All newly formed Alluvial Levels contiguous to rivers and estuaries, which have successively risen above the water, shall be resurveyed, entered into the schedules according to their actual measurement, and a description of them forwarded to the Fiscal Board. They shall be reported for assessment after a period of ten years, in accordance with the law for Dry Lands,* and on the year when they are reported for the levying of the tax, they shall be entered into the general memorial of the Superintendent of Finances to His Imperial Majesty, and a report sent in for the inspection of the Fiscal Board.

6. A general measurement of Alluvial lands along rivers and estuaries shall be held once in every five years, in accordance with the law,† for which service an officer of worth and ability shall be selected, who will, with the assistance of the District Magistrates, make the general measurement by actual survey of each piece of land.‡ If any have suffered diminutions from the action of the water, they shall be immediately reported to His Majesty, that the tax on them may be remitted in proportion. If any are increased by new deposits, such must be reported, and the assessment made accordingly; and if there has been neither diminution nor increase, the fact must likewise be reported. In the event of the tides having been excessively high, so that there is no harvest, from the grain being saturated with water, the proper local authority must, in accordance with the law, make a survey of the saturated portion, and a report of the true state of the case must be sent to His Imperial Majesty with the request that the taxes for the current year be remitted on such Levels, in proportion to the damage done.

If the officers charged with the survey should be guilty of any concealment, or should delay in making the reports, an investigation shall be immediately held, and the guilty officials denounced to His Imperial Majesty for punishment.

7. Lands in the districts of Ho-poo and Kin-chow liable to the tax, but which are difficult to bring (again) into cultivation; together with all lands that have not yet been again placed on the list of those paying towards the fixed tax of the

* Subsequently in the 7th year of Kien-lung (A.D. 1742), the answer of the Fiscal Board to a memorial addressed to His Imperial Majesty, was received to the effect that, "in future the assessment must be made after a period of six years on grants of Alluvial Levels, in accordance with the law for Wet Lands." *(Note of the original Chinese.)*

† This refers to the general law of the country, applicable to all the eighteen provinces of China Proper. *(Note of translator.)*

‡ A statement of the results of the measurement must be sent in to His Imperial Majesty within one year. *(Note of the original Chinese.)*

districts in which they are situated,* being all poor, stony, thin land; shall pay fixed taxes at the rate of 0.012 of a tael per mow, in accordance with the lowest scale of the district of Ho-poo. If the original rate on these lands was, however, lighter than 0.012 of a tael, they shall be reported for assessment at such original rate.

Waste Lands and Alluvial Levels which have never been included among those paying towards the fixed tax, if covered in places with sand or saturated with salt water, the sand being deep, weeds thick, and the soil stony, poor, and difficult to bring into cultivation, shall pay for each mow a tax of 4 ho, 2 keu, and 8 chaou in rice, and 0.00464 of a tael in money, in accordance with the scale of taxes for the unproductive Salt Lands of Heang-shan and other districts.† On the arrival of the time when lands brought into cultivation are reported to His Majesty, lists distinctly separating the different kinds of these lands shall be sent in to the Fiscal Board; and they shall be assessed at the periods fixed for Wet and for Dry Lands.

Whoever deceitfully reports rich fertile lands well capable of cultivation, for assessment according to a light scale, shall be punished as the law directs; and if the local authorities fail to discover and report the fact, they shall at the same time be denounced to His Imperial Majesty for punishment.

On the Cultivation of Waste Government Lands.‡

1. Poor people without property, natives of the following nine Departments of this province, viz Kwang-chow, Shaou-king, Lo-ting, Nan-heung, Shaou-chow, Leen-shan, Hwuy-chow, Chaou-chow, and Kea-ying, shall be at liberty to cultivate the Hill Grounds, and Waste Lands generally in the same, in accordance with the regulations in force in the four Departments, Kaou-chow, Leen-chow, Luy-chow, and Keung-chow; with the exception, however, of the hill grounds belonging to the Yaou and Le mountaineers, of which the people shall not be allowed unjustly to take possession for cultivation.

The party who intends bringing a piece of land, no matter of what extent, into cultivation, must first repair to the local authority and present a statement containing his individual and family names, and indicating the piece in question; which will then be registered as ground being brought under cultivation. After it has been brought into cultivation, so as to form a regular piece, a plan must be drawn shewing its extent in every direction, which must be presented to the local authority, with the request that it may be surveyed; and the latter

* This passage refers to lands which were formerly under cultivation, but have been rendered unfit for it by natural causes, in particular by having had sand deposited on them by rivers overflowing their natural bounds. This has frequently been the case in the districts of Ho-poo and Kin-chow, mentioned in the text, where the rivers fall rapidly rom the mountains in which they have their sources, on the borders of Kwang-se. *(Note of translator.)*

† This law is likewise applicable to Waste Plains (table lands) among mountains and in other little frequented places. *(Note of the original Chinese.)*

‡ This refers to old Hill and Forest Lands, as distinguished from *newly formed* Alluvial Levels. *(Note of translator.)*

will, after the survey, grant a deed placing the cultivator in full possession. No assessment shall be made on such lands for the tax.

Odd patches not forming complete lots, the extent of which does not perhaps amount to ten mow, and which are barely fit for growing vegetables and miscellaneous produce, need not be reported, &c., &c., as above, at the time their cultivation is undertaken, but only after they have been reclaimed—an exemption granted, in order to manifest compassion for the cultivators. Whoever has at a former period spent labour and money in cultivating any such piece of land without the cognizance of the authorities, and who has succeeded in reclaiming it, shall be allowed to give information thereof; on which the land in question will be surveyed, and a deed given for it by the local authorities. If a legal dispute is pending respecting any such piece of land, the proper local authority must instantly survey the same and try the case, deciding in favour of the party that expended the labour and money to bring it into cultivation, who shall be placed in full possession of it, without any assessment being made for the tax; and official clerks and runners shall not be permitted to delay the settlement of the case, so as to involve the party entitled to the possession in embarrassment.

2. The permission hereby given to cultivate waste Government lands refers exclusively to dry plains, the soil of which is mixed with sand and stones, on the tops of mountains, and the faces of hills, situated among the lands of the people, and shall not be used as a cover to report, in the manner above specified, wet alluvial levels, or land reclaimed by others.

If at the place reported for cultivation there are graves belonging to other people, the cultivator shall not be permitted to carry on his operations close to, so as to encroach on or injure them, but shall keep at an additional distance of one chang, besides the four chang from the centre of the grave (required by the general law.) Whoever violates this regulation shall be prosecuted and punished as the law directs. If the possessor of the grave should avail himself of circumstances to commence deceitful litigations, he shall be dealt with according to the law on "Taking forcible possession of hill ground belonging to the Government or to private individuals." If the possessor of the grave should himself cultivate the adjoining land, or if other people should at a period long past have reclaimed land in its immediate proximity, it is hereby provided, in order to put a stop to litigations, that neither of the parties shall be constrained to yield to the other, but each shall remain in full possession of his property as before.¶

On Common Tenure.

What I have denominated common tenure is that species by which the *mín*, *i. e.* the people, as distinguished from the mandarins and soldiers, hold the great bulk of the real property contained in the eighteen provices of China Proper. I have given it this appellation

¶ Proposed to His Imperial Majesty, sanctioned and promulgated in the 12th year of Taou-kwang (A.D. 1832.)

to distinguish it from the tenure by military service, or military tenure; and to it I shall exclusively confine my remarks.

All tenants hold immediately of one lord, the Emperor, there being no mesne lords in China. There are also no allodial proprietors; indeed the idea of allodial property does not, so far as my experience goes, excite any admiration in the thoroughly despotized mind of a Chinese, who seems on the contrary rather proud of the fact that the "great Emperor" is lord of all the land in the country.

The conditions or incidents of common tenure are the payment of an annual tax and of fees for alienation; to which may be added, the performance of personal services, which the holders of real property are, in common with other able-bodied Chinese, bound to render to the mandarins as representatives of the Emperor. Under former dynasties it was customary to compound for this latter incident of the common tenure, by what may be termed a scutage, in Chinese *Yaou-yin* (lit. service money,) which seems however in the process of time to have come to be regarded more in the light of a *direct* tax under a different denomination, than as an equivalent for personal services. For though I have been unable to discover either in the "Collected Statutes" or the "Fiscal Code," any enactment reimposing them, still their actual performance is at present required in several of the northern provinces, while the laws prescribing penalties for the evasion of the same stand unaltered in the latest editions of the Penal Code. During the period extending from the 11th year of Kang-he (A.D. 1672) to the 58th year of Keen-lung (A.D. 1793) the whole of the above mentioned compound for personal service, to which the people generally in the eighteen provinces were then liable, amounting in all to 3,295,804 taels, was gradually added to the land-tax in proportions determined by the ratio between the whole amounts of the two kinds of payments in each province. At present, when waste lands are brought into cultivation the proportionate scutage is at once added to the sum for which each lot is assessed as tax; and as no personal services are exacted in the southern provinces, all that is commonly known among landed proprietors there, as the conditions upon which they hold their property, are, first, the annual payment of a sum of money, and secondly, the fees for alienation; but these latter are, as we shall presently see, evaded to a great extent. For the rich districts nearest Canton, the average rate of the annual tax is about two mace per mow, which includes, however, all the illegal but well ascertained fees levied by the agents of the mandarins. In the less rich parts of the country it is considerably lower.

The tenure by which the people *(min)* hold fish-ponds, and ground on which houses are built, is that of common tenure just described.

On Alienation.

1. *By Sale.* The accompanying Chinese document is, with the exception of the names, a facsimile of a Deed of Sale of a piece of land about twenty-five miles from Canton. It consists of two parts. The first, the Deed of Sale itself *(ke)* granted by the seller, is written on brownish paper of a course texture called *pe che*, skin, or cover paper, either from its toughness or because it is often used to cover packages. It is employed by the people for deeds on account of its durability, and may therefore be called the parchment of China. The second part, the deed-end *(ke-wei)*, is a printed form, of which a number are issued at a time from the office of the Superintendent of Finances for the province to the different district magistracies, where they are obtained by the purchasers of land on application. The mandarins who have, on account of the fees, a direct interest in the non-durability of this part, use the ordinary thin paper for it. The two together form the only Title Deed legally necessary of the property conveyed by them; but as a further security against dispute the purchaser usually demands from the seller the Deed of Sale executed when the property was conveyed to the *latter*; and if a property has changed owners frequently, three or four sets of Deeds of Sale are thus often collected in the possession of the existing proprietor. The deeds of sale for buildings are in their form and nature exactly like those for cultivated lands, the only difference being that another kind of property is described in them. The preamble to the Deed-end forms a fair example of those frequently occurring in legal official Chinese documents, which, from their quotations contained in quoted abstracts of letters, themselves quotations of other quoted letters, are rendered almost as obscure as most of our legal documents have become, in consequence of their obsolescent style and bewildering repetitions. Both the Deed and the Deed-end in a great measure explain themselves, as will be seen from the accompanying translations; and in my next paper I will offer some observations regarding such few portions as might not otherwise be understood.

I will then also give an account of the preliminary steps taken by the contracting parties previous to the close of the transaction by the delivery of the deed and payment of the price of the land.

THOMAS TAYLOR MEADOWS.

DEED OF SALE.

CHAOU-TIH-SHING.

18

Hwang-kwei-lung, the party who executes this deed of absolute sale in perpetuity, having at present a piece of cultivated land held by common-tenure, which was allotted to him as his share of that left by his grandfather, and which is liable for the tax for four mow and three fun, is situated in the place known by the local name of Pih-tang-tsun, is the fourth piece from the river, and has distinctly ascertained boundaries in all directions, extending on the east to the bounds of the Chow family, on the south to the bounds of the Woo family, on the west to the bounds of the Ho family, on the north to the bounds of the Wang family; and which piece of land he, on account of his urgent necessities, and with the concurrence of his mother, desires to dispose of by sale at fifteen taels per mow, the actual price of the day. He has, therefore, after having called on the other members of the family, none of whom will purchase it, next commissioned Hoo-yu-ming as negotiator, who has gone about with a notice, and by inquiry found out Chau-tih-shing, who will purchase it to be his property. The price of the entire piece has been fixed at sixty-four taels and five mace, to be weighed in scales. The agreement has been made by the three persons and with the consent of the two parties. On the same day the land has been measured, the boundary stakes set up, the deed executed, and the transaction closed; the money and the deed being mutually delivered without the least want or deficiency. The tax, amounting, to three shing of rice, is contained in that of the subordinate family of which Hwang-ta-ching is the head, in the sixth kea of the seventy-ninth too of Tso-kang; but the purchaser can, according to his own pleasure, remove it to that of the additional family of which Chaou-yun-chang is the head, in the eightieth too of the same paou, and himself make payment. This piece of ground was actually left by the grandfather of the seller, and has hitherto not been pledged, mortgaged, had money borrowed on it, &c. Should, however, any person raise a dispute respecting it, the purchaser shall not be implicated in the same, but it shall be settled by the seller and negotiator. The land and water passages are both to remain open as of old. This land having been once sold, is not redeemable, but is given up in perpetuity. And as a verbal agreement affords no proof, this deed of absolute sale is now executed, and delivered, together with the deed of the former proprietor, to the purchaser to hold in proof thereof.

Leang, district magistrate of Nan-hae, and bearing by Imperial authority the title of sub-prefect, finds on inspection the price in the deed to be sixty-four taels and five mace.

Negotiators { Hoo-yu-ming / Hoo-yuen-chang

1. The mother and son, the sellers, have in the presence of all the parties, received the price of the land in full, amounting to sixty-four taels and five mace in perfect dollars weighed in scales.

(Impression of the finger of the mother, of the maiden name of Chin.)



This deed of absolute sale in perpetuity was executed on the 15th day of the 3d month of the 19th Taoukwang year, by Hwang-kwei-lung, in his actual handwriting.

(A true Translation.)

T. T. M.

DEED-END.

No. OF LETTER.

The Superintendent of Finances for Kwang-tung, in obedience to an Imperial rescript and a memorial to the Emperor.

It appears on inspection of the records, that on the 22d day of the 1st month of the 15th Keen-lung year, a communication was received from the Governor-General and the Governor to the following effect:

"We have received a letter from the Board of Revenue stating,—

"'The Honan office having, as appears by the records, presented this Board with the draft of a Memorial in reply to His Imperial Majesty, on the subject of Fuh-ning, Superintendent of Finances for Ho-nan, having sent in a memorial, with a set of regulations appended, requesting that 'on the sale of real property a Deed-end might be attached to the deed and seals affixed, that it might be preserved by the proprietor, and be by him presented to the prefects and district and township magistrates for examination, &c.,' this Board presented it to his Imperial Majesty on the 12th day of the 12th month of the 14th year, and on the same day received the following Imperial rescript:—

"'Let it be done according as is proposed. Respect this.'

"This Board has therefore to send a copy of the original memorial, with the exemplar-sheet to be published, to the Governor-General and the Governor of Kwang-tung, that they may take measures in respectful obedience to the Imperial will. To this a document (the copy of the memorial) is attached."

The attached document states:

"'Hereafter, when the Superintendents of Finances distribute exemplars of Deed-ends to be issued to the people, they must form part of a numbered series. In the first half of the document must be entered, in detail in the usual manner,

the name of the proprietor, the number of fields or houses transferred, and the amount of the price and of the tax. In the latter half the seal of the Superintendent of Finances must be previously impressed over the blanks, and when the tax is paid, the price in the deed and the alienation fees must be entered minutely in the places having the impression of the seal over them, and given to the proprietor to look over, when the characters on the part where the two halves are to be divided must be written and the division made. The first half of the document is to be given to the proprietor to have and to hold, and the latter half sent with others of the class, together with the quarterly returns, for the examination of the Superintendent of Finances.

"'As a line of hand-writing is thus equally divided in two parts, none of the amounts can possibly be altered. The former custom of the district magistrates and Superintendents of Finances previously examining the Deed-ends is to be abolished, in order to save troublesome correspondence.'

"In consequence of this having reached us, we have now to communicate it to you together with an exemplar sheet."

In consequence of having received this, I now, as in duty bound, issue engraved exemplar sheets.*

Hereafter, whenever a landed proprietor comes to hand in a deed and pay the alienation fees, you must forthwith, in obedience to the regulations now fixed, levy a fee for the deed of three per cent on the price of the property as specified in the deed, and a fee for the government examination fund of one per cent on the same amount. You must then fill up the blanks in a Deed-end, write the characters on the place to be divided according as is shewn in the exemplar sheet, and, having divided it, give one part to the proprietor and deliver the other to this office. If any person neglects to apply for a Deed-end, such person must be punished in accordance with the law against "Evasion of the taxes." A necessary Deed-end.

PARTICULARS.

The proprietor ____ has bought ____ pieces of {ground / cultivated land} ____ or ____ No. of houses situated in ____ the place locally called ____ paying duty ____ hundred and ____ mow ____ fun ____ le ____ haou ____ sze ____ kwuh ____ wei ____ keen ____ sha ____ chin ____ yae for the price of ____ thousand ____ hundred and *sixty-four taels five mace* ____ candareens ____ cash ____ haou.

The fee payable for the deed amounts to ____ hundred and ____ taels ____ mace ____ candareens ____ cash, and the fee to the examination fund ____ hundred and ____ taels ____ mace ____ candareens ____ cash ____ haou ____ sze ____ kwuh.

* The Deed-ends are addressed to the district magistrates.

Issued by the Superintendent of Finances No. 18 of the word year
FOR THE PROPRIETOR *Chau-tih-shing*.

24th Taoukwang year. Price paid by the proprietor ____ thousand ____ hundred and ____ taels ____ mace. Total of fees ____ hundred and ____ taels ____ mace ____ candareens ____ cash.

A true translation, (only one or two of the blanks in the original Deed-end having been filled up.)—T. T. M.

ARTICLE II.

HOT SPRINGS OF YONG-MĂK.

A SHORT ACCOUNT OF A VISIT TO THE HOT SPRINGS OF YONG-MĂK: BY J. C. BOWRING.—(Read before the ASIATIC SOCIETY, 6TH JULY, 1847.)

At the distance of about twenty miles to the N. N. W. of Macao, and on the island of Hiang-shan, is a valley of considerable extent encircled by high mountains, which from its remarkable appearance and the existence of several boiling springs in the centre, is generally supposed to be the site of an extinct volcano.

Having had an opportunity of visiting this spot during a short stay at Macao in the month of March last, I have now the pleasure of laying before the Society the substance of a few notes taken at the time, which it is hoped will not be found void of interest.

A gentleman residing in Macao who is well acquainted with the surrounding country, having offered to conduct me to the place, we started before sunrise from the inner harbour, and passing round the north-end of Lappa, after a pull of about two hours through narrow and intricate passages, entered a channel of considerable width, which runs up from the Broad-way and leads directly up to the spot to which we were proceeding.

Following this channel, in about two hours more we reached the boiling springs, which are situated nearly in the centre of the plain, and not far from the village of Yong-măk. By the time, we arrived at the spot it was late in the forenoon, and the sun being powerful, the steam from the pools, which during the cold weather or early in the morning is to be distinguished at a considerable distance, was not visible until we were close upon them, but the smell of the waters was very perceptible as we approached, much resembling that of several of the mineral springs in England.

The space over which the springs are scattered, and which may be considered their peculiar locality, is perhaps seventy or eighty yards square, from all parts of which steam may be seen to rise, and the ground everywhere shakes and trembles under foot. The Chinese villagers have at various times attempted to fill up the pools which have shewn themselves at different points in this plot, but without success, as the water has always broken forth in other places. They do not however appear to have been disturbed of late.

At the time of our visit the principal springs were three in number, the largest being nine or ten feet in diameter, and none of them of any depth. The water boils up through the mud at the bottom with considerable force, and runs off in a continual stream into the channel close to whose banks the pools are situated.

Having no thermometer with us, we were unable to ascertain correctly the temperature of the water, but close to the edge, where the depth was not more than two or three inches, we judged it to be about 150° or 160°. In the centre, where the water may be seen to boil up from below, the heat must be far greater, and on a previous visit my companion found it to be 170°; it is probable, however, that the water does not remain at a uniform temperature, and it is doubtless at times hotter than 170°. The Chinese who live on the spot are in the habit of boiling their rice, &c. here, which is easily done by placing the articles in a basket which is slung on a bamboo and then immersed. In this manner we boiled a number of eggs, and found that in two minutes they were in a perfectly eatable state, and in five minutes were thoroughly done.

The water is perfectly clear, and salt, though free from the bitterness perceptible in sea water. It has been found to be highly serviceable in cutaneous diseases, and I have been informed that it was employed on several occasions with much success by the late Dr Pearson.

The mud at the bottom of the pools is of a dark colour and covered with shining metallic-like particles. It has been probed to a great depth without any resistance being met with, and my companion, who had often visited the spot before, assured me that he had tried it and found no bottom at thirty fathoms.

Perhaps the most remarkable circumstance relating to these springs is the alteration of the level of their waters with the ebb and flow of the tide in the adjoining channel, which would seem to indicate some communication below, and that the water should retain so high a temperature under such circumstances is not a little curious. At

the time of our visit the tide had still about two hours more to flow, and from marks on the sides of the pools it appeared that the waters would rise from eight to ten inches higher than they then were.

The valley, as before mentioned, is surrounded by high mountains, and resembles a vast amphitheatre; and when it is remembered that basalt and other volcanic rocks are frequently met with along the coast to the westward, the opinion generally entertained that this was the crater of a volcano appears at first not to be without foundation: but an examination of the spot will easily shew that it is incorrect. The mountains in no way differ from those on this island and on the mainland in this neighbourhood, being of granite formation, covered with a scanty soil consisting of the detritus of the rock, and in no part is there any trace of volcanic agency.

At the entrance of the valley are two villages, Goei-poo and Chi-fong, the one on the right and the other on the left hand, and at the head of the channel at the further extremity of the plain is a third of large size. Besides these and the village of Yong-mäk, various smaller hamlets are distributed along the base of the mountains, and the whole district appears to be exceedingly populous.

In the immediate vicinity of the hot springs the sugar-cane appears to grow well, but the remainder of the valley consists of extensive rice fields. During the winter months these are a favourite resort of the sportsmen of Macao, as they then abound with wild fowl; and even at the period of our excursion, in the middle of March, myriads of teal and wild duck covered the paddy swamps.

The distance from Macao will render this place inaccessible to most persons, but those who have leisure and can devote a day to an excursion to the hot springs of Yong-mäk will find their trouble amply rewarded.

Since the foregoing was written I have been favoured by Dr Harland with the subjoined result of his analysis of the water of the Yong-mäk springs, and I here beg to express my thanks for the care and trouble he has bestowed on the subject.

It will be seen that several of the remarks contained in the above paper are borne out by the analysis, and the want of the bitterness so perceptible in sea-water is fully accounted for by the total absence of muriate of magnesia. That no trace of this salt should exist is remarkable, as it has been shewn that the springs are situated

within a few paces of the channel which runs directly up from the sea, and in which the rise and fall of the tide is considerable.

With respect to the smell perceptible on approaching the springs, Dr Harland remarks,—"there is nothing in the water itself to account for it, though it is quite possible that the water may naturally contain a small proportion of some gas which has escaped (from the specimen examined) by being so long in bottles, which really are not so perfectly tight as I had expected, and on this account I make the remarks at the commencement of my notes. It is more probable, however, I think, that the smell you allude to is caused by the effects of the high temperature on the immediately adjoining vegetable matter.—Hongkong, *March* 2*d*, 1848."

ANALYSIS OF THE WATER.

Before mentioning the results of the Analysis, it is proper to remark that the specimen of the water sent to me for that purpose had been preserved for several months in glass-stoppered bottles; but as the bottles had not been completely filled and the stoppers inserted whilst under water, a space of several cubic inches remained full of air in each bottle, and the stoppers themselves did not fit so accurately as is necessary for such purposes.

No sediment whatever was found to have been deposited in the bottles, the water remaining perfectly clear and limpid, free from any smell, and having a cool purely saline taste.

After the repeated application of various appropriate tests, not the slightest trace of sulphuretted hydrogen or carbonic acid gases, nor of Iodine, magnesia, nor iron, could be detected.

24 fluid ounces (or 10957.5 grains) carefully evaporated to dryness in a small porcelain basin, and the residuum heated to redness, afforded 66.5 grs. of solid anhydrous saline matter; and if to this we add 23.84 grs. of water, which is the exact proportion of water of crystallization required by the resulting salts in their crystallized form, we have 90.34 grs. as the total amount of solid crystallized saline matter contained in the above quantity of water. The proportion of the different salts in the 24 ounces is as follows:—

Muriate of Soda	56.29 gr.	containing	6.65 of water and	43.64	Chloride of Sodium	
Sulphate „	27.85 „	„	15.69 „	„	12.25	Anhydrous Sulphate of Soda
Muriate of Lime	11.54 „	„	1.50 „	„	9.95	Chloride of Calcium
Loss	65				65	
Total	90.34	crystallized saline matter	23.84	water of crystallization	66.50	Anhydrous saline matter.

The wine pint of 8750 grains contains, therefore,—

Muriate of Soda (common salt)	40.34 grains
Sulphate „ (Glauber's salts)	22.24 „
Muriate of Lime	9.21 „
Loss	52 „
Total	72.31 grains

When the locality of these springs is taken into consideration, the following comparison between the water of Yong-mäk and ordinary sea-water will no doubt be interesting to many:—

	In 10,000 grains of water, there are in the *Water of Yong-mak*	*and in Sea-water,*
Muriate of Soda	45.80	220.01
Sulphate „	23.41	33.16
Muriate of Magnesia	60.09	42.08
Muriate of Lime	10.53	7.84
	81.83	303.09

We can thus see how it is that the Yong-mäk water is so free from any unpleasant bitter taste, for it contains no trace of any salt of Magnesia; whilst in sea-water on the contrary, the disagreeable bitterness of which is so familiar, there is a considerable quantity of that intensely bitter salt, the Muriate of Magnesia.

The reputed medicinal virtues of the Yong-mäk water are satisfactorily accounted for by the large proportion of Muriate of Lime found in it, this salt being a favourite medicine with many for the cure of scrofula and similar diseases. Pereira, in his *Materia Medica*, after mentioning the names of several eminent physicians who have found this very efficacious as an internal remedy in such cases, says that "occasionally, though rarely, it has also been employed externally: thus a bath, containing 2 or 3 ounces of it, either alone or with Chloride of Sodium, has been used in scrofula," and it is somewhat curious therefore to find that the Yong-mäk water contains both these salts, and the former in almost exactly the proportion here recommended; as a bath of 13 gallons will contain 2 ounces of Muriate of Lime, and 8¼ ounces of Chloride of Sodium (common salt.)

W. A. Harland, M.D.

Hongkong, 2*d March*, 1848.

ARTICLE III.

CHINESE ANATOMY AND PHYSIOLOGY.

A TREATISE ON THE CHINESE SYSTEM OF ANATOMY AND PHYSIOLOGY: By Dr W. A. Harland,—(Read before the Asiatic Society, September 7th and October 5th, 1847.

PART I.—ANATOMY.

After the numerous accounts of the Science of Medicine, as understood and practised by the Chinese, which are to be met with in the writings of many of the most eminent Sinologists, it may be thought quite unnecessary to intrude any further remarks on this subject: it is one which can have but little interest to any but medical men, and I believe that the greater part of our profession have such a

thorough contempt for all that the Chinese know of Medicine, so far at least as has yet been ascertained, that they deem any further investigation of it to be a complete waste of time. To these objections, however, I would answer, that the subject has never yet been fully examined by medical men acquainted with the language; that many of the older writings of the Chinese clearly prove them to have been better acquainted with Anatomy and other Sciences formerly than they are now; and moreover, in addition to the interest attached to such an investigation, it is of great consequence for us to become thoroughly acquainted with all their theories and prejudices, however ridiculous we may consider them, if we hope ever to introduce European Science and Civilization by means of works published in their own language. Indeed, with this latter object in view, we must bear in mind that the Chinese generally are endowed with excellent reasoning powers, so that when we enter into an argument with them for the purpose of convincing them of the truth of our own doctrines, we can make but little progress towards their conversion when they find that we are unacquainted with their own views or writings on the subject; and in this respect, so far as my limited experience goes, I certainly agree with the remark made by Mr T. T. Meadows, "that the man who enters into an argument with them on subjects they understand, must have all his wits about him, without which, and without reason on his side, he need not hope to prevail."

Like most other people, the Chinese have paid considerable attention to the "Healing Art" since the earliest ages of their existence as a nation, as is amply shewn by the great number of very voluminous works which they have written on the subject at various times, as well as by the high estimation in which its more eminent professors have always been held by them. From the obscurity, however, which hangs over the first periods of their history, we cannot avoid feeling much difficulty in believing in the very great antiquity assigned to their earliest medical writers: for instance, they say that the Emperor Shin-nung composed a Materia-Medica 3100 years before Christ, and that after this the Emperor Hwang-Te wrote the Soo-wán or "Plain-Questions," about the year B.C. 2630. According to this statement, therefore, the first named work was written about 752 years, and the last 282 years, before the Mosaic deluge; but although this is scarcely probable, yet the mere tradition that such was the fact certainly proves that considerable attention was

paid to Medicine at a very early period: it may also give some additional weight to a suggestion made by Mr Medhurst, that the great knowledge of Astronomy possessed by the ancient Chinese, was obtained traditionally from the Ante-diluvian Patriarchs; and if such were the case with Astronomy, may not some of the other sciences, Medicine included, have been likewise transmitted from the same source?* The "Nan-king," a very ancient and celebrated work written during the Chow dynasty, about 1050 years before Christ, is still extant, and has been largely quoted by all succeeding authors. The famous work on the doctrine of the pulse, by Wang-Shŭh-ho (epitomized by Du Halde), was written during the reign of Che-Hwang-te, the Book-burner, about the year B.C. 510, and in it the author frequently speaks of more ancient works. A new edition was published A.D. 1693, during the reign of Kang-he.

About the year 229 of our era, Dr Chang-kae-pin composed the first regular work containing prescriptions in addition to the theoretical part of Medicine, and after this a great many medical books were published, especially during the Tăng and Sung dynasties: during the former of these, about A.D. 750, Dr Wang-ping published a new edition of the "Plain Questions" by the Emperor Hwang-te, and added a commentary by himself, to the original work. The great Materia-Medica, or "Ta-pun-tsaou," was written by Lo-she-kan, and published by his son about A.D. 1600, during the reign of Wan-leĭh.

The source from which I have principally derived the substance of the present essay is a book entitled "E-tsung-kin-kĕen," or "Golden Mirror of Medical Authors," compiled by Imperial authority from the best works of previous writers, but more especially from the "Nan-king" and the writings of Dr Chang-kae-pin; it was published in 1743, the 7th of Kĕen-lung, and is one of the largest Chinese medical works, occupying 32 octavo volumes, and containing upwards of 400 wood-cuts. I have also examined a set of 4 large Anatomical plates, containing an epitome of Anatomy from the "Golden Mirror," and published under the authority of the Medical Board at Peking; and for further information I am likewise

* "The Emperor Yaou's knowledge of Astronomy is so much in advance of his age, that we can account for it in no other way than by his having received his knowledge from the ante-diluvian Patriarchs, the length of whose age enabled them to make observations which would escape the notice of their more short-lived successors."—MEDHURST's *Translation of the Shoo-king*, Preface, p. 6.

indebted to a smaller set of plates containing extracts from various unnamed authors.

From what has already been said, it is evident that so far as antiquity is concerned, the Chinese system of Medicine has high claims to our consideration, being superior in this respect to what is contained in the works of Pythagoras or Hippocrates, and perhaps also to the ancient Vedas of Bramah, which are supposed by many persons to be the oldest works extant, next to the Pentateuch of Moses, written about 1452 years before Christ.

Their system on the whole has much resemblance to that which was propagated in the Western World by Pythagoras 550 years before the Christian era, and of which many traces still exist in Europe; indeed, it is probable that both were derived from the same original source, since it is certain that that philosopher derived a great part of his knowledge from the East, which even in those early ages was looked upon as the mysterious abode of superior wisdom in all departments of human learning. Amongst the Chinese, however, Medical Science, if such it may be called, as now understood and practised by them, is a strange combination of a few Anatomical facts and some really valuable practical observations buried under an absurd mixture of Astrology and Superstition; and yet after all, ridicule it as we may, it is certainly no worse than, nay in many respects very similar to, what was practised in Europe during the 16th and 17th centuries. Their philosophers admit the existence of Five Elements (五行) Woo-hing, viz.—Fire, Earth, Metal, Wood, and Water, and believe that the human body is made up of these in various proportions, each element however having its own peculiar seat in one or more of the Viscera, from which storehouse or reservoir it is distributed throughout the body by means of the all-pervading principles Yin (陰) and Yang (陽) *

For the sake of convenience in description, the Chinese Anatomists, like our own, divide the human body in various ways; some into a right and left side; others into the trunk and extremities; though the most usual division is into exterior and interior.

On the outer surface, they point out and give names to a great many isolated spots symmetrically arranged on the right and left sides, and which are useful in describing the locality of any external disease, wound, &c., as well as in shewing the proper places for the application of the numerous outward remedies of which the Chinese

* See below, under the head Physiology.

are so fond; but this division, or marking out into regions, is carried to such an absurd degree of minuteness, as to give names to the various furrows and wrinkles on the palms of the hands and soles of the feet, &c.

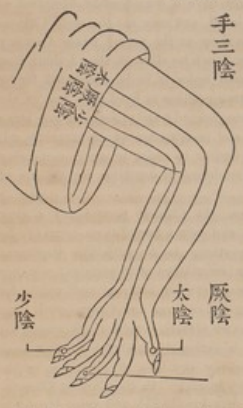
There is also another set of names, besides those just mentioned, to be found in a Chinese Anatomical Plate of the surface of the body, and intended to point out the positions of an immense number of Sinuses (尤) (Heuě) or Cavities, which are supposed to exist beneath the surface, and through which it is believed the blood flows in the course of its circulation; they are represented by a series of rings connected together by lines which run in various directions, though similarly arranged on each side of the body. Now as these sinuses are purely imaginary, and have no existence whatever in nature, it seems so difficult to account for their invention, that I would suggest the following as a *possible* explanation:—It is well known that the superficial veins have a considerable dilatation at every point where a valve is placed, and may not the early Chinese physicians have given names to these at the period when Anatomy was cultivated by them? If so much be allowed, then I think that the arrangement in their present order is to be accounted for by supposing the records of their true position to have been lost at the time when all books, &c., were burned; and dissection not being afterwards practised, memory and imagination would naturally call in the aid of certain lines or figures to assist in again recovering their former knowledge and rendering it available for the use of posterity.

Of the Organs of Circulation, the Chinese possess but a very limited amount of knowledge, and only a few of them appear to be aware that the Heart has anything to do with this important function. It has not yet been ascertained with certainty whether they really make a distinction between arteries and veins, for although they speak of the King (經) or large and direct vessels, and the Lŏ (絡) or small and transverse vessels, besides those which are called Yin and Yang, yet it is extremely doubtful whether such distinctions are intended to convey any idea of difference in the quality of the blood circulating in each. In the Chinese Chrestomathy, arteries are translated Mih-kin (脈筋), and veins Heuĕ-kin (血筋); but these terms were not at all clearly understood by several Chinese doctors whom I consulted. The total number of principal vessels is said to be 24, allowing 3 Yin and 3 Yang in each of the

four limbs, and which, after entering the trunk, unite together in pairs, and by this union form the 12 King (經) or "Noble Organs," in other words the Viscera.

The Yin and Yang vessels respectively receive the same names both in the upper and lower extremities, the three Yin being called Tae-yin (太陰), Shaou-yin (少陰), and Keuĕ-yin (厥陰), and are situated on the inner side of each limb; whilst the three Yang, viz: the Tae-yang (太陽), Shaou-yang (少陽), and Yang-ming (陽明), are to be found on the outer or posterior aspect. The three Yin of the Hand are said to go from the Tsang* to the hands, and the three Yang from the hands to the head; the three Yang of the feet, go from the head to the feet, and the three Yin proceeding from the feet, enter the abdomen. The source and termination of each vessel is given as follows:—

OF THE HANDS.



The Tae-yin is the King-Lŏ† (經絡) or blood-vessel of the Lungs; it arises from the Chung-foo sinus, and terminates in the Shaou-shang sinus.

The Shaou-yin is the blood-vessel of the Heart; it arises from the Keih-tseun sinus, and terminates in the Shaou-chang sinus.

The Keuĕ-yin is the blood-vessel of the Pericardium; it arises in the Tĕen-che sinus, and terminates in the Chung-chung sinus.

* The Tsang viscera are five in number, viz.—the Heart, Liver, Spleen, Lungs, and Kidneys, and are said to belong to the Yin. (See below, under the head Viscera.)

† *i. e.*, it is the principal vessel, together with all the smaller transverse vessels which issue from it. The same term King-Lŏ, is applied to each of the 24 great vessels, and only omitted below to avoid repetition.



The Tae-yang is the blood-vessel of the Small intestines; it arises in the Shaou-tsih sinus, and terminates in the Ting-kung sinus.

The Shaou-yang is the blood-vessel of the San-tseaou;* it arises in the Kwan-chung sinus, and terminates in the Urh-mun sinus.

The Yang-ming is the blood-vessel of the Great intestines; it arises in the Shang-yang sinus, and terminates in the Ying-hëang sinus.

OF THE FEET.



The Tae-yin is the blood-vessel of the Spleen; it arises in the Yin-pĭh sinus, and terminates in the Ta-paou sinus.

The Shaou-yin is the blood-vessel of the Kidneys; it arises in the Yung-tseun sinus, and terminates in the Yu-foo sinus.

The Keuĕ-yin is the blood-vessel of the Liver; it arises in the Ta-tĭn sinus, and terminates in the Ke-mun sinus.

* See below in the description of the Viscera.



The Tae-yang is the blood-vessel of the Urinary-bladder; it arises in the Tsing-ming sinus, and terminates in the Che-yin sinus.

The Shaou-yang is the blood-vessel of the Gall-bladder; it arises from the Tung-tsze sinus, and terminates in the Keaou-yin sinus.

The Yang-ming is the blood-vessel of the Stomach; it arises in the Tow-wei sinus, and terminates in the Le-tuy sinus.

Such is the Chinese version of the number and distribution of the principal blood-vessels, and it is calculated that the whole length traversed by the blood in a single circulation is exactly equal to 162 cubits. The smaller vessels are said to shoot off in succession from the larger ones and to traverse everywhere without interruption, so that by means of the two the blood is transmitted throughout every part of the body.*

Lymphatic Circulation.—The Chinese are entirely ignorant of the existence of Lymphatic vessels,—at least, no account of them has yet been found in any writings hitherto examined.

Nervous System.—Of the Brain, they know little or nothing, except its situation:—it is called the "Marrow of the Head" or "Spinal Marrow's receptacle," but appears to hold a very subordinate

* The Heart is described below, along with the other Viscera.

rank in the opinion of the Chinese. The Spinal-cord is described as an elongation from the Brain, with which every part of it is continuous, and it is also intimately connected with the Kidneys: branches (nerves?) are said by some to proceed from each side of it; but here it must be borne in mind that the word Kin (筋) appears to be used indiscriminately both for Tendons and Nerves.

With regard to the *Muscular part* of the body, they merely distinguish it by the general term Yŏ (肉) "Flesh," and have no idea of its arrangement in distinct masses, each with a particular action and use of its own.

Of the *Bones*, they appear to possess a tolerably correct knowledge, and though it does not extend to minute particulars, yet they name each, and describe them with considerable accuracy, not excepting the phalanges of the fingers and toes. In their descriptions of the Spine, however, there is much confusion, different authors giving a different number of Vertebræ, and in stating the position of any organ with respect to the Spine, some count the Vertebræ from below and some from the top, whilst others again reckon from the middle, either upwards or downwards.

Chinese Anatomists have devoted by far the largest share of their attention to the examination and description of the various *Viscera*, whose important and mysterious functions have afforded a fine field for the exercise of their imagination.

They divide these organs into two classes, viz:—Tsang (藏) and Foo (腑), which together make up the 12 King (經) or "Noble Organs," sometimes also called the 12 Kwan (官) or "Rulers."

The Tsang are 5 in number, including all the solid or parenchymatous viscera, as the Lungs, Heart, Liver, Spleen, and Kidneys; but of the Foo, or hollow organs, there are six, viz: the Large-Intestines, Small-Intestines, Stomach, Gall-bladder, Urinary-bladder, and Pericardium. This, however, only gives us 11 King, and as they are entirely ignorant of the existence of the Pancreas,* they have been obliged to add an imaginary organ or set of organs called San-tseaou (三焦) in order to complete the necessary number, 12.

The following descriptions of the several Viscera are derived almost exclusively from the "Golden Mirror," Vol. 30:—

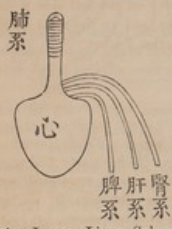
* In man at least, though they are quite familiar with it in the Sheep and Pig.

THE LUNGS—*Fei* (肺)



Are the most important of the 5 Tsang; they have 4 sides,—are attached to the third vertebra, covering the Heart, and contain 12 separate cavities. The "Nan-king" says, they weigh 3 catties and 3 taels*—that they have 6 lobes or leaves, and 2 ears; in all, 8 divisions. Dr Chang-kae-pin says that the Lungs have a white glistening aspect, and are hollow within like honey-comb, but have no opening below: during inspiration they are full, but during expiration they are empty, and are, in fact, a man's air-bag, containing much air and little blood.

THE HEART—*Sin* (心)



Is situated below the Windpipe and above the Diaphragm, and is attached to the fifth vertebra (one author says to the sixth, counting from above downwards.) Its form is pyramidal and circular, and it has the appearance of the unopened bud of the Water-lily. It is impervious below, but has 7 orifices above, opening upwards towards the Tongue, and by 4 of these apertures tubes pass out to the remaining 4 Tsang, viz: Lungs, Liver, Spleen, and Kidneys. Within its cavity there are several hairs† (三毛) (San Maou,) and externally it is surrounded

* The weights and measures employed are,—
For length.—The Chih or Foot, (nearly equal to 13 English inches) divided into 10 Chinese inches.
For capacity.—The Kŏ, containing 3 English cubic inches.
10 Kŏ make one Shing, nearly equal to an English pint.
10 Shing make one Tow, a little more than an English gallon.
For weight.—The Kin, or Catty, equal to 1⅓lbs. avoirdupois,
containing 10 Taels, each equal to 1½ oz. avoirdupois.
One Tael contains 24 Choo or pennyweights.

† These 3, or several, hairs are intended, no doubt, to represent the Musculi Pectinati, or tendons attached to the valves.

by red and yellow fat which forms the Pericardium. The "Nan-king" says that the Heart weighs 12 taels, and is capable of containing 3 Kŏ, or about the third of a pint, of seminal fluid; it is an organ containing little air and little blood.

THE LIVER—*Kan* (肝)



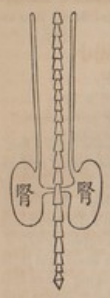
Is situated below the Diaphragm, and its upper surface is attached to the lower edge of the ninth Vertebra. It communicates above with the Heart and Lungs, but has no opening below. It contains much blood, but little air. The "Nan-king" says that the Liver weighs 2 catties and 4 taels: on the left side it has 3 lobes, and on the right side 4, altogether 7 lobes.

THE SPLEEN—*Pe* (脾)



Has the form of a sickle, and is connected with the same membrane as the Stomach, to the left extremity of which it is attached above, but below to the 11th Vertebra. It contains much air and little blood. In the "Nan-king" we are informed that the Spleen weighs 2 catties and 3 taels, that it is 5 inches in length, and 3 inches wide, and has about half a catty of fat scattered over it in masses.

THE KIDNEYS—*Shin* (腎)



Are attached to the lower part of the 14th Vertebra: they are two in number, and together weigh 1 catty and 2 taels. They contain little blood and much air. Dr Chang-kae-pin says, that they have the form of Kidney-beans placed side by side corresponding with each other, and that they are attached to each side of the Spine, at a distance of about an inch and a half from its centre. Externally they are completely covered with yellow fat, and two tubes pass out from each of them, the upper tube going to the heart, and the lower one to the great bone of the Spine, which it joins at a point a little more than half a handsbreadth from its commencement. In the centre of each Kidney there are 2 sinuses or cavities, from one of which the vessel proceeds to the Spine, and through it to the Brain.

THE LARGE INTESTINES—*Ta-chang* (腸大)



Have 16 contortions on the left side of the navel, and this contorted portion is 21 feet in length and 4 inches in circumference, or rather less than an inch and a half in diameter, and is capable of containing 1 Tow of rice or 7½ Shing of water. At the termination of this part they are attached to the Spine, and here become 8 inches in circumference, or rather more than 2⅔ inches in diameter, which dimensions are retained throughout a length of 2 feet 8 inches, so that this portion is large enough to hold 9 Shing and 3⅓ Kŏ of rice. According to the "Nan-king," the Large Intestines contain much air and little blood, they weigh 2 catties and 12 taels, and the weight of the Anus alone equals 12 taels. Dr Chang-kae-pin observes that the wide part is greater in proportion, as there are more contortions

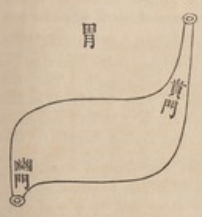
in the remainder: he also says, that the "Straight Gut," Chĭh Chang (直腸), is the last portion of the Large Intestines, and terminates below at the Anus.

THE SMALL INTESTINES—*Seaou-chang* (腸小)



Are attached posteriorly to the Spine, and in front to a point a little above the Umbilicus. They are repeatedly folded towards the left side, having in all 16 contortions; they are 32 feet in length and 2⅔ inches in circumference, or rather more than $\frac{8}{10}$ of an inch in diameter, and capable of containing 2 Tow, 4 Shing of rice, with rather more than 6 Shing, 3⅓ Kŏ of water. The upper opening of the Small Intestines is the inferior mouth of the Stomach, and is situated about 2 inches above the Umbilicus, and near the Spine; at about an inch below this, they become attached externally to the Umbilicus near the Shwuy-Fun sinus, where the lower mouth is situated, opening into the upper orifice of the Large Intestines by the Lan-mun (闌門) or "Obstructed Doorway" (the Ilio-cæcal valve.) They contain much blood and little air, and weigh 2 catties 14 taels.

THE STOMACH—*Wei* (胃)



Is said to be 1 foot 5 inches in circumference, 5 inches in diameter, and 2 feet 6 inches in length. When bent double it can contain 3 Tow 5 Shing of water and grain mixed together, and when 2 Tow of grain are allowed to remain for some time in the middle, then 1 Tow and 5 Shing of water will fill it. It contains much air and little blood. In the "Nan-king" its weight is said to be 2 catties and 1 tael. Dr Chang-kae-pin says, that the upper mouth of the Stomach is called the Fun-mun (賁門) or "Bubbling Doorway," and that its lower mouth, which enters the upper mouth of

the Small Intestines, is called the Yew-mun (幽門) or "Hidden Door," (the Pylorus)

THE GALL-BLADDER—*Tan* (膽)



Is described in the "Nan-king" as being situated in the middle of the small lobe of the Liver. It weighs 3 Taels, 3 Choo, and is 3 inches in length, containing, when full, 3 Kŏ of gall. It has much blood but little air.

THE URINARY BLADDER—*Pang-kwang* (膀胱)



Is situated at the 19th Vertebra below the Kidneys, and in front of the Large Intestines. It has no opening above, but below it has an orifice 2½ inches in circumference. It contains much blood and little air. In the "Nan-king" its weight is said to be 9 Taels and 2 Choo, with a diameter of 9 inches, and capable of holding, when full, 9 Shing and 9 Kŏ of water.

THE PERICARDIUM—*Sin-paou-lŏ* (心包絡)



Appears to have puzzled the Chinese Anatomists—at least, if we may judge from their contradictory statements respecting it. The "Nan-king" says it has no form, but Dr Hwa-show calls it the Show-sin, or "Heart's receptacle," and says it is situated around the Heart, above the transverse diaphragm and below the perpendicular diaphragm, or Mediastinum; and further, that it is attached to the transverse diaphragm, and consists of an outer tendinous membrane like silk, containing a quantity of yellow fat next the Heart. Dr Chang-kae-pin denies all this, and agreeing with the "Nan-king," says this description is all mere talk, and that the Pericardium really has no form.

One author entirely omits it in his enumeration of the 12 king, and substitutes in its place the Shen-chung (腎中), the Mediastinum, or perpendicular diaphragm.

THE *San-Tseaou* (三焦).

As these are purely imaginary organs, without even a shadow of existence in nature, it is difficult to obtain a correct idea of what is meant by them. Du Halde calls them the "Three Stoves," or sources of Natural Heat, but in the description of a small anatomical plate in the *Chinese Repository*, they are called the "Three Passages," and the following translation of the letterpress on the original diagram in the "Golden Mirror," is there given: *

三焦



"The upper Tseaou terminates at the superior orifice of the Stomach, and governs the Ingesta, but not the Egesta.

"The middle one commences at the upper curvature of the Stomach; it regulates the Fermentation and Digestion of the food, and sends forth the milk and watery secretions in the form of vapour, transforming them into the lighter and more subtle fluids which flow upwards to the Lungs, there to be converted into blood, by which the animal frame is supported.

"The lower one commences below the Ilio-cæcal valve, it governs the Egesta but not the Ingesta." †

In the "Golden Mirror" we also find the following,—

"The Classics say that the Upper Tseaou is as it were a Vapour—the middle one like a Sponge, and the lower one like a Flowing stream; they are the regulators of the flowing streams or watery secretions, and are organs which contain little blood and much air."

* The annexed diagram is only a quarter the size of the Original, and the groups of characters which should fill each space are omitted.

† *Chinese Repository*, 1840, vol. ix., p. 194.

The "Nan-king" ridicules these descriptions, and says that they have a name indeed, but no form, and on the whole, therefore, I am inclined to translate the term San-Tsaou as "Three Regions," believing them to be merely three divisions of the trunk, and that the above descriptions have been given on account of the nature of the principal functions performed in each. In this way the Upper region containing the Lungs may be compared to a vapour,—the Middle region containing the principal solid or parenchymatous organs, besides the greater portion of the small Intestines, whence the Lacteals suck up or absorb the nutritious portions of the food, so far resembles a sponge,—and the Lower region whence the Urinary and Seminal Secretions and the Alvine evacuations escape from the body, may indeed be compared to a flowing stream.*

The *Ming-mun* (命門) or "Gate of Life"



Is another imaginary organ which is often spoken of, and apparently considered of much importance, but its position appears somewhat uncertain. Both in the "Golden Mirror" and the work of Dr Wang-shŭh-ho, from the latter of which this Diagram is copied, it is described as a circular opening or door in the centre of the spine between the two kidneys. The upper figure represents it on a large scale, shewing the alternations of Yin and Yang—the latter being white and the former black: in this way also the right kidney is shewn to be Yang, and the left one Yin. In an anatomical plate of a female described in the *Chinese Repository*, the two characters, Ming-mun, are written in the space occupied by the uterus, and in the accompanying letter-press it is said that in the female the uterus is the Ming-mun, but that in the male the right kidney performs this office.

* For the other supposed uses of these organs see under Physiology.

From the above descriptions of the various Viscera it appears almost certain that the Chinese knew more of Anatomy at a former period than they now do, for if they had not examined the organs they describe, they could hardly have given such appropriate names to many of them (*e. g.* Lan-mun or "Obstructed Doorway," to the Ilio-cæcal valve, and Yew-mun or "Hidden Door," to the Pylorus), nor is it at all likely that they would attempt to give the weights and dimensions of the different viscera unless they had, at some time or other, really endeavoured practically to ascertain these points. Certainly they are very often far from the truth in such matters, but we could not expect to find the results of former observations handed down through so many ages without losing much of their original correctness; and above all things, Anatomical facts and details would soonest be lost, especially when Dissection, the only check against growing errors, ceased to be practised amongst them.

PART II. PHYSIOLOGY.

To give a complete exposition of the views entertained by the Chinese as to the mode in which the various functions carried on in the human body, and which together constitute life, are performed, would require an extensive acquaintance with their system of Astrology, which is so much mixed up with Medicine and general Physics that some knowledge of each is essential to the thorough understanding of the others. Such, moreover, would extend beyond the limits of a short essay like the present, in which, after offering some explanation of the meaning to be attached to one or two words employed by the Chinese to express certain subtle fluids or active principles supposed by them to exist in the human body, and to be necessary to its existence in the healthy living state, only a brief outline of their ideas respecting the uses and actions of some of the most important viscera, and their theories of Digestion, Circulation, and Secretion, &c., can be attempted.

Of these subtle fluids or active principles the most important are the Yin (陰) and Yang (陽), two powers which act reciprocally upon each other in opposition, and exist everywhere throughout the universe, maintaining the harmony of nature by their proper equilibrium, but immediately destroying it whenever the balance is lost.

In the human body, therefore, any excess or deficiency of either of them leads to serious results and becomes a fertile source of disease.

It is difficult to conceive a clear idea of the exact mutual relation existing between these two powers, which are said to have produced all things, though they are generally looked upon as a kind of male and female energy, as appears to be implied by the wonderful productive powers ascribed to them. It is probable, however, that these terms, when applied to the animal economy, might often be considered in a similar light, and perhaps with as clear an idea, as the words positive and negative in electricity, which have become so generally used of late years to explain any otherwise inexplicable phenomenon.* In both cases, the terms are used to express certain opposing forces, which only become known to us by their effects when either of them is in excess, but of whose existence we are not cognizant so long as the equilibrium is maintained. The Chinese represent the Yin and Yang by a variety of diagrams of which the most frequent is formed by describing a semicircle on the opposite side of each half of the diameter of a circle, so as to divide the circle into two equal portions, each having the form of a comma; one is then painted black, and the other red or white.†

The dark portion represents the Yin or female (negative?) which is considered the inferior or grosser of the two, and which, in its uncombined state, constitutes the Pih (魄) or animal spirit, residing in the Lungs.

The light or red portion of the circle is appropriated to the Yang or male (positive?), which is the pure, subtle, invisible matter, and which, when uncombined, constitutes the Hwan (魂) or human soul, and is believed by the Chinese to reside in the Liver.

After the Yin and Yang, the Ke (氣) or Air is next in importance. The word Ke usually implies air, vapour, breath, or the animal spirit, but must not be confounded with Fung (風), the external air or atmosphere. It is through the medium of the Ke that the various watery secretions are formed, and it is said to circulate along with

* It is not however intended to imply that the ancient Chinese were in any way acquainted with the science of Electricity, but simply to shew that when a Chinese speaks of Yin and Yang, the idea he has of them is similar to that which we frequently have when using the terms positive and negative. The Chinese certainly very readily comprehend the leading facts in electricity, when the words Yin and Yang are employed for negative and positive in explaining these phenomena to them.

† Other diagrams are more simple, *e. g.* a black circle surrounded by a red or white zone; or merely a circle divided into equal portions by its diameter.

the blood; not however mixed with it, but occupying the outer part of the interior of the blood-vessels, next the parieties,—the blood itself being in the centre of the tube, and immediately surrounded by a covering of the Ke.

With regard to the blood, the Chinese possess very little information, having no idea of the existence of the blood-globules, nor of the change which the venous blood undergoes in its passage through the Lungs. The following account of the blood by Dr Lew-tsung-how is a specimen of the most correct of their notions respecting this fluid:—

"The blood," he says, "is the essence of the food, and its changes are produced in the Spleen; it all passes through the Heart; the Tsang receive it from the Liver, after which it proceeds to the Lungs, and the watery portions flow out at the Kidneys. It flows throughout the whole body."

The following account of the circulation of the Blood is translated from the small set of anatomical plates before referred to:—

"The commencement of the circulation is from the Chung-Tsaou (or Middle Region) to the Tae-yin and Yang-ming blood-vessels of the Hand; from the Yang-ming of the Hand it proceeds to the Yang-ming and Tae-yin of the Foot; from the Tae-yin of the Foot to the Shaou-yin and Tae-yang of the Hand; from the Tae-yang of the Hand to the Tae-yang and Shaou-yin of the Foot; from the Shaou-yin of the Foot to the Shaou-yang in the middle of the Hand; and from the Shaou-yang of the Hand to the Shaou-yang and Keuĕ-yin of the Foot, from which it returns again to the Tae-yin of the Hand. The united length of these blood-vessels is 162 cubits. At one expiration the blood moves three inches, and at one inspiration it also moves three inches;—the expiration and inspiration together make one breath, and during the breath the blood moves six inches.

"During the day and night a man breathes altogether 13,500 times, and the blood moves 50 times round the body, or a distance of 8100 cubits, performed during 100 Keĕh of the Clepsydra. The Yang is incessantly moving at the rate of 25 revolutions, or a distance of 4050 cubits, and the Yin also makes 25 revolutions during the same period of time;—every half hour therefore the blood flows once round the body, or a length of 162 cubits."

Such a view of the course and rate of the circulation, taken in connection with the supposition that each internal organ has a Yin and Yang blood-vessel appropriated to its own use, and connected with corresponding vessels on the surface of the body, renders it almost a natural consequence that they should believe it possible to ascertain the condition of an internal organ merely by the indications of a pulse in some external part of the body:—though it is still difficult to conceive why they should suppose that an examination of three different points in the same blood-vessel of each wrist

should be capable of giving all the indications required. In each wrist the pulses are named, Inch, Bar, and Cubit, (the first being nearest the hand); and the following table exhibits their connection with various viscera, when examined by the physician with different degrees of pressure.

LEFT WRIST.

Inch	when lightly	pressed,	indicates	the state of	the Small Intestines.
,,	,, heavily	,,	,,	,,	Heart.
Bar	,, lightly	,,	,,	,,	Gall bladder.
,,	,, heavily	,,	,,	,,	Liver.
Cubit	,, lightly	,,	,,	,,	Urinary bladder.
,,	,, heavily	,,	,,	,,	Kidneys.

RIGHT WRIST.

Inch	when lightly	pressed,	indicates	the state of	the Large Intestines.
,,	,, heavily	,,	,,	,,	Lungs.
Bar	,, lightly	,,	,,	,,	Stomach.
,,	,, heavily	,,	,,	,,	Spleen.
Cubit	,, lightly	,,	,,	,,	San-tseaou.
,,	,, heavily	,,	,,	,,	Ming-mun.

This table also shews the sympathy which is supposed to exist between the several organs, as between the Small Intestines and Heart, between the Liver and the Gall bladder, between the Urinary bladder and the Kidneys, between the Large Intestines and the Lungs, between the Stomach and the Spleen, and between the San-tseaou and the Ming-mun.

Of the influence and functions of the Nerves, the Chinese have not the slightest idea, as might be expected when they cannot distinguish between Nerves and Tendons. The only use of the Brain appears to be that it has something to do with the elaboration of the Seminal fluid, and communicates with the Kidneys by means of the Spinal cord; the office of the latter however appears to be very subordinate, since it is said to be entirely governed by the Kidneys.

The Chinese know nothing of the Chemico-vital processes of Secretion; they suppose that all the Secretions are produced either by simple filtration or by the condensation of some vapour.

Of the process of Digestion their ideas are exceedingly crude and unsatisfactory. The food, after mastication, enters the Stomach along with the fluids, and after having been subjected to the triturating action of the Spleen and the application of the animal heat, the

Spirit and Essence again pass through the upper aperture* and ascend to the Spleen and Lungs, thence to be diffused throughout the various blood-vessels of the body. The more solid matters and the water pass downwards until they arrive at the Ilio-cæcal valve† where the water permeates into the bladder whilst the fæcal dregs are carried onwards through the Large Intestines.

The following examples of the very fanciful notions which the Chinese entertain regarding the functions and uses of the Viscera are taken from the "Golden Mirror":—

"The Spleen rubs against the stomach and grinds the food; it also keeps up the proper degree of heat in the 5 Tsang. It moves the muscles and the lips, and thus regulates the opening of the mouth; moreover, it directs our secret ideas, so that they become known to us.

"The Liver regulates the tendons, and ornaments the nails of the hands and feet.

"The Heart regulates the blood-vessels, beautifies the complexion, and by its means we are enabled to open the ears and move the tongue.

"The Kidneys govern the bones, beautify the hair of the head, and open the orifices of the 2 yin (anus and urethra.)

"The Diaphragm being spread out like a membrane beneath the heart, and intimately joined all round to the ribs and spine, it thus covers over the thick vapour so that the foul air cannot ascend."

The San-tseaou, are stated (in the Chung-tsang classic, as quoted in the "Golden Mirror") to be the essence of Man's three sources of Life; and Dr Haou says that the storehouse of the "Central pure principle" (the middle Tseaou), "is the supreme ruler of the 5 Tsang and 6 Foo, and preserves the vital principle in the blood-vessels, whether these be external or internal, right or left, upper or lower. The Three Tseaou, "he continues," penetrate everywhere, both internally and externally, to the right and left, upwards and downwards; they extend over the whole body like so many streams, harmonizing the interior, and taking care of the exterior, giving honour to the Left and nourishment to the Right, directing the upper parts, and rectifying the Lower; nothing therefore is more important than these."

The Ming-mun is made to perform a most important part during the act of Sexual Intercourse, and is thus described,—

"Waving the Heart's banner (*i. e.* rousing the animal passions) at once moves the "Door of Life" and this door taking in the breath of Life from the Three Tseaou, the seminal fluid follows the movement, and immediately flows out."

* And hence this, the Cardiac orifice, is called the Fun-mun or "Bubbling Door."
† And therefore called Lan-mun or "Obstructed Door."

As an appropriate conclusion to the above short account of Chinese Physiology, may be added the following brief summary translated from "A diagram of the Beautiful Temple of the Viscera," one of the four small anatomical plates before alluded to:—

"The Classics say that the Heart is the Prince and Ruler of the body, and the source of Life; the Lungs are the ministers from whom Laws and Government arise; the Liver is the Great General, and the originator of all Schemes and Stratagems; the Gall-Bladder is the Centre of Adjustment, whence we derive all just Decisions and the settling of Disputes; the Mediastinum is the Ministers' servant and the fountain of Joy and Happiness; the Spleen and Stomach are the keepers of the Storehouse, and the source of the Five Tastes; The Large Intestines are the Censors of our Actions, and produce the transformations of our food; the Small Intestines take charge of the superabundant food and perfect its changes; the Kidneys regulate our strength, and from them all clever and ingenious ideas emanate; the San-Tseaou (or Three Regions) influence the flowing streams, and are the source of the principles which regulate the watery secretions; the Urinary-bladder is the District Magistrate, it is the receptacle of the watery secretions, and its vapour being transformed, is then able to escape. These 12 King, or Rulers, acting reciprocally with each other, not one of them can be dispensed with."

ARTICLE IV.

CHINESE COPPER COINAGE.

NOTES ON THE TSIEN, OR COPPER CASH OF THE CHINESE: Extracted from a native publication, the *Ta-tsing Hwuy-tien*,* BY MR. C. B. HILLIER, and communicated by the President.—(Read before the ASIATIC SOCIETY, November 4th, 1847.)

THE following abstract contains the principal facts of interest mentioned in the paper:—

Tsién are coined exclusively at the Government mints, which are Nineteen in number, and distributed as follows,—two are attached to the Boards of Revenue and of Public Works, one in each of 14 provinces of China Proper, one in Thibet, one at Ele, and one in Hwuy-ching, for the coinage of the Poo-ne Tsién.

The exact amount of Tsién to be coined annually in each mint is fixed by regulation, except in Thibet, where the coinage is unlimited. The number of Tsién coined during the year at Canton, is 34,560,000, but should the year contain an intercalary month, then they cast 2,880,000 more.

大清會典

Each Tsién should be circular, four-fifths of a tsun in circumference, and have a square hole in the centre: it should bear as an inscription on the obverse, the words Tung-paou, (Current Coin,) with the designation of the reigning Emperor, all in the Chinese character; and on the reverse, the name of the mint at which it was coined, in Tartar characters, except in the Poo-ne Tsién, for which the Mahommedan character is used. In the Tsién of Thibet, we find on the obverse, the date of the coinage in addition to the words Tung-paou, and the designation of the reigning Emperor; whilst on the reverse, there are the words Paou-tsang, likewise surmounted by the designation of the reigning Emperor. In the mints of Thibet, Ele, and Hwuy-ching, the name Kién-loong may be impressed upon one-fifth of all the Tsién coined, in commemoration of that monarch's victories in those places.

The Tsién sent to Court for the Emperor's use, are called Yang Tsién, (Pattern Cash,) whilst those in common circulation are termed Che Tsién. Of Yang Tsién, 100 weigh a catty, but Che Tsién and Poo-ne Tsién weigh one-fourth less, or only 12 taels for the hundred. Thibetan Tsién are distinguished as Large or Small, and pass current according to their intrinsic value: 10 of the large or 20 of the small should weigh one Tael, and consequently the former are equal to one mace, and the latter to five candareens each.

The composition of the alloy of which Tsién are made, varies considerably; thus,—the alloy for Yang Tsién contains 6 copper and 4 zinc; for Che-Tsién 54 copper and 46 of lead, zinc, or tin, in various proportions.

In 7 of the 16 mints of China Proper, to every 54 catties of copper, is added 42 catties 12 taels of zinc, and 3 catties 4 taels of lead; but in the remaining 9, (including that of Canton,) to the same amount of copper is added 46 catties of zinc. In the mint at Ele, however, on account of the difficulty of procuring zinc, they add 29 catties of lead and one catty of tin to 70 catties of copper; whilst the Poo-ne Tsién are made of pure copper, and the Thibetan from silver.

Of all Che Tsién 1000 are called a Chuen, or String; of Poo-ne Tsién 100 are called a Tăng-kih, equal in value to a Chuen of Che Tsién; and of Thibetan Tsién, 9 large or 18 small ones are equal to one tael of silver. Throughout the whole of China Proper, the Government, in their receipts and payments, reckon one Chuen of Tsién equal to one tael of silver; but this rule

has an apparent exception in Yun-nan, where the soldiers are paid at the rate of 1200 Tsién to the Tael, as compensation for various items of their expenditure.

In Hwuy-ching the Poo-ne Tsién are reckoned at one Tăng-kĭh to a tael of silver, and in Thibet 9 large or 18 small Thibetan Tsién, equal 9 mace of silver.

Laws Against Forgers.

In the Chinese Legal Code, we find penalties provided for numerous grades of offences relative to the clipping and illicit coinage of Tsién. The following are specimens:—

Clipping Che-tsién.—Penalty on principal, immediate decapitation and forfeiture of goods; on accessories* before the fact, immediate strangulation.

Illicit Coining of Tsién.—When the furnace is constructed for the coinage of 10,000 Tsién and upwards, the penalty on principal and workmen is strangulation after detention in prison; on accessories before the fact, (including those who purchase for use or sale,) 100 blows, and transportation 3000 le to another province; penalty on proprietor of premises, responsible elder, &c. having knowledge of the fact and not informing, 80 blows, and transportation within the province for 2 years. When the furnace is constructed for the coinage of less than 10,000 Tsién, the penalty on the principal offender is transportation 4000 le to the frontier.

Penalty on the commander of a government vessel smuggling illicit Tsién, 100 blows and transportation within the province for three years; and a penalty of 80 blows on those on board who knowingly refrain from reporting.

The penalty on a father, brother, or uncle on the father's side, having lived in the same house, and knowingly shared the profits with a principal offender, (sentenced to decapitation or strangulation,) is one degree less severe than that on the principal.

The following are all the clauses relative to the uttering of counterfeit coin:—

Any broker, shopkeeper, or other person, who shall mix illicit with good Tsién, and proceed to utter the same, whatever the amount, shall be sent into slavery for life at a provincial garrison.

* The term *Accessory* includes responsible elders, proprietors of the premises in which the offence was committed, &c., should they have accepted bribes to screen the offender.

Any person who, having purchased clipped Tsién, shall mix them with good Tsién and resell them to the amount of 10,000 or more, shall be subject to the last-named punishment; but should the number be below 10,000, he shall merely receive 100 blows, and wear the cangue for one month.

ARTICLE V.

THE MINES IN CHINA.

ON THE MINES OF THE CHINESE EMPIRE: BY THE REV. C. GUTZLAFF, *Principal Chinese Secretary in the British Government in China*,—(Read before the Asiatic Society of China, July 6 and August 3, 1847.)

Of the Geology of this country we know little, and still less of the Mineralogy. So long as no free intercourse and open travelling to all parts of the empire are allowed, no satisfactory account of the treasures contained in the bowels of the numerous mountains, can ever be obtained. Foreigners have seldom had an opportunity of interesting themselves in the mineralogical resources of the Celestial Empire, until very recently, when some cogent reasons for the first time made them desirous to ascertain what amount of precious metals China was able to furnish. Mercury, which until very recently was always imported from foreign parts, became all at once an article of exportation. Coals were found, to our great astonishment, on the banks of the Yang-tsze, where we had believed them to be unknown. The northern parts of Formosa, and even Kwang-tung province, had furnished this article for centuries, without our being aware of its existence. But these matters might have passed into oblivion, if another cause had not roused the attention of the commercial community, whilst it filled the hearts of the Mandarins with dismay. Hitherto bullion, either in the shape of sycee, the produce of China, or in dollars, the hoards of the past from foreign importation, had generally been sufficient for the circulation. After the war, however, a great quantity disappeared as by magic, no one knew how, and the value of cash fell to the lowest possible rate, whilst many articles of foreign trade, had either to be bartered for Chinese goods, or payment in cash to be received, instead of the former ready exchange for silver.

The Government was greatly embarrassed by the scarcity of sycee, and considering it a positive evil, which required redress, or would

entail incalculable misery, various propositions were suggested to remedy the defect. Many discussions as to the causes which produced the great scarcity of the precious metal naturally arose. The opinions on such an important subject were much divided, and the measures adopted for counteracting the misery which had ensued were still more varied.

It is considered a sure proof of patriotism to insist that the scarcity of Sycee arises from the large exportation by foreigners, and hence the general outcry was repeated, as before in 1839, that the Barbarians were carrying all the Silver out of the country. As no one contradicted the assertion, it was set down as a matter of fact, and thus one reason given to account for the decrease of bullion. Still there were men who viewed the matter in quite a different light, and were not backward in giving vent to their opinions. The rigorous measures against Opium in 1839, put a stop for a time to trade throughout the whole empire. Men of substance were often denounced for having participated in the illicit traffic, and thus deprived of all their property. The consequence was, that every prudent individual who had capital at his disposal, withdrew and hid it, and the bankers ceased for a time to carry on business. The war followed immediately afterwards, property became insecure, profits were very uncertain, and by far the greater part of the circulating medium was buried under ground, to await a more auspicious moment. The most extensive holders of capital are people from Shan-se; they may be found in every city where trade is carried on, as the principal bankers, who command the money market. These persons stopped their operations almost to a man, and thus produced a scarcity of bullion; such as had not been felt since the accession of the present dynasty to the throne. The conclusion of peace did not restore confidence, because the people became clamorous, defied Government, and thus endangered the security of property. The more scanty the supply, however, the greater grew the demand, so that sycee rose rapidly in value, and the question with all parties naturally was, how to supply this urgent want.

Amongst the advisers there were some who suggested the opening of mines on a large scale. To this project very valid objections were made. "If,"—so reasoned its opponents,—"the ore is rich and yields much, people will neglect their acres and assemble in myriads at the mountains to obtain a fortune; instead of the anticipated riches, we shall have starvation, fearful contests for mines amongst the populace, and

a spirit of resistance against the constituted authorities. Whatever advantage therefore might accrue from these speculations, the injury following in their train would counterbalance it, and it is much better to avoid such a catastrophe." As this mode of thinking is according to old custom, the strongest argument in China, the plan was instantly laid aside. That which cannot be done legally, however, is suffered to go on by connivance, and such was the case in this instance. Many poor people joined together to search after metals, and though in various enterprizes their labour was vain, it has in others been richly repaid. They of course did not always hit upon Silver or Gold, yet often found Nickel, native Cinnabar, Mercury, &c., the very existence of which in China was previously doubtful. The scarcity of Silver therefore has given rise to much mining in a clandestine way. Those engaged in it must pay a fee to the local authorities, otherwise the laws against such undertakings would be put in force, and all labour lost. As the utmost secrecy is every where observed by all parties, it is difficult to make a calculation of the amount of property thus produced. There are however a number of mines acknowledged by Government, and under its direction, and of these we shall now speak in detail.

Such is the extent of the Chinese territory, that there are few productions of other countries which may not be met with in some part or other of it. This remark naturally includes the dependencies, which are integral parts of this huge empire. But before this can be practically proved, there must be greater freedom of intercourse, much travelling and zealous research, on the part of foreigners. The natives having once formally acknowledged that their ancestors arrived at the acmé of wisdom, do not feel inclined to institute an examination into the capacities of their soil, and the treasures of their mountains. Even if they entered on a scientific examination, they are too far behind in knowledge to profit materially from such observations. This applies with peculiar force to Geology, a science as such unknown in China, whilst Mineralogy is still in its infancy, and Mining is carried on in the most clumsy and expensive manner. To the western scholar therefore will fall the task of pointing out the inexhaustible resources beneath the surface of the earth. When once the mighty Kwăn-lun mountains have been measured, their branches traced as far as the Himalaya, their whole extent through Yun-nan and Sze-chuen ascertained, the highest peaks in Kwei-choo, the Switzerland of Asia, been viewed, and the mighty Teën-shan range followed

from Kan-sŭh to the Daurian mountains,—the results will be most extraordinary. To judge from the metals discovered accidentally, and obtained without much exertion, in those regions, there must be rich veins, of the very existence of which the Chinese have never dreamt, and which only a practised eye can point out to them. At present we have scarcely learnt the names of these ridges, the countries through which they run are almost unknown, and the subject is elucidated by a very short hint, that in such and such a place there are Copper, Lead, Silver, Gold, or Iron mines, without any specific details; the remainder we have to guess. The only existing account is a statistical enumeration of the principal mines, extremely meagre and unsatisfactory, and only comprising China Proper, without any of the dependencies. With this for our guide, and the relations of casual travellers, we have compiled the following pages. The little we know at present makes us desirous to enter more deeply into the subject at a future day, and if possible to draw aside the hitherto impenetrable veil which hangs over central Asia, and its gigantic mountains. Free permission to foreigners to examine every spot, would be the first step the Chinese ought to adopt in order to become acquainted with the productiveness of their own soil in all its bearings, and to collect treasure where general barrenness seemingly indicates nothing but absolute want, whilst hid in the depths from every common eye, there are riches of which Peru and Mexico might justly boast. The discoveries in the Ural mountains and in Siberia, with the occasional observations of some intelligent visitors of North-western China, and the productive mines of the Russians near the Chinese frontiers, amongst mountains in no way different from those which cross the dominions of the Emperor, warrant the entertainment of the most sanguine hopes.

If we traverse the Chinese dependencies, we find Thibet to be the land of Gold. The metal is collected from mines and from the beds of rivers, either in small particles amongst the sand, or attached to pieces of stone, or in lumps and in irregular veins. Mining is there very imperfectly understood, and the want of fuel as well as the rigorous climate greatly interfere with the process. The Gold mines belong exclusively to Government. If any adventurers wish to undertake the working of them, they must give security for paying 400 catties of pure bullion beforehand, whatever may be the success of their enterprise; and if they meet with solid masses, the Government comes in for another share. Rock-salt is found in great

abundance in the neighbourhood of L'hassa; Mercury and Cinnabar at Bathang. The most extensive Gold mines are at Tardzong and Lethang, and the proceeds are very large; at the latter place is likewise a Silver mine, of which, however, the produce is scanty. West of L'hassa and near Lun-chee are other mines of the precious metal. At the Dentsarga lake the Turquoise is found, in H'horungdszong and Ghiamelho the Lapis lazuli, (a stone highly prized in China, especially when shewing many gold veins) and in Rywulse there is an Iron mine.

The quantity of Gold produced must be very considerable, though the Government itself is perhaps not aware of the exact amount. This is proved by the quantity used in gilding idols, by the immense hoards of this metal, especially at the capital and in all the numerous temples, the treasures possessed by the Camasand nobles, the large sums amassed by the Chinese and Mantchoo officers residing there, and the amount annually exported by the Chinese caravans. We believe that the Dalai Llama has more of it than the Incas of Peru ever possessed, and that Thibet contains greater riches in bullion than Mexico. The predatory expeditions of the Eluth and Ghorkas sufficiently shew how large must have been the store, when such an immense booty as they carried away could be collected in an instant. The inhabitants, however, are extremely tenacious of this valuable commodity, and will rather suffer extreme want than part with it. Hence they are poor and wretched amidst all their riches, and bullion loses its value to the possessor by being kept from circulation.

If we proceed south-westward we discover several Silver mines in the disputed mountainous territory between Birmah and China. The produce was sufficient to attract the cupidity of the Chinese Government, and the celebrated Emperor Keën-lung twice waged an unsuccessful war, with immense loss of life and treasure, to possess himself of these rich regions. Though they were politically never gained, the Chinese obtained them by dint of perseverance, greater enterprize, skill, and capital, than either the Birmahs or Laos, the natives of the soil, could shew. They are worked, up to the present moment, with the utmost secrecy, so that notwithstanding very minute inquiries, no one has ever been able to elicit the least information. Thus far we know for certain, that the pure Silver obtained there amounts to something very considerable. Government has given up the superintendence, but extorts large sums from the miners as well as from the traders.

In the north-western parts of Tunkin, bordering on Yun-nan and Kwang-se, there exist rich Silver mines, said to produce 213,600 taels on an average per annum. This same ridge contains others belonging to the Chinese, and under the control of the Mandarins on the boundaries, which are said to yield annually from 300,000 to 400,000 taels. The cost of mining, however, appears to be very great, so as not to leave much profit. When we consider that the Chinese are not acquainted with even the most simple machinery for pumping out water, and that all is done by human hands, without much contrivance to facilitate the labour, it will be evident that the outlay must be very considerable, and that deep mines cannot be worked at all.

In Eastern Turkestan the celebrated Jade stone, so highly prized by the Chinese, is found. It is discovered in its greatest beauty in the Khoten river (Hoteën in Chinese) in Lat. 37°. This flows from the Karanguy-tuk, a ridge connected with the Kwănlun mountains. About 30 expert divers in one squad under the command of a Mandarin, try when the water is lowest in summer, to discover these stones, and the moment one is brought up, the gong is struck and a red sign made to aid in the computation of the produce. The smallest stones are about the size of a chestnut, but some of 300 to 400 catties have been met with, though very rarely. The colours vary from snow white to green and yellow; black and reddish ones are very rare, and are therefore the more prized. Latterly some were discovered on the Mirdshai mountain 16½ geographical miles south-east from Yarkand. They are of a much coarser description, and difficult to detach from the rock. To effect this the miners make a large fire and cover it over with sods, whereby the stone becomes brittle, and is easily cut off.

The immense pains taken to procure this stone, the sums expended to cut it with infinite trouble into ornaments of every description, and the large consumption of it throughout China, sufficiently prove its fictitious value. The fair one boasts with pride of an armlet and bracelet made of this substance; men do not disdain to wear what ought to be exclusively woman's gear, and form various other ornaments for use and show; but principally thumb-rings for use in archery, and seals. The highest personages procure the Jade in various forms, and the Emperor adorns his palace with large pieces in the shape of sceptres, the emblems of peace and plenty, skilfully cased in wood, with various engravings, amongst others a beautiful flower. This

latter is put on the table as an object of curiosity, and a proof of the wealth of the owner.

The Chinese ascribe to it much miraculous power, in preserving the wearer from sickness and injury; and the Jade is moreover the emblem of moral virtues, such as mildness, firmness, constancy, and other sterling qualities; so that the possessor of this gem is benefited in various ways, and at the same time guided on the road to perfection. Our high-born European dames would sooner dispense with their Diamonds and Pearls, than a Chinese lady with her Jade, though the value is far less. The constant demand and high price have given rise to many imitations, in which the Chinese are not behind any nation. Though it is an imperial monopoly, much is smuggled by private individuals, and sold to advantage. The number of men whom the mere cutting employs, is almost incredible, and first rate ornaments require years of incessant labour to bring them to perfection. It is however in works of untiring plodding, that Chinese workmen most excel.

Turkestan furnishes other stones, in our estimation far more valuable than the above, but little in demand in China. In the Ele river some Gold-dust is found, in which the Buchorians pay their tribute. In the neighbourhood of Kou-chay we find the Pth-shan, a very remarkable volcano, and the natives obtain there a considerable quantity of Sal ammoniac, Saltpetre, Sulphur, and some Copper; the tribute was once paid in the first named commodity. The mountains of Khongor, two hours East of Ele, abound in Coals and Iron. Copper is also found near Yarkand, but we nowhere discover any traces of Silver.

On the north-western frontiers in the Khirgis steppes, the Russians most advantageously obtain Copper, Silver, and Lead from the mountains. The same chain stretches out to the Chinese frontiers, and the geological nature of the ridge does not differ; but no efforts have yet been made by the inhabitants to imitate their neighbours in gaining those subterranean riches. There are some mineral sulphuric fountains, in very high repute for their medical qualities, and visited by thousands afflicted with scrofulous and cutaneous diseases.

The Mongolian steppes cannot boast of much mineral wealth. The Agates and Pebbles found in Kobi, are of the most beautiful description. Here and there is also a stratum of Coal, of which the inhabitants of the extensive deserts, on account of the rigorous climate,

stand very much in need. Yet they are not fond of working the mines. On the Tro river some Iron ore is found, and not far from Urga are Sulphuric mineral fountains. The river of Argun furnishes Jasper and Carneols. In the eastern part of the Dourian mountains we meet with beautiful Beryl crystals, and other stones, which however are not much esteemed by the natives. Here, as well as in the Russian part of these regions, are many traces of mines formerly extensively worked by a race known under the name of Chuden, now long extinct. It does not appear that they exhausted all the mineral treasures, for up to this moment the Russians work several flourishing Silver mines at Nerchinsk and near the Shilka. The want of fuel and the severity of the climate, as well as the scanty population, prevent the extension of mining enterprize. On the Chinese frontiers nothing at all is undertaken, although many circumstances are there far more favourable than in the former country. The mountains around the Argun contain Copper ore.

We do not remember ever having heard of any metals being found in Mantchouria, although so large a country cannot be entirely destitute of such treasures. The neighbouring Korea produces Gold, Silver, Iron, Salt, Crystal, and Coal, but in very small quantities.

The mountainous surface of Turfan has many still undiscovered riches, but centuries are likely to elapse before these can be rendered available for the use of man. The inhabitants seek Gold-dust in the sand of their rivers, the produce is however very trifling.

We have thus taken a cursory view of the mineral wealth of the Chinese dependencies, and shall now turn our attention to that of

CHINA PROPER.

Gold Mines.

From the most ancient times, the Chinese considered Sŭh-chow as the key to the north-western boundaries in the direction of the desert of Kobi, (Lat. 39° 45′ 49,″ long 99° 7′ East;) and Se-ning as the principal pass towards Turfan, (Lat. 36° 39′ 20,″ Long. 100° 48′ East.) The intervening space between these two places was therefore by the Mantchoos incorporated with the Empire though running far into the steppes, and inhabited by foreigners. The country is known under the names of Bar-koul (Se-chin) and Oroum-tse

(Teih-hwa); the latter is a most remarkable spot. There is at Burga Bulak-tae, on the western confines, an abyss about 13½ geographical miles in circumference, covered with hot ashes, and a crust of sulphur and salt. So pestiferous are its exhalations, that not a bird can fly over it without falling into the crater, nor any human being or animal approach it with impunity. Not far from Teih-hwa are the celebrated productive mountains that yield a large quantity of Gold. They are situated in Suy-hae district, some also in the barbarous regions of Urkitla and Usoo, and are worked to a considerably extent by the natives. Over fifty of them Government appoints a head-man, who becomes responsible for the payment of 3 per cent of the pure metal to Government. All the proceeds must be cast into bars by certain shroffs, who affix their stamp to them, to attest the purity. Ingots that have not received this mark, are liable to confiscation. To prevent smuggling, Government has appointed military posts near all the mines. The Gold is paid into the hands of inspectors, who must keep a very accurate account, and forward it to the capital as often as a Mandarin of high degree proceeds to Peking. The average annual amount is not stated, for the bullion is paid into the Emperor's exchequer, and not carried to public account. The works are very extensive, and above 30,000 miners are constantly employed.

There are other mines in Tun-huang district. Government does not allow above 2,000 men to work them, and appoints overseers to control the miners, and to take care that the 3 per cent be properly paid into the treasury. The very minute regulations regarding the mining operations, sufficiently prove that smuggling is extensive, and the number of persons employed perhaps three times that allowed by law. All the proceeds of the revenue are paid into the hands of the administrators of the Imperial treasury.

In one of the most desert parts of Shen-se province, on the northern frontiers at the Ho-poo-tă and Ha-la mountains, much Gold-dust is found. Government does not interfere in this enterprize, but exacts a security from the head-man of every 50 mines, to pay regularly of every tael of pure gold, 23 per cent into the public treasury, and 3 per cent additional for contingencies. Though some of these exactions are regularly discharged, a great part of the precious metal, which is obtained by uncommon dexterity, is smuggled and privately sold.

The real Gold land in China, is Yun-nan province. The Yang-tsze-keang, which flows through its territory, has the name of Kin-sha-keang, or Gold-sand river, and the natives employed in washing amount to several hundred thousands. Government, in order to levy the tax, has divided the river into small districts, each of which pays a monthly rent of one mace in gold, and 7 taels 2 mace 6 candareens per annum, as a fee. The works are principally at Yang-plh, a district in the north-west, inhabited by aboriginal tribes, the most persevering workers of the mines under the direction of the Chinese. As the exactions on the part of Government are by no means heavy, the enterprize thrives, and the labour is remunerating.

The mines at Ho-king (Lat. 26° 32′, Long. 100° 22′ East), Plh-ya, and Poo-tsaou, are celebrated for their productiveness. Government grants licenses to master miners, for which they pay every month 2 mace and 5 candareens in gold, with an annual rent of 7 taels 2 candareens, and during an intercalary year, 1 tael and 2 candareens in addition. The large number of people employed here proves the importance of these mines.

In the south-western part of this province, on the frontiers of Cochin China, in the district of Kae-hwa, the famous Gold mines of Ma-koo are situated, and not far from them those of Man-so. They are entirely in the possession of hardy mountaineers, who pay a trifling tax to the Chinese Government. The ore is found amongst the most frightful mountains, inaccessible to every one except the natives, who with the agility of a chamois, ascend the highest cliffs, and rarely miss their footing.

Richer than any of the above, are those in Kwei-choo province, at King-she, within the Sze-nan district, on the frontries of Sze-chuen, a region inhabited by Meaou-tze tribes. They pay 40 per cent of the net produce, and 3 per cent for fees. The Gold obtained, here is of the best description,but to get at it great dangers must be encountered, and the privations of the miners in their perilous pursuit exceed all belief. The mountaineers are the more numerous workmen. The country around is destitute of nearly every other production; so that the people are extremely poor, in the midst of the most gorgeous riches.

Such are the principal Gold mines in China. There are many smaller ones in Sze-chuen and Yun-nan, as well as in other provinces, worked secretly, often to a large extent, but of which no accounts are kept.

Silver Mines.

The most productive are found in Sze-chuen, amongst frightful mountains in Yen-yuen (Lat. 27° 20′, Long 101° 32′.) We shall here enumerate the principal places. Kea-tsze-kwa, Peaou-tsze-kow, Keen-chung-chin, Sha-kow, Ning-fan-ying, and Koo-peĕt, with many other localities. The ore is found in conjunction with Copper, and the miners pay 25½ per cent of the net produce to Government. The best Sycee is obtained here. If the melters understood better how to extract the Silver from the mixed ore, the gain would be far more considerable, but in this art the most experienced are mere children compared with our metallurgists. Most of the mines are situated on the south-western frontiers, bordering on Yun-nan, not far from the Golden-sand river (Kin-sha-keang.)

The Silver mines of the latter province are very numerous. The She-heën mines in Tang-chuen district (Lat. 26° 02′, Long. 150° 15′ E.) situated on the same ridge of mountains as the former, are so rich as to be able to pay to Government each an annual rent of above 1,302 taels, and every intercalary year 106 taels more. At the already mentioned Poo-tsaou, each pays 421 taels, and the Silver mines there are far more celebrated than the Gold mines, employing four times the number of miners. Those at Mat-sĕo-te in Kae-hwa yield each 706 taels per annum to the Mandarins; those towards the frontiers of Birmah, such as Koo-hĕo and others, 567 taels. The assemblage of poor people in these otherwise sterile regions, is very great, and they work for small wages, and can scarcely procure the necessaries of life. The regions all around are moreover very unhealthy, so that many die of disease. So great however is the love of gain, that they hasten together from all quarters to drag out a miserable existence in search of Silver. Farther south at Sze-kih-la, on the frontiers of Tun-kin each mine delivers annually 60 taels to the overseers. These are situated in Nan-gan-chow (Lat. 24° 54′, Long. 101° 41′,) as well as those of Malung; the Government levies there about 22 per cent on the ore, as it is brought out of the mine, for it is very rich, and the miners are in this manner prevented from circumventing the Mandarins; thus they obtain about 698 taels

per annum on an average from each mine. At the still more productive mines in Tsoo-yung, (Lat. 25° 06′, Long. 101° 43′ 10″) at Yung-ching, the Mandarins take one-third of the ore, and realize on each about 3,375 taels per annum. These are situated in the centre of the province, and have been worked for several centuries. The heavy exactions however upon this perilous labour, have in some measure checked enterprize, otherwise the mines would have become more celebrated than those of Potosi. The superintendents are responsible for the payment of a certain sum into the Imperial treasury; and before entering on their office give a security to that effect, so that Government is always secure of its revenue. The sums derived from this quarter are very considerable, but the total amount per annum is kept a profound secret. There are in Nan-gan the Shïh-yang mines, which pay 20 per cent in direct duty and an additional 10 per cent on the pure silver. In Mung-tsze district (Lat. 23° 34′, Long. 103° 36′ 10″ E.) in the southern parts of the Province, there are the Ko-kew mines, and several others bearing names derived from the Laos language. In Keïn-shwuy are the Muh-hih mines. Towards the southern frontiers of Sze-chuen, in Chaou-tung (Lat. 27° 20′, Long. 103° 5′) we find the Lŏ-ma and San-taou-kaou mines, which pay 18 per cent on the silver produced, including all duties. In Yung-chang district, on the frontiers of Birmah, in a country inhabited by Laos tribes (Lat. 25° 04′ 40″, Long. 99° 25′ 55″) there are the Măng-leën mines, for each of which the native authorities pay 300 taels per annum. They are much worked and yield a large profit, notwithstanding the clumsy apparatus of the miners.

Not far from the banks of the Kin-sha, in Le-keang (Lat. 26° 51′ 36″, Long. 100° 27′ 20″) there are some very celebrated Silver mines at Hwuy-lung, which pay 18 per cent to Government. Being situated in a very populous region, they are most diligently worked. There are others at Hung-ma in Shun-ning district (Lat. 24° 38′, Long. 100° 08′ E.) which pay annually each about 800 taels to Government.

About 15 of the above mines pay a stipulated sum of 24,114 taels to Government, others from 8,000 to 25,000 taels per annum. The whole annual produce of Silver throughout Yun-nan is not below 5,000,000, and some of the regions along the Kin-sha and Tun-kin frontier, vie with the most favoured spots in Mexico and Peru in abundance.

Kwei-choo (the rich district) has many considerable Silver mines, of which the Cha-tsze and Choo-hwang-tang in Wei-ning (Lat. 26° 43′, Long. 104° 15′ East) are the most productive, paying 40 per cent to Government. The tracts where the ore is found are fully as uninhabitable as those of Peru, being almost all situated between snow and ice, with a very scanty vegetation, so that the necessaries of life are very dear.

There are some mines in Kwang-se province, in Ho-che district, (Lat. 24° 42′, Long. 107° 43′ 10″ E.) at Nan-tan, which pay 18 per cent on the net produce. At Kwa-hung the Mandarins receive for each picul of ore 3 taels, whilst they levy, on the very productive mines at Tsaou-muh in Fun-ho district, 24 per cent. These mines are worked with very great diligence, and well repay the labour.

Our readers are perhaps not aware, that there are several Silver mines in Kwang-tung province, but by no means to be compared with the foregoing. It shews the caution and secrecy with which the work is carried on, for even the natives are scarcely aware of their existence. In most the Silver ore is found mixed with Lead, and pays 55 per cent duty, the highest which is any where raised on similar works, no doubt with the view of preventing a turbulent population from engaging too largely in mining speculations. We shall enumerate the principal ones, without being able to give the annual amount, of which no accounts are kept even by Government. We find them at Shan-jin in Chin-ping district (Lat. 24° 29′, at Le-shoo-wan in Fung-shun, at Ta-ho in Ta-poo (Lat. 24° 40′, Long. 116° 43′ E.) and at Tsang-che-lin and Ta-wan. Last year other mines of a very productive nature were discovered in the direction of Tun-kin in Lo-ting district. Notwithstanding all our inquiries, we have never been able to ascertain the particulars. Government has most extensively profited by the opening of them, and they are worked at present with considerable vigour.

From the above it would appear, that most of the mines are along a chain of mountains, between 27 and 24 degrees of latitude, which stands in immediate connection with the mighty Kwăn-lun ridge, and runs in a south-easterly direction through three provinces, till it reaches the sea-shore. If geologists were allowed to travel in China, this might be a valuable hint for instituting more extensive researches. We have never heard of any veins immediately to the north of the Yang-tsze, and which, if they exist, are not yet discovered.

Respecting other mines we may be very brief.

Iron Mines.

It would be tiresome to enumerate all the places where this useful metal is found, which seems to be spread throughout the whole empire, and we therefore merely mention the principal spots.

There are very large iron works in Keang-se, in Yew-heen, and Chang-ning. Each of the furnaces established there melts about 1200 catties iron every day, and pays to Government 2 taels and 4 mace per diem.

In Ché-keang large quantities are found at Yun-ho. Sun-yung, for the melting of Iron ore, which is procurable without much labour, pays to Government 1 tael and 6 candareens, or even less, with various perquisites to the superintendents.

Fo-keën produces a large amount. In Sha-heen every furnace pays 28 taels 660 per annum. This is also the case at Yung-gan; whilst in Yew-ke a duty of 43 taels is levied. There are furnaces in many other districts, most of which pay only 11 taels per annum to the mandarins. Fo-keën, which to our knowledge possesses no other metal, is very rich in Iron, and exports a great quantity both of wrought and cast metal.

In Hoo-kwang, where likewise a few Iron works are found, the Mandarins take one-fifth of the produce.

The largest Iron works in Kwang-tung are at Fŭh-shan, (Fut-san) the Birmingham of China. The ore is most extensively found in more than twenty different districts, of which we mention only Tsing-yuen, Tsung-kwa, Lung-mun, Lŭh-fung, &c. We suppose that this province is richer in this respect than any other in the Empire. It uses however, the whole of the raw material for home consumption, and moreover imports a very considerable quantity from Kwang-se to supply its manufacturers, who excel in making all kinds of utensils of cast iron, and trade in them to other provinces very largely. Iron is found in the latter provinces at Yung-fŭh, Lin-kwei, and other places. The duty on its production is very trifling, each furnace only paying 10 taels per annum.

Another province which abounds in Iron is Sze-chuen, where it is found at Ping-woo, Chaou-yang, Hung-ya, and many other places. According to the returns of Government 74,900 catties of ore give 21,870 of pure Iron, of which the Mandarins take 20 per cent. At other places, the superintendents insist upon the payment of 33 per cent; but it is also less at other mines.

Shen-se provides the North with Iron, the regulations respecting mining are however not so onerous as in Sze-chuen, where the production is as much as possible circumscribed by Government, lest the mountaineers should obtain it in large quantities and forge arms. No one is permitted to engage, without express permission from Government, either in melting or trading in this article.

Yun-nan, so rich in other metals, has likewise considerable Iron-works at Lŭh-king, Tăng-yuĕ, and other districts. The duty exacted from this branch of industry is very considerable; but is moderate if compared with other parts of China. There are furnaces at Ketăng, at Yŭe-chou, Ho-sin, &c.: whether Iron works are more advantageous than Silver mines, we have not been able to ascertain. Each melting establishment pays annually from 8 to 10 taels to Government; did they prove very lucrative, the Mandarins would not fail to levy a higher rate of perquisites.

Copper Mines.

Yun-nan is richest in Copper. The mines, however, are not worked as others by private adventurers, but on account of Government, which pays at a certain very low rate for the pure produce. China wants an immense quantity of base coin or cash for circulation, and to ensure a sufficient amount of metal for casting it, Government monopolized the Copper mines. Whether this policy is not very questionable, and instead of bringing advantage to the treasury, entails a real loss, we shall not at present discuss. The best Copper is found in the greatest abundance towards the Birmah frontiers, at Wei-ning, Tang-tan, Ta-shwy, Lŭh-lŭh, Ta-kung, and Ning-tae, as well as other places. Many mines are exhausted at the present moment, and yield a very sparing supply to immense labour. There are two large issues, whence the transport of Copper proceeds to the capital. The one comes in an easterly direction to the Yang-tsze, and consists of 63,334, piculs; the other, sent on a small river westward, amounts to abo t 60,000 piculs, and joins the other on the great stream of China. It requires about 17 months to go to Peking and return to the mines. The expenses during so tedious an inland passage are very heavy, and the article is nearly doubled in cost on arriving at the capital, whilst much is lost in passing the rapids of the upper Yang-tsze and traversing other dangerous places. Arrived at the mint, a quantity sufficient for the coinage of the year is retained, and the remainder sold. It

fetches a far higher price than the foreign Copper sold at Canton, and like the Japanese, contains a small quantity of Gold, which the Chinese do not understand the mode of extracting.

There are smaller mines worked by private individuals, but they are few and unproductive, and the Government, when in want of the materials for issuing cash, does not scruple to seize upon the whole store. What is found in the other provinces is very trifling, and to make up the deficiency in the various provinces, China is obliged to purchase annually large cargoes in Japan.

Tutenague is met with in Kwei-choo at Sëen-hwa, Fuh-chih, Ma-koo, and other places, and is likewise sent for the same purpose to the court. We do not know the exact amount of the produce; but private individuals are allowed to trade in it. In respect to Lead, which is met with in the same province, and likewise in Hoo-nan, the same restrictions exist, and as it is a very bulky article, the cost of transport is very considerable.

Quicksilver and Native Cinnabar Mines.

These have latterly risen to very great importance, and are likely to lead to considerable results.

Native Cinnabar is found in Yun-nan, Yung-ping district, at Sele, and San-taou-kow, where it pays 10 per cent. In Kwei-choo, (Hinge district,) at Po-yaou, and Pan-keae, it pays, with the Orpiment found there, 20 per cent; in Kwang-se at various places the duty is the same.

The most extensive Quicksilver mines are in Sze-chuen in Se-chang district, and in Kwei-ning-yuen. The Government expressly appoints officers to prevent more than 8000 catties being taken from the bowels of the earth, and the duty levied is 30 per cent. The consequence is extensive bribery, and the working of the mines to a greater extent than if they were free.

Equal to these in importance are those at Hinge and many places in Kwei-choo province, which pay the same duty. The produce is at least ten times more than the above mentioned stipulated amount. Private dealers may without any restriction work these mines.

The reader is perhaps aware that Arsenic is frequently found, as also Nickel, but of the mines I can give no account. Had the metallurgy of this country a mere theoretical importance, it would be worth the trouble of bestowing on it the pains of investigation.

It has however a practical tendency, which is daily more and more acknowledged, and a visit of an intelligent geologist to Kwang-se, Yun-nan, Sze-chuen, and Turfan, would greatly benefit the Chinese themselves. Before this is undertaken, we cannot expect that the produce of the mines will materially increase. It is perhaps difficult to say how many years will still elapse before such permission can be obtained, but the first scientific researches of this kind, we shall hail as a new era in the trade and circulating medium of this country. The real interests of the nation and commerce at large would urge such an examination, which carries with it no loss, but would ensure essential advantages.

JOURNAL OF PROCEEDINGS.

A desire had long existed among some of the foreign residents for the establishment of a society for the investigation and discussion of matters relating to the Arts, Sciences, Literature, Natural Productions, &c. of China, and as the number of members of a scientific body called the "China Medico-Chirurgical Society" had been gradually diminishing so as to render it difficult to obtain any meetings except at irregular and frequently long intervals, several of its members, after some discussion and frequent private conversation on the subject, agreed to call a public meeting for the establishment of a new society on a more extended footing.

In accordance with these views, and in pursuance of resolutions adopted at a preliminary meeting held on the 5th of January 1847, at which were present Drs Balfour, Young, Barton, Dill, Harland, Bankier, Grant, and Fletcher, and Messrs Bowring, Shortrede, Watkins, Stuart, Mercer, Burn, and Bevan, the "Philosophical Society of China" was founded, and a deputation, consisting of Drs Young, Dill, and Harland, was appointed to wait upon His Excellency the Governor to request him to become Patron of the Society.

The following gentlemen were nominated Office-Bearers :—

President,
Major H. P. Burn, Esq.

Vice-presidents,
Dr Kennedy, Dr Balfour.

Council,
A. Shortrede, Esq., Dr Harland,
J. C. Bowring, Esq., Dr Barton.

General Secretary,
W. F. Bevan, Esq.

Treasurer,
Dr Young.

Curator,
C. T. Watkins, Esq.

JANUARY 11th, 1847.

Honourable C. M. Campbell, Esq. in the chair.

A report from the gentlemen who had been deputed to wait upon the Governor was handed in, to the effect that His Excellency acceded to the resolution adopted at the previous meeting, and proffered every assistance in

his power towards furthering the objects of the Society. His Excellency also intimated that he had repeatedly received communications from Lord Auckland, President of the "Royal Asiatic Society," expressing his desire for the establishment of a branch of that Society in China, and suggested that the present might be a favourable opportunity for carrying out Lord Auckland's views. After some remarks on the report just read, and on the altered prospects of the Society, the following resolution was submitted by Mr Shortrede, and unanimously agreed to—"That the proceedings of the meeting of the 'Philosophical Society of China,' held on the 5th instant, in so far as they had reference to the constitution of the Society and the nomination of office-bearers, be rescinded; and that a Committee be now appointed for the purpose of drawing up laws for the interim regulation of the affairs of the Society, and preparing a list of gentlemen to be recommended as Office-bearers—the Committee to report on Monday the 18th instant at half-past four o'clock."

The following gentlemen were named as the Committee,—Major Burn, Colonel Brereton, Mr C. J. F. Stuart, Mr J. Stewart, Captain J. Clark Kennedy, Dr Balfour, Dr Young, Dr Harland, Mr Campbell, Mr Bowring, Mr Melville, Mr Bevan, Mr Wade, Dr Kinnis, the Rev. Mr Stanton, Mr Mercer, and Mr Shortrede,—five to form a *quorum*.

After some discussion it was resolved that all gentlemen who had attended any of the meetings before the laws were passed and the Office-bearers elected, should be considered members of the Society on their signing their names on the list of members.

A list was then sent round for signature, when all who had previously attended —with two exceptions—together with the following, signified their desire to become members of the Society :—

The Honourable C. M. Campbell, Mr Charles St G. Cleverly, Mr A. Scott, Mr A. Melville, Dr Kinnis, Captain J. Clark Kennedy, the Rev. Mr Steedman, Mr A. Bird, Rev. V. Stanton, Mr D. Scryngeour, Mr R. Strachan, and Mr G. Strachan. To these were added Mr R. J. Gilman, Mr C. F. Still, the Honourable J. W. Hulme, Mr Cairns, Mr J. Stewart, and Colonel Brereton.

JANUARY 19TH, 1847.

Lieut.-Colonel Brereton in the chair.

The Committee appointed at the last meeting for the purpose of framing laws and selecting Office-bearers, for the approval of the members of the Society, handed in their report, to the following effect,—

The first subject to be taken into consideration was the name to be given to the Society, and after some discussion, it was agreed to recommend that it should be called "The Asiatic Society of China." In order to facilitate the further operations of the Committee it was divided into two sub-committees, the one to select Office-bearers, and the other to frame the Laws of the Society, and their respectiver eports were received and considered by the General Committee on the 18th instant.

The Chairman then read to the meeting the proposed Laws and list of Office-bearers as follows, which were confirmed by the Society :—

LAWS OF THE ASIATIC SOCIETY OF CHINA.

Adopted at a General Meeting of the Society held at Hongkong, on Tuesday, January 19, 1847.

I.—The ASIATIC SOCIETY OF CHINA is instituted for the investigation of Arts, Sciences, and Literature in relation to China.

II.—The Society shall consist of Resident, Honorary, and Corresponding Members.

III.—Members residing in any part of China shall be considered *Resident*.

IV.—Eminent individuals, and persons who may contribute to the objects of the Society in a distinguished manner, are to be eligible as *Honorary* Members.

V.—Persons resident in China may, upon special grounds, and with the recommendation of the Council, be elected *Corresponding* Members.

VI.—Honorary and Corresponding Members are to be admitted to all the privileges of the Society, but are not to vote at its Meetings, or be elected to any of its Offices, or take part in its Private Business.

VII.—All Members, whether Resident, Honorary, or Corresponding, shall be elected by Ballot. A Candidate for Resident Membership must be proposed and seconded at a General Meeting of the Society, but shall not be balloted for until the next succeeding General Meeting. Honorary and Corresponding Members, if approved of by the Council, may be admitted during the Meeting at which they are proposed and seconded.

VIII.—No Candidate shall be elected unless he has in his favour Three-fourths of the Members voting.

IX.—Every Member, on his Election being intimated to him, shall signify his adherence to the Laws of the Society by inserting his Name in a Book to be kept for the purpose, or, if absent, intimating his readiness to do so by Letter addressed to the Secretary.

X.—The Office-bearers of the Society shall form the Council, and shall consist of,—A President; Four Vice-Presidents; Six Councillors; Three Secretaries,—General, Corresponding, and Chinese and Foreign; A Treasurer; and a Curator; who together shall have the Direction of the affairs of the Society.

XI.—The Office-bearers shall be elected Annually at the Anniversary Meeting in January, and the two Senior Vice-Presidents, and three Senior Councillors, shall be ineligible for immediate re-election to the same Offices.

XII.—Three shall form a Quorum of the Council, and Five of a General Meeting.

XIII.—The Functions of the Office-bearers shall be as follows :—

1. The President shall preside at the Meetings of the Society and of the Council, keep order, state and put Questions, and cause the Laws of the Society to be enforced.

2. One of the Vice-Presidents shall, in the absence of the President, exercise all the Functions of his Office.

3. The *General Secretary* shall arrange and attend the Meetings of the Society and of the Council, and record their Proceedings, and shall exercise a General Superintendence under authority of the Council.—The *Corresponding Secretary* shall conduct the Correspondence of the Society, and obtain for Members all requisite information on subjects relating to the objects of the Society.—The *Chinese and Foreign Secretary* shall be Interpreter to the Society, and conduct the requisite intercourse with China and Foreign countries. The Secretaries shall together superintend the Printing and Publishing of the Transactions of the Society. In the absence of one of the Secretaries, either of the others may act for him; and in the event of all being absent, the Council shall appoint a Substitute.

4. The Treasurer shall receive and pay out all Moneys on behalf of the Society, keep an Account thereof for the satisfaction of the Council, and submit a Statement of the Pecuniary Affairs of the Society to the Anniversary Meeting.

5. The Curator shall have charge of the Museum, arrange the Specimens, and preserve the Preparations and Donations; and, in the meantime, he will be called upon to take charge of the Library, keeping a List of the Books, giving them out to Members in the manner directed by the Council, and seeing that they are returned in proper time and in good condition.

XIV.—Each Resident Member shall pay to the Funds of the Society on Admission a Fee of Ten Dollars, and an Annual Contribution of Twelve Dollars, unless he is elected between the 1st of July and the Anniversary Meeting in January, in which case Half the Annual Subscription only will be payable for that Year.

XV.—Honorary and Corresponding Members may be admitted without paying any Entrance Fee or Annual Subscription.

XVI.—Resident Members, upon giving Notice in writing of their intended Departure from China, shall, on the recommendation of the Council, be placed on the List of Honorary or Corresponding Members; and in the event of their return to China, may be replaced by the Council on the List of Resident Members.

XVII.—The General Meetings of the Society shall be held on the First Tuesday of every Month, and at such other times as may be resolved on, and duly notified to Members.

XVIII.—The course of Business at the General Meetings shall be as follows, (the first three Sections comprising the Private Business):—

1. The Minutes of the preceding Meeting shall be read, and signed by the President, or whoever shall in his absence occupy the Chair.
2. Any specific or particular Business which the Council may have appointed for the consideration of the Meeting shall be proceeded with.
3. Candidates duly proposed and seconded at a previous Meeting shall be balloted for, and new Members may be nominated.
4. Donations shall be laid before the Meeting.
5. Titles of Papers for consideration of next Meeting shall be announced.
6. Papers and Communications shall be read and discussed.

XIX.—Strangers on a visit to China may be admitted to the Sittings of the Society, but shall not be present during the Transaction of its Private Business. They may be proposed in writing by any Member, and the Question being put from the Chair and carried, they shall be introduced.

XX.—Communications and Papers read to the Society may be printed by Order of the Council, and at the Expense of the Society, under the Title of *Transactions of the Asiatic Society of China*.

XXI.—Every Resident Member of the Society shall be entitled to a Copy of any Paper so published, subsequent to his election, and the Council shall have authority to present Copies to other Societies and distinguished Individuals.

XXII.—General Meetings and the Council of the Society shall each have power to pass Bye-Laws for the Regulation of their respective business.

XXIII.—The Council shall have power to fill up any Vacancies that may occur during the Year.

XXIV.—The Laws of the Society shall not be altered unless upon a Notice given by Two Members one Month, at least, before the subject is taken into consideration; and it shall farther be necessary that Nine Members be present, and Two-thirds vote for the Measure; or it shall be adopted if unanimously approved of at two General Meetings.

OFFICE-BEARERS,—1847.

President.
His Excellency Sir JOHN F. DAVIS, Bart., F.R.S.

Vice-presidents.
Major General D'AGUILAR, C.B., JOHN STEWART, Esq.,
Major E. P. BURN, Dr KINNIS, Dep. Insp. Gen. of Hospitals.

Councillors.
Lieut.-Colonel BURRETON, R A., C.B.&K.H., Honourable C. M. CAMPBELL, Esq.,
PETER YOUNG, Esq., Colonial Surgeon, A. H. BALFOUR, Esq., Surgeon,
W. T. MERCER, Esq., J. C. BOWRING, Esq.

Secretaries.
General—ANDREW SHORTREDE, Esq.
Corresponding—Captain CLARK KENNEDY.
Chinese & Foreign—THOMAS WADE, Esq.

Treasurer.
W. F. BEVAN, Esq.

Curator.
C. T. WATKINS, Esq.

The Chairman then stated to the meeting, that a suggestion had been made to the Committee, to nominate individuals of high official rank to honorary offices; but it had been decided that such a measure would not be expedient, and accordingly, in electing His Excellency Sir John F. Davis president, he requested the meeting to understand that it was not because of the station he occupied, but solely on account of his known scientific and literary acquirements. The Secretary added, that as one of the original members of the "Royal Asiatic Society," and being already in communication with its president, the Earl of Auckland, regarding the formation of a branch in China, it would be of the utmost consequence to this Society that His Excellency should accept the office assigned to him; and a deputation, consisting of the Chairman and the Secretaries, was therefore appointed to wait upon His Excellency to request his acceptance of the office of President.

After an explanatory statement of the origin of the present Society, it was moved by the General Secretary, that, on the understanding that its apparatus and books be handed over to the "Asiatic Society of China," the members of the "Medico-Chirurgical Society," who signified their desire on the subject before the next General Meeting, be admitted members without ballot or entrance fee. The motion was unanimously agreed to.

FEBRUARY 15TH, 1847.

The Inaugural Meeting of the "Asiatic Society of China" took place at the Society's rooms in Stanley Street, on Friday the 15th of February, 1847, His Excellency Sir John F. Davis, President, in the Chair:—

The General Secretary intimated that the Council had recommended that Professor Stanislas Julien of Paris be elected an Honorary member, and that the following gentlemen be elected Corresponding Members of the Society:—

Rev. S. R. Brown, Hongkong.
" W. Gillespie, "
" J. F. Cleland, "
Mr W. A. Macy, "
Rev. W. Dean, "
" Dr Devan, "
" Dr Bridgman, Canton.
" Dr Parker, "
Dr Ball, "
Rev. Jas. Bridgman, "
Mr S. W. Bonney, "
Rev. I. J. Roberts, "
" G. Pearcy, "
" S. C. Clopten, "
" T. McClatchie, Shanghae.
" Dr W. H. Medhurst, Shanghae.
" W. C. Milne, "
" Dr W. Lockhart, "
" E. W. Syle, "
Right Rev. A. Feliciani, Hongkong.
Right Rev. Dr Boone, Shanghae.
Rev. Alexander Stronach, Amoy
" John Stronach, "
Rev. W. J. Pohlman, Amoy.
" J. Lloyd, "
" H. A. Brown, "
Dr H. A. Cumming, "
Rev. L. B. Peet, "
" D. J. Macgowan, Ningpo.
" W. Lowrie, "
" Dr McCartee, "
Mr E. Cole, "
Rev. K. J. Way, "
" A. P. Happer, "
" A. W. Loomis, "
" J. W. Quarterman, "
" S. Johnson, Foo-chow.
" J. Goddard, Siam.
" M. Jenks, "
" Dr Bettelheim, Loo-choo.

Right Rev. F. G. Rizzolati, *Bishop of Arsidia, and Vicar Apostolic of Hoo-kwan.* Right Rev. H. F. Libois, Hongkong. Rev. Michael Navarro, Hongkong.

On the motion of the President, the suggestions of the Council were unanimously adopted.

The President then read a Preliminary Address, which, on the motion of Mr John Stewart, V. P., was ordered to be printed for circulation amongst the members, and to be included in the Transactions of the Society. (Vide *Appendix.*)

The names of fourteen gentlemen, proposed as Resident Members, to be balloted for at the next General Meeting, were then read.

MARCH 2d, 1847.

Mr John Stewart, V. P., in the chair.

The following gentlemen, proposed and seconded at the Inaugural Meeting, were now duly elected Resident Members of the Society :—

Captain A. N. Campbell, 18th Royal Irish Regiment; Mr C. Agabeg; Mr A. Dixson; Mr J. M. Smith; Mr Framjee Jamsetjee; Hon. Major Caine; Mr Edward Pereira; Mr C. J. Braine; Hon. A. R. Johnston; Mr Pope; Mr Martin Ford; Mr Wilkinson Dent; Mr F. T. Bush, and Mr Donald Matheson.

Ten new Candidates were then proposed and seconded.

Captain Kennedy read to the Society a paper by T. T. Meadows, Esq., Interpreter to H. B. M. Consulate, Canton, on the "*Acquisition, Common-tenure, and Alienation of Real Property in China,*" accompanied by a fac-simile and translation of a Deed of sale. Vide *Transactions.*

APRIL 5th, 1847.

Major H. P. Burn, V. P., in the Chair.

The following gentlemen were elected Resident Members of the Society :—

Mr Robert Jackson, Amoy.
„ J. D. Muir, „
„ W. H. Mitchell, „
„ T. T. Meadows, Canton.
„ F. C. Macgregor, „
Mr W. Brown.
„ W. S. Parkes, Shanghae.
Rev. C. Gutzlaff.
Mr M. C. Morrison, Foo-chow.
„ T. W. L. Mackean.

A paper was read by Dr Dill on a large Phasma from the Pelew Islands, apparently an undescribed species. The specimen was presented to the Society by Dr Dill :

This fine insect is an inhabitant of the Island of the Coral Rock in the Pellew group, and is said to be regarded with great veneration by the islanders, who imagine that it imitates the sound of their voice, and have consequently given it the name of "Ung a rolla calloo," signifying, in their language, "echo." Like most of the family, it is slow and sluggish in its movements, remaining clinging to the under side of the branches of the tree on which it feeds, and which it does not quit until it has devoured the whole of the leaves.

This species is of unusual size, being about 10 inches in length. Being a female, it is difficult to decide to which section of the family it belongs, but as there are traces, though very slight, of the tegmina, it is probable that the male is winged. The meso and metathorax are spined laterally, and the segments of the abdomen from the second to the sixth, both included, are dilated. The ovipositor is very remarkable, being nearly 2 inches in length, and resembling in form a Chinese spoon. The antennæ are of moderate length, the first and second joints of nearly equal size, the third somewhat shorter, and the fourth shortest of all. From this they gradually increase in length.

Should the insect eventually prove to be an undescribed species, Mr Bowring proposed for it the name of *Phasma spinipes*, from the very strong armature of the legs.

MAY 4th, 1847.

Major H. P. Burn, V. P., in the chair.

The Corresponding Secretary intimated that Dr Harland had been unanimously elected a member of Council in the room of Colonel Brereton, returned to England.

Mr T. Smith was elected a Resident Member, and the Rev. E. Huc of Macao a Corresponding Member, of the Society. Upon the recommendation of the Council it was decided that three Committees should be formed for the purpose of drawing up lists of questions, on the various subjects for the investigation of which the Society was instituted. Such lists or portions of them, when formed, to be circulated both by the Society and by individual members.

The objects of Committee No. 1 *to be,*—

Topography and Natural Productions, animal, vegetable and mineral, of the different provinces, districts, cities, or places in China, accessible to members and correspondents; together with the physical, moral, and intellectual Character, Food, Dress, Classes, and Number of the inhabitants; the Diseases most prevalent and fatal, with their probable Causes, and the state of the Medical Sciences.

Committee No 2,—

The state of Agriculture, Manufactures, and the Mechanical Arts; Commerce, with the Imports and Exports to and from other countries.

Committee No. 3,—*

Language, History, state of Science, Literature, and the Fine Arts, Constitution or Form of Government, and Political Relations with neighbouring Provinces or Foreign States.

A paper was read by Mr Wade, on the Syrian Inscription found at Sin-gan-foo, giving particulars of its discovery and history, and interpretations of its Syrian and Chinese characters.

After adverting to the various translations of this inscription that have been published, Mr Wade gave it as his opinion that that by Dr Bridgman is the most correct.

JUNE 1st, 1847.

Mr P. Young, Councillor, in the Chair.

Mr R. B. Jackson, Foo-chow-foo, and Mr A. Humphreys, Hongkong, were duly elected Resident Members of the Society.

The Corresponding Secretary intimated that he had received letters from several of the Corresponding Members of the Society, residing at the Northern Ports, expressing the warmest interest in the success of the Society.

* For a series of "*Suggestions for future Discussion*" by Mr Gutzlaff, on the various subjects comprized by the 3d Committee, vide *Appendix.*

among the members in China. The thanks of the Society were also returned for the offer of a set of journals of the "Royal Asiatic Society."

JANUARY 11TH, 1847.

Major Burn, V. P., in the chair.

A Special General Meeting of the Society was held for the purpose of electing Office-bearers for the ensuing year, where the following appointments were made :—

President,

Sir JOHN FRANCIS DAVIS, Baronet, F.R.S.

Vice-presidents,

Honourable A. R. JOHNSTON, Esq., Rev. VINCENT STANTON,
" W. T. MERCER, Esq., J. C. BOWRING, Esq.

Councillors,

PETER YOUNG, Esq., JOHN CAIRNS, Esq.,
ANDREW SHORTREDE, Esq., Dr DILL,
EDWARD PEREIRA, Esq., A. L. INGLIS, Esq.

Secretaries,

General—Dr HARLAND.
Corresponding—Rev. S. W. STEEDMAN.
Chinese and Foreign—THOMAS WADE, Esq.

Treasurer,

Major H. P. BURN.

Curator,

(Vacant.)

REPORT OF THE COUNCIL.

On the expiration of their term of office, the Council beg to lay before the members a short account of the progress and present state of the Society. In the first place, as regards our Funds, the balance handed over by the late Treasurer on his resignation, as shewn by the papers now on the table, is but small, amounting to $24.32 only, to which, however, must be added the sum of $274.00, being Entrance Fees and Subscriptions for the past year not yet collected, making in all $298,32 ; but it is with satisfaction that the Council announce that there are no outstanding claims against the Society, except a small portion of an account for Sundries ordered from England and not yet received. The principal item of expenditure has been House-rent ; but having succeeded in finding a tenant for the upper part of the house at a rent of $15 per month, this will in future be materially reduced ; and as in other respects also the expenses of the Society will be lessened, it is expected that our funds will prove sufficient for our purposes.

During the past year Eight papers and communications of various kinds have been read, among the most interesting of which may be mentioned Mr T. T. Meadows's able paper on the "*Acquisition, Common-tenure, and Alienation of Real Property in China,*" and likewise that by Dr Harland on the "*Chinese System of Anatomy and Physiology,*" the latter accompanied by four diagrams of large size, illustrative of the subject, for which the best thanks of the Society are due to the donor.

It is possible that the expectations entertained by many of the members as to information to be collected and results to be obtained, may not have been realized ; but the Council would beg to remark, that, situated as we are with regard to China, our progress at the outset could scarcely be anything but slow. Looking, however, to the cordial expressions for the welfare of the Society received from our different Corresponding Members at the Five Ports, and the attainments of many of these gentlemen, it is confidently hoped that we may ere long be furnished with much novel and interesting matter, which we shall be the medium of making known to the world at large.

A Committee has been appointed by the Council to select and revise for publication such of the papers communicated as they may deem advisable, and the First Number of the Transactions of the "CHINA BRANCH OF THE ROYAL ASIATIC SOCIETY" will be shortly printed for distribution among the Members.

Our Collection of Curiosities and objects of Natural History has made satisfactory progress, as may be seen ; though, from the difficulty of procuring the services of a competent Curator, but little has hitherto been done towards classifying and arranging the Specimens. This has not, however, been entirely overlooked, and the whole will gradually be brought into order. It may be here remarked that we are in expectation of shortly receiving further desirable additions to the Zoological department.

It is with much pleasure that the Council call the attention of the Members to the gradually increasing Library, now consisting of several hundred volumes, many of the works being highly interesting and valuable as references. According to the Laws of the Society, the duties of Librarian devolve upon the Curator, and the same cause that has prevented the classification of our Specimens, has consequently delayed the arrangement of our Library; but a considerable number of the works are now catalogued, and the numbering and labelling of the whole will shortly be completed.

In conclusion, the Council would suggest that if attendance were more regular, and a more active part were taken by the members in discussing the various subjects brought under consideration, at the Monthly General Meetings, and greater readiness shewn in communicating such information bearing thereon as they may be possessed of, the interests of the Society would be materially advanced.

Hongkong, 13th *January*, 1848.

APPENDIX.

SUGGESTIONS FOR FUTURE DISCUSSION.

BY THE REV. CHARLES GUTZLAFF.

Language.

1. Origin—Extent—Past and present state—Written and oral medium—Dialects.

2. Similarity to the cognate tongues, Cochinchinese, Laos, Siamese, Cambodian, Pegu, and Birmese. The monosyllabic nature—The accentuation peculiar to all these languages.

3. Affinity to the languages and dialects spoken by the Meaou-tsze, Yaou, and other aboriginal tribes of the interior, and principally in the mountainous regions of south-western China.

4. Influence of the Chinese language exercised upon the Japanese, Korean, Mantchoo, Mongol, Thibetean, Uigur, and Turkish languages.

5. Effects of the adoption of the Chinese mode of writing on the Chinese themselves, as well as on the surrounding nations—Advantages and disadvantages—Progress and stagnation of the human mind—Exclusive policy, and separation from all the world.

6. Lexicography and Grammar of the Chinese language—Labour of natives and of foreigners—Philosophical arrangement of the characters as well to their form as their meaning—Explanation of words—Single and compound words—Etymology as known to foreigners—Syntaxis.

7. Style and composition—Classics, prose and poetry.

8. Comparative view of the Chinese language in juxta-position with the Sanscrit and Lemetic languages, and the Greek and Latin.

9. Facilities and difficulties of the acquisition of the language to foreigners—Rules and directions to lessen the labour.

Remarks.—1. It would be well that members of the Society presented such native as well as foreign books as treat of the language, and that those which could not be obtained here, should be procured elsewhere, whilst the Grammars and Dictionaries of the Mongul, Siamese, Cochinchinese, Laos, Birmese, Cambodia, Pegu, Mantchoo, Japanese, Korean, and Thibetean languages ought to be obtained, to form a whole set in the Society's library for reference.

2. Some of the subjects mentioned above have never or very imperfectly been treated of by foreigners, and should be placed foremost as objects worthy of the labours of any member of the Society who feels inclined to undertake such a task. Our energies should not be wasted upon retailing what others have fully discussed.

3. By endeavouring as much as possible to elicit the ideas of others, and moulding the various views into a whole, we shall be able to indicate or determine the future labours of the Society. Time however will be required for a thorough investigation of the matter, whilst it will be necessary to discard as much as possible all trivial observations which are not to the point.

History.

1. Acceptation of the term with the Chinese—Nature of their History—Peculiarity of their historical works—Various classes of historians—Historical novels.

2. Authenticity of Chinese history ancient and modern—Credibility of the facts related—Concurrent testimony—Evidence derived from the annals of the neighbouring nations, monuments, coins, &c.

3. General observations on the three first dynasties, Hea, Shang, and Chow—A parallel history of ancient Egypt, Assyria, Babylonia, and India, with the two first—Awakening and progress of the human mind during the Chow dynasty, contemporary with the same event in Greece—Sages of China compared with the philosophers of Greece, their contemporaries.

4. Conquests of Che-hwang-te—Extension of Chinese dominion a century after Alexander the Great—Dispersion of the Chinese races to a far greater extent than the Greeks.

5. View of China under the Han dynasties, during the rise and progress of the Roman empire to universal dominion.—The confines of both meet at the Caspian—First intercourse between the respective empires.

6. Indirect influence of China upon Europe by driving hordes of Huns, Turkish, and Tartar tribes from its frontiers to the west, and thus most materially contributing towards the migration of the nations and the overthrow of the Roman empire.

7. Great anarchy in China from the year 200 to 600 of our era under contending dynasties—Retrogressive movement to barbarism.

8. Revival of China under the Tang and Sung dynasties—Christianity and Mahommedanism reach the country—Arabian intercourse.

9. Incursion and final usurpation of Tartar tribes, ending in the conquest of the whole country by the Mongols—The far East and a considerable part of the West under the same dominion—A powerful foreign influence—First intercourse with the west by means of enterprising travellers—Short-lived sway of the Mongols, and its causes.

10. Considerable vigour of the nation at the commencement of the Ming dynasty—Extension and consolidation of the empire, and its subsequent rapid decline.

11. The Mantchoo conquest and its consequences—A parallel between this line of princes and their predecessors, especially the Mongols—Present state and prospects—Particular characteristics of the various Emperors of this dynasty.

Remarks.—1. The field thus indicated is very wide, the materials are plentiful, but ill arranged, and no historical spirit, in the true sense of the word, has yet disturbed this chaos. If subjects the most interesting and least known were gradually taken up, and fully as well as pleasantly, without causing weariness, discussed, something essential might be given to the world. Historical novels have hitherto been almost entirely overlooked.

2. We ought to procure the best historical works in Chinese, as well as those published in German and French, for the library.

Literature.

What do the Chinese understand under classics?—What is the difference between the productions of the Greeks and Romans under the same name?—What their intrinsic value to the nation? what to foreigners?

A sketch of ancient Chinese literature until the end of the Han dynasty A. D. 267—Beauties and defects of the composition—Number of works that have come to us, and the principal subjects on which they treat.

Poets of the Tang dynasty—Historical writings—Works on arts and sciences—Distinguishing marks of the literature of this period—Extensive collection of authors—Who are the most eminent?—What subjects were treated in a masterly manner?—Were the Chinese of that period in literary acquirements superior to or behind the Arabs, their contemporaries?

Labours of the Sung scholars, collections made, commentaries written—In what are they distinguished from our scholastic writers?—Who are the most celebrated writers of that period?—In what particulars did they excel?—What did the human mind gain by their lucubrations?

Describe the authors under the Ming dynasty—What are the principal works in the Ningpo public library, which were brought to perfection by the princes of that dynasty?

What is Kang-he's excellence as a writer?—What the labours of the authors who published under his patronage?—What is the respective value of their books, compared with the productions of their predecessors?—How does Keen-lung rank as an author—enumerate the books which his reign produced?—What are the efforts of living authors?—What the value

of essays published at the examinations, and of the poetry which graduates write professionally?

A general and masterly view of the whole literature, compared with the literary progress of the West.

Estimation in which literature is held by the Chinese and by the Government—Institutions for its promotion—Honours and emoluments as rewards—Influence of the literati on the people—Their acquirements—Colleges—Universities—The Han-lin at the capital—Library at Peking—Examinations—Bent of the Chinese mind—Effect of literature on all other institutions.

Arts.

1. Have the Chinese any idea of what are, strictly speaking, Fine Arts? and in which departments do they excel?

2. What was the state of Music amongst the ancients? what amongst the present generation?—What facts are there to prove that the nation has a sense of the harmony of tones?

3. What rank ought original Painting to hold? what the imitative power of the Chinese in this art?—Who were their most celebrated painters? and what specimens of their art have they left behind?—In what branch of the art do they principally shine?

4. What have the Chinese effected as Sculptors? Do the statues at the graves of princes in any way resemble the production of the Greeks and Romans? What relics of antiquity are to be seen up to this day to convey an idea of Chinese art, in this respect, as cultivated by the ancients?

5. What are the general ideas prevalent respecting Architecture?—In what buildings do Chinese excel? in which consist the greatest defects?—Temples, palaces, public buildings in general—What are the structures which rival pyramids in durability?

6. What progress have the Chinese made in Hydrostatics and Hydraulics?—What are their most celebrated canals, compared with similar works in Europe, and especially in Holland? are they worthy of our notice?—What are the stupendous works undertaken to restrain the Yellow River?

7. In what state is the art of Navigation on the rivers and on the seas?—When was the compass invented? when actually used by Chinese sailors?—How far did Chinese voyages extend before our era?—What traces exist in Arabia, Persia, and Ceylon?—To what extent were the enterprises of Kublai-khan carried?—Present state of this art.

8. What rank do the Chinese hold amongst other Asiatics in respect to the art of War?—When was gunpowder invented?—Were the rockets and guns alluded to in history, as having been used in the 3d century, of a different construction from the former?—What is entirely Chinese? what adopted from foreigners?

9. When was Printing from wooden blocks invented?—What were the effects on the spread of literature?—To what extent is it now applied?—What has been done for xylography in general?

10. What are the Institutions for the encouragement of art?—What is the estimation in which artists are held?—Are the Chinese capable of appreciating anything beyond the useful?—Have they as a nation a sense of the beautiful and sublime?

Constitution and Form of Government.

1. In how far does the epithet of Patriarchal apply to the Chinese Government?—In how far can it be called a consistent and pure despotism?

2. What are the democratic institutions? and how do they co-exist with absolutism?

3. How have we to view the Chinese Government, theoretically and practically, when comparing it with that of Russia, Austria, and Prussia?—What the difference and resemblance?

4. What analogy does it bear to the Mahommedan States of Western Asia?

5. What was the progressive rate from feudal tenure and oligarchy, and all the intervening stages, to its arrival at perfect despotism?

6. The Emperor and his court—Resemblance to the court of Assyria, Babylonia, and Rome under the later Emperors.

7. Military Government thoroughly blended with civil institutions—Pretorian bands—Imperial Clan—Mantchoo banners—Mongolian auxiliaries.

8. Does physical force, administrative wisdom, or opinion, support the throne?

9. What is the weakness or strength accruing to the Supreme Government from concentration? (a system carried to perfection in China.)

10. What constitutes the deliberative, what the executive power?—Who are the real ministers of state?—What are the administrative functions of the six supreme tribunals?

11. What is the religion of State, when viewed as a political engine?—What power does the Emperor acquire by appearing as the representative of all living beings?—What ascendancy does he maintain over the Dalai Lama, and in general over the Shamanists of the Mongols, as Heaven's Son?—In how far do the Mandarins of all degrees exercise their power over the nation, by performing solely the ritual established by law?

12. What is the nature of the provincial administration? and what in general the system of official rank of low and high degree?

13. What is the system of finances in all its branches; its perfections and defects?—What its resources; prospects for the future—Present state of defalcation, with its course?—Source?

14. What is understood by Law in this country?—How many codes are there?—What is their nature compared with the labours of Menou and other Asiatic legislators?—What is the actual state of the administration of justice?

15. What is the military and naval power at the disposal of Government?—What the police?—What the power exercised by ancient institutions and prejudices?

16. What are the public works maintained by Government?—What are the real advantages derived by the nation from the pretended fostering care of the Mandarins?

17. What are the municipal institutions for the maintenance of order?—How far does slavery extend, and why can it never become general?

18. Who are the privileged classes?—What are the prerogatives of nobility?—What the influence of noblemen?—What the power of literary graduates, or better of the nobles of literature.

19. What is the present actual state of the Chinese Government?

Political relations with neighbouring Provinces and foreign States.

1. Ancient relationship of China with the neighbouring states, Korea, Tartary, and Western Asia in general, and subsequently with the countries along the Caspian. and the Roman Empire.

2. Political relations with the hordes of Turkestan during the great migration of nations—With Mongolia—With Southern Asia, and the Archipelago.

3. Foreign relations occasioned by the Mongolian conquest—With Siberia—With Japan—Cochinchina—Indirect with the crusaders—With Java—Sumatra and Persia—Russia and Poland—General influence upon all Asia—Intercourse with the Arabs and Mahommedan Princes.

4. Foreign relationship since the accession of the Mantchoo Dynasty—Incorporation of Mongolia and Thibet—Political ascendancy over Turkestan—Relationship with the Khingis hordes—with the Usbeks and other Mahommedan tribes—with the Eluths—with Ladhak—In the south with Ava, Siam, Cochin-China—Present political relations with Russia, and objects of the embassy now at Peking—with Japan, Korea, and the Loo-choo islands—with Great Britain, France, and the United States.

5. Principles laid down by the Chinese cabinet in all diplomatic intercourse.

6. Various embassies sent by the Mantchoos—Reception of ambassadors from foreign countries at the Court of Peking.

7. Political estimation of foreign intercourse—Decided aversion to such relations.

8. The Chinese Government in its relations to a vanquished foe or small states, and to a conqueror and the empires of the west.

9. Board for foreign affairs and colonial matters.

10. Establishment of Lamas, the representatives of the Thibetean and Mongolian hierarchy.

State of Science.

1. Progress made by the Chinese in the history and geography of their own country—in general history and geography of other parts and regions.

2. Knowledge of Mathematics and of Astronomy in particular, to what extent cultivated in the capital—Considerations on the Chinese arithmetical system in use throughout the Empire.—What did the ancient Chinese, contemporary with the Babylonians and Chaldeans, know of Astronomy?—What do they owe to the Arabs and Europeans?

3. In how far are Zoology, Botany, and Mineralogy known amongst the Chinese—What is their practical progress in Chemistry and in Pharmocopeia?

4. What is the degree of speculative science, especially philosophy, to which they have attained?—Peculiarities of the systems of antiquity of the middle ages during the Sung dynasty, and of the present generation.

5. Knowledge of Natural Philosophy, how far advanced?—What has been done for Experimental philosophy?

6. What rank is held by scientific men?—What honours attach to their station?—What are their principal pursuits?

7. What rank ought we to assign to the Chinese, in a scientific point of view, when compared with the Hindoos, Japanese, Persians, and Turks?

8. Scientific enterprise, how encouraged or opposed by Government?—Scientific genius of the nation?

9. What sciences are still entirely unknown in this country?—What kind of books written upon the various subjects?—What the scientific institutions?

10. What is the scientific influence exercised by China on Eastern Asia? what the benefits derived from it?

11. Future prospects as far as the Chinese themselves are concerned—What have foreigners done in this respect? and how far are they now engaged in such pursuits, for the benefit of the Chinese?

12. What works would prove of the most advantage if published in Chinese, for the nation at large?

MEMBERS OF THE SOCIETY IN 1847.

RESIDENT MEMBERS.

January 5th, 1847.

Dr A. H. Balfour.
Major H. P. Burn.
W. T. Mercer.
J. C. Bowring.
Dr George K. Barton.
„ W. A. Harland.
„ J. Grant, 42d M. N. I.
„ F. Fletcher.
„ P. Young.
Andrew Shortrede.
Charles Tyrell Watkins.
Dr R. Dill.
Charles J. F. Stuart.
W. F. Bevan.

January 11th.

Charles Molloy Campbell.
Charles St George Cleverly.
Adam Scott.
Archibald Melville.
Dr J. Kinnis.
Captain J. Clark Kennedy, 18th R. I.
Rev. S. W. Steedman.
Alexander Bird.
Rev. V. Stanton.
D. Scrymgeour.
R. Strachan.
G. Strachan.
R. J. Gilman.
C. F. Still.
Hon. Chief Justice Hulme.
John Cairns.
John Stewart.
Lieut.-Colonel Brereton, K.A.C.B.
S. J. Hallam.
Major-General D'Aguilar, C.B.

January 19th.

E. Farncomb.
A. L. Inglis.
G. Morrison.
W. H. Miles.
Hugh Mackay.
J. A. Olding.
J. Phillips.
Benjamin Seare.
Captain R. I. Nell.
Patrick Dudgeon.
Dr Kenneth McK. Kennedy.
Norcott D'E. Parker.
Archibald Dunlop.
His Excellency Sir John F. Davis, Bart.
T. Wade, 98th Regt.

March 2d.

Captain A. N. Campbell, 18th R. I.
C. Agabeg.
And. Dixson.
J. M. Smith.
Framjee Jamsetjee.
Major William Caine.
Edward Pereira.
C. J. Bralse.
A. R. Johnston.
John Pope.
Martin Ford.
Wilkinson Dent.
F. T. Bush.
Donald Matheson.

April 6th.

Robert Jackson, Amoy.
William Brown.
H. S. Parkes, Shanghae.
J. D. Muir.
F. C. Macgregor, Canton.
T. T. Meadows, "
Charles Gutzlaff, Canton.
M. Crofton Morrison, Fú-chau-fu
W. H. Mitchell, Amoy.
F. W. L. Mackean.

May 4th.

Thomas Smith.

June 1st.

R. B. Jackson, Fú-chau-fu.
Alfred Humphreys.

July 6th.

Captain Charles D'Aguilar.

September 7th.

C. Empson, Shanghae.

November 4th.

John Burd.

HONORARY MEMBER.

February 15th, 1847.

Professor Stanislas Julien, Paris.

CORRESPONDING MEMBERS.

February 15th, 1847.

Rev. S. R. Brown, Hongkong.
" William Gillespie, "
" John F. Cleland, "
Mr W. A. Macy, "
Rev. William Dean, "
" Dr Devan, "
" Dr E. C. Bridgman, Canton.
" Dr Parker, "
Dr Ball, "
Rev. James G. Bridgman, "
Mr S. W. Bonney, "
Rev. I. J. Roberts, "
" G. Pearcy, "
" S. C. Clopton, "
" T. McClatchie, Shanghae.
" Dr W. H. Medhurst, "
" W. C. Milne, "
" Dr William Lockhart, "
Right Rev. Dr Boone, "
Rev. E. W. Syle, "
" Alexander Stronach, Amoy.
" John Stronach, "
" W. J. Pohlman, "
" John Loyd, "
" H. A. Brown, "
Dr H. A. Cumming, "
Rev. I. B. Peet, Fú-chau-fu.
" D. J. Macgowan, Ningpo.
" W. Lowrie, "
Rev. D. B. McCartee, Ningpo.
Mr E. Cole, "
Rev. R. Q. Way, "
" Andrew P. Happer, Canton.
" A. W. Loomis, Ningpo.
" J. W. Quarterman, "
" S. Johnson, Fú-chau-fu.
" Rev. J. Goddard, Siam.
" N. Jenks, "
" Dr Bettelheim, Loo-choo.
The Right Rev. F. G. Rizzolati, *Bishop of Arsidia, and Vicar Apostolic of Hoo-kwang.*
The Right Rev. Anthony Feliciani, " N. F. Libois,
Rev. Michael Navarro,

May 4th.

Pere E. Huc, Macao.

September 7th.

Rev. J. L. Shuck, Shanghae.
" T. W. Tobey, "
" M. T. Yates, "
" F. C. J. Johnson, Canton.
" J. V. N. Talmage, Amoy.
" E. Doty, "
" P. D. Spalding, Shanghae.
" M. C. White, Fú-chau-fú
" J. D. Collins, "

REPORT

OF THE

MEDICAL MISSIONARY SOCIETY IN CHINA.

FOR THE YEAR 1847.

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VICTORIA.

PRINTED AT THE HONGKONG REGISTER OFFICE.

1848.

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MINUTES OF THE GENERAL MEETING,

HELD ON THE 1ST OF OCTOBER, 1846.

A General Meeting of the Medical Missionary Society, was held in the Hospital, Hongkong.—DONALD MATHESON, *Esq., in the chair.*

It was proposed and agreed:—

I. That the Treasurer be authorised to disburse to the order of

Dr. W. H. CUMMING for personal expenses,	$200.
For Hospital expenses, Amoy,	100.
Also to Dr. LOCKHART, Shanghai,	100.
Also to Dr. MACGOWAN, Ningpo,	100.

II. That this Meeting deeply regret the differences which have existed during the last two years among some of the Members of the Society, and desire the restoration of confidence and co-operation.

III. That the Rev. S. R. BROWN, Rev. V. STANTON, Rev. W. GILLESPIE, and A. BALFOUR, Esq., be appointed a Special Committee to confer with the Members of the Society resident in Canton, or with a Special Committee appointed by them, on the subject of a re-union and re-organization of the Society.

IV. That the thanks of this Society are due to Dr. BALFOUR for his kind and unremitting services in the Hospital, Hongkong, during the absence of Dr. HOBSON, and also to Dr. LITTLE, Surgeon in H. M.'s Royal Navy, for his assistance in the Hospital; and that they cherish a grateful remembrance of the valuable services of the late Dr. DILL in the same Hospital, and on behalf of the Society in general during the past year.

V. That the thanks of the Meeting be given to DONALD MATHESON, Esq., for his conduct in the chair.

WILLIAM GILLESPIE,
Corresp. Secretary.

October 2d, 1846.

MINUTES OF THE GENERAL MEETING.

HELD ON THE 1ST OF DECEMBER, 1847.

At the Annual Meeting of the Medical Missionary Society, held on the 1st of December, 1847, in the Society's Hospital, Hongkong.—DONALD MATHESON, *Esq., in the chair.*

It was proposed and resolved:—

I. That the Report be approved of and adopted.

II. That the Corresponding Secretary be empowered by the Society to correspond with the Edinburgh and Glasgow Medical Missionary Society with the view of securing the services of a Medical Missionary to take charge of the Hospital, now vacant by the resignation of

Dr. Hobson. That Dr. Balfour be requested in the meantime to conduct the Hospital for a few months, and afterwards Dr. Hirschberg of the London Missionary Society, who it is hoped during the summer months would be able to reside upon the premises.

III. That the thanks of the Society be presented to Drs. Lockhart, MacGowan, Cumming, Balfour, and Hobson, for the gratuitous and valuable services rendered by them in the Hospitals at Shanghai, Ningpo, Amoy, and Hongkong, and that the reports of their proceedings be printed for general information.

That $200 be voted for the use of the Hospital at Ningpo, and that Medicines and Surgical Instruments to the amount of £50 be forthwith ordered for the use of the Hospital at Hongkong.

IV. That the following gentlemen be appointed office-bearers for the ensuing year:—*President*, T. R. College, Esq., M.D., *Vice-Presidents*, Rev. E. C. Bridgman, D.D., Donald Matheson, Esq., Rev. V. Stanton, W. Davidson, Esq., Dr. Young, Dr. Morrison, and *ex-officio* the Medical Officers of the Society; *Recording Secretary*, Dr. R. Dill; *Corresponding Secretary*, Dr. B. Hobson; *Treasurer*, T. W. L. Mackean, Esq.; *Auditor of Accounts*, T. D. Neave, Esq.

V. That the powers granted to the Special Committee be renewed, and that the Rev. J. Cleland, and W. A. Macey, Esq., be elected into the vacancies caused by the departure of the Rev. S. R. Brown, and the Rev. W. Gillespie, and that they be empowered to call a Special Meeting whenever they are in a position to give a definite statement of their proceedings.

VI. That the thanks of the Meeting be given to Donald Matheson, Esq., for his conduct in the chair.

BENJAMIN HOBSON,
Acting Secretary.

December 3d, 1847.

REPORT OF THE CHINESE HOSPITAL AT SHANGHAI,

In the Year 1845–46,

By WILLIAM LOCKHART, Esq.,

Member of the College of Surgeons, London.

In accordance with the wish of the Subscribers to the Medical Missionary Society as expressed at the General Meeting at Hongkong, last year; it was determined to form a local Committee at Shanghai in January last, and the following gentlemen agreed to act for the benefit of the Society, viz:—

A. G. DALLAS, Esq.
T. C. BEALE, Esq.,—*Auditor.*
CHAS. SHAW, Esq.,—*Treasurer.*
WILLIAM LOCKHART, Esq.,—*Secretary.*

At a Meeting of the local Committee held at the Hospital, October 22d, 1846.—Present, T. C. Beale, Esq.; Chas. Shaw, Esq.; William Lockhart, Esq.

Mr. Lockhart presented the Report of the last operations of the Society for the year ending June 30th, 1846, and submitted it to the local Committee.

The Report was approved of, and directed to be sent to the Committee of the Medical Missionary Society at Hongkong.

The last twelve months of the Society's operations in this place, have little in their character different from that which has been laid before the Subscribers in former reports. As will be seen from the list of patients, the number attended to has been 10,140, which shows that the natives are as anxious as ever to avail themselves of the offer of medical relief. Up to the present time the patients have been attended to in the premises formerly occupied; but these were found to be ill adapted to the purpose, and in a few weeks a new and commodious hall for the reception of out-patients, and good wards for the in-patients will be opened. This building has been erected through the liberality of friends to the cause, in Shanghai and England, and it is proposed to vest the property in the hands of some of the British residents at Shanghai, conditionally that it shall be always used for the purpose of an Hospital and Dispensary for the Chinese, or on certain other conditions which will be hereafter specified in the trust deed. It will be rented for the present to the resident medical officer of the Medical Missionary Society at such rent as the Committee think proper. The above plan of obtaining the requisite accommodation was judged the best that could be devised, and it was thought that by giving a local control over the affairs of the Hospital, more interest would be excited in its behalf, and a better prospect of its usefulness being maintained would thus be secured.

The summer of 1845 was wet, and consequently cool, but the dampness of the weather had an unfavorable influence on the health of the people generally, and as hot dry summers are the best for ripening the fruit and the grain, so they appear to be the best for the benefit of man.

In winter and spring when the weather is wet, the people suffer much from catarrh, cough, and rheumatism; but in summer and autumn should there be any continuance of wet weather, diarrhea, and dysentery are the most prevalent disorders. Intermittent fever also exists to some extent, but it is remarkable that this latter affection should present itself so seldom except in parts of the country which are low and marshy. This subject has been alluded to in previous reports, and further experience confirms the opinions therein offerred respecting intermittent fever at this place. The city and all the surrounding country presents an extensive flat or level of alluvial soil, which when dug into to the depth of four feet yields water abundantly; were the surface constantly irrigated for the purpose of rice cultivation, possibly intermittent fever might prevail here, as it does under such circumstances at Chusan. The cultivation of cotton, wheat and many kinds of edible vegetables however prevails in this district, and

as this does not require irrigation, the surface is for the most part dry, except during the season of heavy rains. It is also worthy of observation, that catarrh, dysentery, diarrhea, &c., appear to take an intermittent or periodical character among the natives and also among Europeans. The latter are also more subject to intermittent fever in all its various forms than the former; the natives have of course become thoroughly acclimated, and are not affected by the climate to the same extent as are the foreigners; European children are especially subject to this aguish influence, and almost all the disorders of children take a periodic form. This subject merits further enquiry, and it is of much consequence that it be always attended to by medical men practising their profession in a climate such as that of China, and especially in those parts where rice is grown to a great extent. Notwithstanding the great changes of temperature to which this part of the country is subject, the heat in summer being sometimes 100° and 101°, and the cold in winter at its lowest for last year 15°, and the changes frequently so sudden that the thermometer falls 30° or 40° in twenty four hours, still it is gratifying to find that since Europeans took up their residence here three years ago, they have on the whole enjoyed so large a measure of good health.

RANGE OF THERMOMETER IN THE SHADE IN THE OPEN AIR.

1845.—JULY,	Average by day	88°	by night	78°.
	Maximum do.	94	do.	80.
	Minimum do.	70	do.	67.
AUGUST,	Average do.	90	do.	78.
	Maximum do.	94	do.	78.
	Minimum do.	75	do.	68.
1845.—SEPTEMBER,	Average do.	78	do.	69.
	Maximum do.	88	do.	77.
	Minimum do.	68	do.	63.
OCTOBER,	Average do.	67	do.	60.
	Maximum do.	79	do.	71.
	Minimum do.	58	do.	49.
NOVEMBER,	Average do.	59	do.	46.
	Maximum do.	73	do.	60.
	Minimum do.	49	do.	37.
DECEMBER,	Average do.	40	do.	30.
	Maximum do.	61	do.	50.
	Minimum do.	30	do.	18.
1846.—JANUARY,	Average do.	38	do.	28.
	Maximum do.	47	do.	40.
	Minimum do.	30	do.	16.
FEBRUARY,	Average do.	46	do.	34.
	Maximum do.	55	do.	46.
	Minimum do.	32	do.	25.
MARCH,	Average do.	47	do.	38.
	Maximum do.	57	do.	46.
	Minimum do.	39	do.	31.
APRIL,	Average do.	57	do.	47.
	Maximum do.	81	do.	71.
	Minimum do.	47	do.	44.

MAY,	Average by day	72°	by night	65°.
	Maximum do.	88	do.	69.
	Minimum do.	55	do.	47.
JUNE,	Average do.	83	do.	71.
	Maximum do.	101	do.	83.
	Minimum do.	64	do.	61.

On the 4th of August, 1846, at ¼ to 4 A. M., a severe shock of an earthquake was felt at this place, lasting for about 60 seconds. The vibration of the earth appeared to be in a direction from East to West, and consisted of one severe shock, followed by a second slighter shock, and the continuance of the vibration or oscillation for the above space of time. The motion of the earth was great, but slow; had the same amount of motion taken place in a shorter space of time, much damage to the city must have ensued; as it was, few if any accidents occurred, but the Chinese were very much alarmed. Several pendulum clocks stopped, especially those facing the East or West. From accounts since received, the earthquake is known to have been felt over the whole of the southern portion of Keang-nan, and the northern part of Che-kiang, but its action must have extended much farther. The centre of the earthquake was probably in Japan, and may be supposed to have resulted from a violent eruption of one of the large volcanoes in that country. On the night of the same day, another but very slight shock was also felt; but although it was distinctly perceptible, it might possibly not have attracted attention, had it not already been aroused by the occurrence of the violent shock in the morning. Slight shocks of earthquake are not uncommon here, but the natives generally allow that the one above noticed, was much more severe than those ordinarily felt.

During the winter season, ice is collected in large quantities and carefully stored in ice-houses, the walls of which are constructed of mud and are about 12 feet thick; the roof is thickly thatched with rice-straw and the door well covered over at all times. The ice is used almost exclusively by the Chinese for the preservation of fish, but there is another use made of it which has only lately been ascertained. When any one dies in a wealthy family, the friends sometimes wish to keep the body for three days, and if the weather be hot the body is placed on a plank and two or three pecuks of ice on the floor underneath it; this being renewed as it melts, keeps the body at a low temperature and to a great extent prevents decomposition.

Several cases of suicide, and attempted suicide by swallowing opium presented themselves as usual, and it may be remarked that severe counter-irritation on the surface offers an excellent adjunct in the treatment of such cases, rousing the powers of life, and enabling the stomach to feel the effects of emetics, as in the following case:—A young man, 22 years of age, took a large quantity of opium, because his father had scolded him for spending 700 cash. He was perfectly comatose, pupils contracted, and skin insensible both to pricking with a pin, and pinching with spring-forceps, mouth firmly closed. He had been made sick with *tung-yew* or wood-oil, (as it is usually called, being the drying oil used by painters), and goat's blood. Solution of

sulphate of copper was poured down his throat, followed by a mixture of mustard in hot water, slight vomiting was induced by the finger put into the fauces, but it was evident that no good would be done by these means. Violent stimulants were therefore applied to the skin, moxa to the epigastrium, over which a mustard poultice was applied, with boiling water to the legs; by these means he was roused in some degree and groaned from pain, violent vomiting quickly supervened, which brought up a quantity of opium, after which he rapidly regained his sensibility, and in an hour or two was out of all danger, but complained of feeling very sore.

One night about 11 o'clock, a man was seen standing at a door with a lantern in his hand, calling apparently on some absent person, at intervals, and in a plaintive tone. He was answered by another person within the house in the same tone of voice. On enquiry it was found that a child in the family had fever and delirium, or as the native phrase runs, "his soul had gone away or was wandering abroad." The father then hangs up on the side of the house a paper figure of Buddha, which he burns, and having lighted the candle in a lantern, holds it at the door while he calls in a mournful and beseeching tone for his child, "A-sze hwuylae," "A-sze come home," on which the person who is watching the child replies, "A-sze laetsae," "A-sze has come back." This is continued till the delirium subsides or some change takes place. The wandering spirit is supposed to see the light and hear the cry and then return to its usual abode.

In the case of the loss of the anterior part of the inferior maxilla, the entire arch of the jaw containing 6 teeth, including the lower margin of the bone, had separated, and came away on the application of a slight degree of force, the cavity gradually filled up, and the case terminated successfully.

Entensive laceration of the leg. A man was in a boat filled with empty oil jars; from some accident he slipped and fell among the jars one of which broke, and cut up an enormous flap of skin, fascia, and muscle on the front and lateral part of the leg, from the ancle to the knee; much hemorrhage ensued, but suppuration and granulation went on well, and the case was advancing satisfactorily, when the man was obliged to return home to the country, as his family were afraid of his being among strangers; he was supplied with dressings and no doubt soon recovered.

It may not be out of place in this report to mention two benevolent institutions existing at this place in addition to the Foundling Hospital and Hall of United Benevolence, which have been spoken of in former reports. They are the Humane Society, and the Public Dispensary.

The Humane Society, or Kew-sang-keuh, (establishment for saving life), is situated on the bank of the river, outside the great east gate of the city; its object is to save the lives of those who fall into the river. In cases of accident on board ship, boats are sent to pick up any who may have fallen into the water. The bodies of any thus rescued are taken to the institution, where efforts are made to restore life; but from the list of persons received it would seem that the chief

duty of the superintendent consists in furnishing coffins for his patients. This is done at the expense of the establishment, which like the Tung-jin-tang or hall of united benevolence, is supported by public subscription. Among the plans adopted for restoring suspended animation, one is to place the patient on his back, and then invert a large iron boiler, commonly used for cooking rice, over the abdomen. This they say "on account of the connexion between the empty space, and the distended abdomen of the patient, causes the ejection of water by the nose." Another plan is "to suspend the patient by his feet from the shoulders of a man standing erect, stopping up the anus by a dossil of cotton to prevent the passing of a motion, which would be fatal. This will soon be followed by the flowing of water from the mouth, and the patient's life will be thus spared." This institution does not appear to be carried on with much vigour, and the applications for aid are not very numerous. The list for a year did not contain more than 30 or 40 cases, both of persons who had been saved and of those who had been buried.

The following is a translation of the Report of the Public Dispensary, as printed and distributed among the Subscribers.

REPORT OF THE PUBLIC DISPENSARY,

Attached to the Poo-yuen-tang at Shanghai, for the 25th year of Taoukwang or 1845.

That part of the country called San-woo-te (anciently denominated the kingdom of Woo, and now corresponding to the southern part of the province of Keang-nan) is very damp, and that portion of it which lies near the sea is salt and still more damp than the interior, and in the summer and autumn, is much exposed to strong winds. In the Hwang-poo and Woosung rivers there are the day and night tides, but in the brooks, streams and canals which join them, there being no flow and ebb of the tide, the water is still or stagnant, and acquires a greenish colour and brackish taste; the water of the wells is also affected in a similar manner, and as regards the people who live in these places, the dampness moistens them, the wind shrivels them, the stagnant water soaks them, and they are thus rendered liable to disease. On the cotton lands, if while the cotton plants are growing up, they be choked by weeds they will not thrive, therefore after the rains, during the 5th and 6th months, the labourers immediately leave their houses, and putting on their hats and taking up their hoes proceed to labour, and though midday may have passed they do not stop until their work is accomplished. Hence during the summer and autumn months much sickness prevails among the people. Those who have the means of doing so, call in a physician to cure their indisposition, and it is thus of little consequence, but if the poor and destitute be exposed to these pernicious influences and become sick they are un-

able to procure medical aid, and their diseases speedily become severe. This state of things having come to the knowledge of several benevolent individuals has excited their compassion and sympathy.

At Shanghai several gentleman have established the Tung-jin-tang or hall of united benevolence which has now been carried on for several years; attached to it is an institution called the Foo-yuen-tang, whose object is, to supply coffins on credit; in addition to this a Public Dispensary has lately been established and rules determined upon. The institution was opened on the 18th day of the 5th month and was closed on the 18th day of the 8th month; during this time more than 10,000 persons were attended to, which has all been clearly specified. Now it is far more meritorious and praiseworthy to attend to persons while they are alive, than to afford coffins for them when they are dead, if therefore the gentry would unremittingly do this, they would be the means of assisting the poor and supporting the destitute, and thus by virtuous intentions and good plans the people of this city will be enabled to attain to a good old age. These benefits will not be confined to the city of Shanghai alone, but all persons having compassionate hearts hearing of your good deeds, will they not at once try to follow your example? He who first established the Dispensary was Wang-kwei, those who carried on the work after him were Choo-tsang-ling, Choo-tsang-hwuy, Shin-kwan, Keang-hea-pang and Chin-ping-kwei. I have given these particulars of the institution in this preface that by the minute detail of them, those who have the means may be excited to afford their aid.

Signed by SHIN-PING-YUEN of Tung-heang, by Imperial appointment, and FUNG-CHIN TA-FOO (an officer of the 5th rank) Subprefect of the coast guard for the district of Sung-kiang, and formerly for the 11th, 12th and 17th years of Taoukwang, joint examiner for the degree of Keujin (master of arts) in the province of Keang-nan.

LAN, by Imperial appointment, magistrate of the department of Shanghai, in the district of Sung-kiang, in the province of Keang-soo, who has been elevated 10 degrees and recorded for merit 10 times, issues this cautionary proclamation.

Whereas the officers of nominal rank, Choo-tsang-ling, Choo-tsang-hwuy, and Shin-kwan; the Sew-tsaes or Bachelors of arts Keang-kea-pang, and Chin-ping-kwei have petitioned saying:—"We consider that the miseries of disease and pain are to be pitied by all good men, and that the virtues of pills, powders, plasters and boluses should be dispensed by all benevolent institutions. Since the establishment of the Tong-jin-tang or Hall of United Benevolence at Shanghai, there have been manifested pity to widows, support to the aged, gifts of coffins and burial places for the dead; but the business of affording medical advice and of dispensing medicine has not yet been attended to. Last year we borrowed some rooms adjoining the Tong-jin-tang, to form an additional or assisting establishment, on the principle that

the carrying out of benevolent intentions far and wide, is an emanation of original virtue, besides which this establishment allows coffins on credit as we formerly represented, which is on record. We also wish to imitate the benevolent institutions of Soo-chow, and Sung-kiang, and during the summer and autumn months open an establishment for affording medical advice, and dispensing medicines to the destitute inhabitants of poor villages and hamlets, who are unable to obtain advice or procure medicines; all who apply at the establishment on the appointed days are attended to and furnished with remedies; thus their diseases are cured and health restored, and upwards of 10,000 persons have thus been benefited. On account of the great expense consequent on this establishment, and because it was yet in its commencement, we were fearful it could not be continued for any length of time, therefore we did not make any representation to your worship. We have now collected subscriptions for defraying the expenses incurred by dispensing medicines and providing medical advice, and intend opening the establishment on the 18th day of this month, and have appointed the 3rd and 8th days of the month as the times for attending to applicants (that is on the 3rd, 8th, 13th, 18th, 23rd and 28th, or every five days). On each appointed day patients will be seen and medicines given till midday, when the establishment closes. Now lest any ignorant or vicious persons should come to the establishment, and make a disturbance, giving trouble and preventing the carrying on of this good work, we all petition you to issue a cautionary proclamation."

I, therefore send out this proclamation, having examined into this establishment for affording medical relief by giving advice and dispensing remedies. The aforesaid petitioners having procured funds for the necessary expenses, the work will be carried on, and they may on the appointed days open the establishment, and prosecute their excellent and benevolent intentions, which are much to be commended; and I issue this cautionary proclamation to inform you soldiers and people, that hereafter if any ignorant or vicious persons go to the establishment creating disturbance or causing trouble, their names must be brought to this office, in order that proof of the circumstance being shown, they may be summarily punished. The constable of the neighbourhood must not screen offenders to prevent proper punishment. You must all respect this without contumacy.

A special proclamation, the 6th day of the 5th month of the 25th year of Taoukwang.

THE REGULATIONS.

1st. The expenses of the establishment being defrayed by the subscriptions of the benevolent, it is desirable to use prudence and economy. On all the appointed days for seeing patients there are provided a breakfast, a midday tiffin, and in the afternoon a dinner of meat and vegetables, of which only four bowls are placed on each table for 8 persons, thus shewing the economical arrangements which are made.

2nd. On each day those who give out the tickets are to come to

the establishment early in the morning, and when they open the books and take in the tickets are not to receive any money from the people, and when the physicians give advice they are not to receive any fees.

3rd. The five grades of practitioners, viz: for internal, external, infantile and ophthalmic diseases, and for acupuncture, are requested to attend at the establishment. At the time of giving out the tickets, the number of the ticket, the name of the person, his disease, and the class to which it belongs are to be distinctly registered, for the convenience of the physicians.

4th. The tickets are to be distributed at 7 A. M.; the patients attended to at 8 A. M.; and the establishment closes at 12 M. Those who have received tickets before 12 o'clock are all to be attended to, but if on any day, the number of patients be small, the physicians must still wait till after midday.

5th. After the distribution of the tickets, the patients must sit still, waiting till the attendant who calls in the tickets takes them to the physician; they must not strive to be seen before their turn.

6th. To the patients who have surgical diseases, powders and plasters are given; to those affected with diseases of the eye, ophthalmic remedies are also given, but no medicine will be allowed to those who do not attend in person at the establishment. In cases of internal diseases, prescriptions will be given, but the purchase money of the medicines is not allowed, unless there be some benevolent individuals who subscribe for this purpose; but this cannot be determined upon or taken as a rule.

7th. The physician must come to the establishment early in the morning, and may return home after midday, and should any of his private patients come to the establishment to see him, they must wait until that time.

8th. There being a fixed period for attending to the sick, should any persons be affected with a dangerous disease, and it be inexpedient to give five doses of one medicine, the mode of treatment must be plainly expressed in the prescription; or should any person require daily inspection, whose treatment cannot be specified, such will be allowed to go to the house of the physician, if they take their original prescriptions and wait on him before midday, but the physician must not receive any fee. At the next public day the patient must present himself at the establishment.

9th. The physicians are not to absent themselves on account of wind or rain; they are to remember that their work is from the 18th day of the 5th month, to the 18th of the 8th month.

10th. If any benevolent individuals subscribe towards defraying the expenses of the medicines, and give pills, powders, plasters or boluses, such donations will all be published in the Report at the end of the season.

The 5th month of the 25th year of Taoukwang.

Subscription Paper issued by the Committee of the Establishment.

We respectfully notify to the subscribers, that the Public Dispensary attached to the Hall of United Benevolence was open three months during the past summer, and that it depended solely on subscriptions of money, and donations of medicines. On every appointed day there were more than 1,000 applicants; now considering that the expenses incurred by attending to the diseases of so many of the poor, and by affording them medicines for their relief, were all defrayed by the subscriptions, there being no other resources, and we also wishing to reopen the establishment this year, we issue this exhortation to the merchants and scholars, who delight in works of charity. Some may make donations of drugs, others of pills and powders; some may subscribe for the entire expenses of one of the public days, others for the medicines used in one day, some may make a yearly donation for general purposes, while others may pay for a proportion of the expenses of one day. All these are to be voluntary donations, given without compulsion, and when the business of the season is completed, the whole will be accounted for in the public report. We respectfully request the lovers of virtue and promoters of benevolence to open their purses and afford relief to the sick poor, and by gathering together small donations we shall obtain a sufficient fund, (literally:—by accumulating grains of sand we shall form a pyramid). Thus the whitened bones will be clothed with flesh, and the well nigh dead restored to life, the sick will be healed and immeasurable happiness diffused abroad.

The 4th month of the 25th year of Taoukwang.

There have attended at the establishment 15 practitioners for internal diseases; 4 for infantile diseases; 4 for surgical diseases; 2 for ophthalmic diseases; and 4 for performing acupuncturation.

N. B.—The names of the above are individually recorded in the original. The Committee consists of 29 persons, and Choo-tsang-ling is the president at all its Meetings.

The subscription list is here given; and the subscriptions received from 200 various persons, merchants, shopkeepers, private gentlemen and others, in sums of from one-quarter of a dollar to one hundred dollars each, are separately stated, the whole forming a total of receipts, *cash* 980,805.

The donations of medicines also separately stated comprise musk, ginseng, rhubarb, ophthalmic powders, black tiger plasters, sleeping dragon pills, white pearl ointment, ulcer ointments, dysentery powders, alkaret liniment, camphor ointment, peach-flower powder, ague-plaster, head-ache plaster, sudorific powders, besides various other pills, powders, plasters, and ointments needless to mention.

Account of Patients at the Establishment.

On the 1st day,	attended to	75 men,	64 women.
On the 2d day,	attended to	133 men,	128 women.

The original thus specifies the number of patients for the 19 public days, the largest number attended to in one day being 521 men, 611 women.

The total of patients for the above 19 days, men and women, is	13,519
Prescriptions given,	6,199

On 6 of the public days, four benevolent individuals paid for the whole of the medicine required. Besides this two individuals paid for 100 prescriptions given to patients, who were obliged to visit the physicians at their own houses. The prescriptions thus paid for are included in the account.

Expenditure of the Establishment.

	Cash.
Paid to 8 apothecaries' shops on account of 6,199 prescriptions,	265,710
Paid for various drugs,	169,335
pills, powders, boluses, and plasters,	181,610
bowls, jars, cups, water vessels, pewter and copper vessels, ivory spatulas, measures, weights and scales, &c., &c.,	6,423
wages of servants for making up the medicines, also for charcoal, firewood, lamps, and oil,	22,125
extra drugs,	9,229

Miscellaneous Expenses.

	Cash.	
Paid for the physicians and the attendants' dinners on the 18 public days,	106,316	
dinner at the end of the season,	19,356	
flour cakes for breakfasts and tiffins,	29,460	
dinner at the beginning of the season,	12,893	
dinner to the apothecaries,	13,900	
Dr. Min's boat-hire and postage,	15,300	
Dr. Kaou's boat-hire,	10,480	
candles for the altar,	10,060	
tea,	3,480	
tobacco,	3,678	
200 pencils and 400 sticks of ink,	3,660	
5 subscription books,	2,750	
paper for prescriptions,	3,900	
folding paper for medicines,	3,839	
red paper for placards,	460	
70 prescription books,	3,150	
register books,	900	
envelopes for powders, &c., &c.,	885	
1,700 patients' tickets,	12,148	
cooks wages,	6,300	
attendants 279 days' work,	18,974	
paper for plasters,	2,774	
7 tea-pots,	1,484	
20 towels,	840	
subscription papers,	939	
carving physicians' seals,	866	
rice baskets,	426	
2 water tobacco pipes and 20 common pipes,	1,054	
sundries,	2,347	
loss on bad cash,	2,680	
	294,495	
Total of Expenditure,		949,017

Balance of Accounts.

	Cash.
Entire amount of receipts from Subscriptions,	980,805
Total amount of Expenditure,	949,017
Balance in hand,	31,788

From this Report and the notice of the Humane Society it will be seen that the charge brought against the Chinese in common with all other heathen nations, that among all are found no Hospitals or other Institutions for the relief of the sick and destitute, is not correct. For there are in the city of Shanghai the above two establishments, also a foundling Hospital, an Alms house for the aged and infirm, a poor fund, and fund for the providing of coffins, and perhaps other establishments which have not yet been discovered.

While as may be seen from our Report now presented, medical relief has been afforded to the people of this place, their spiritual necessities have not been neglected. The in-patients are assembled every morning for the reading of the scriptures and prayer in the native dialect; and Mr. Medhurst addresses the whole of the patients, that is the out patients and in-patients, three times during the week on the leading doctrines of the Gospel, also on the Sabbath afternoon. Books and portions of the Scriptures are also freely distributed to the patients, when they return home, which thus find their way to all parts of the country, and it is known that these are not only taken home, but in many cases read and carefully examined. It is hoped that by the knowledge thus diffused, many who have hitherto worshipped only idols, and been shut up in ignorance and superstition, giving up themselves with apathy to the slavery of sin, may not only find relief for their bodily ailments, but be delivered from that worse sickness which taints and pollutes the mind, and be led to look to him who is the Saviour of the world and the great physician of souls. May the God whom we serve grant wisdom and direction to all those who have the management of the affairs and the carrying out of the plans of the Society, causing all that is done to tend to his honour and glory, and the temporal and spiritual welfare of our fellow-men.

The present are times of great promise to China, let us therefore diligently carry on our work, and be encouraged by thought of its importance, and vastness, to aim at doing still more than has yet been accomplished. The field of exertion is wide and ample, and needs as well as merits our fullest exertions and our constant efforts. And it must be remembered that a work of this kind is not for a week, or a month, or a year, but that to give any influence it must be regularly and steadily prosecuted for many years. Luke-warmness and faint-heartedness must not enter in, or all present paying and trouble will be thrown away, and so far as our efforts are concerned the renovation of this mighty empire be still retarded. Would we do any thing to this end, we must aim high, and though we may have to grapple with difficulties, they will only inspire us with more energy and zeal for future labours.

List of Patients attended to from 1st July, 1845, to 30th June, 1846.

Intermittent fever,	117	Tumour of arm,	1
Tussis,	920	Tumour of thigh,	2
Asthma,	192	Carcinomatous tumour on abdomen,	1
Hæmoptysis,	100	Carcinoma of breast,	1
Phthisis,	40	Fracture of radius,	2
Dyspepsia,	1,272	Fracture of humerus,	1
Dysentery,	113	Fracture of clavicle,	2
Anasarca,	12	Fracture of crista Ilii,	1
Ascites,	15	Fracture of thigh,	1
Rheumatism,	1,245	Dislocation of humerus under the clavicle,	1
Epilepsy,	4	Caries of femur,	1
Surditas,	69	Caries of carpus,	1
Leprosy,	23	Caries of metatarsus,	1
Ichthyasis,	4	Loss of the palatal bones,	3
Elephantiasis,	13	Loss of the symphysis maxillæ inferioris,	1
Psora,	290	Osteo-sarcoma of maxilla superior,	1
Psoriasis,	103	Sudden death,	1
Lepra,	92	Suicide from eating opium,	4
Abscess,	114	Attempted suicide do.,	5
Ulcers,	386	Opium smoking,	30
Hernia scrotal	65	Catarrhal ophthalmia,	295
Hernia double and double hydrocele,	1	Chronic conjunctivitis,	500
Hydrocele,	7	Granular lids,	450
Contusions,	3	Granular lids with opacity,	502
Infiltration of pus into the fingers and palm,	1	Granular lids with pannus,	330
Severe contusion of chest,	1	Leucoma,	202
Severe contusion of pelvis,	1	Ulceration of cornea,	817
Laceration of hand,	1	Conical cornea,	40
Extensive laceration of leg	1	Staphyloma,	30
Severe wounds of limbs,	6	Hernia iridis,	10
Spear wounds of thigh,	3	Synechia,	40
Gun shot wounds in body and limbs by pirates,	14	Closure of pupil,	32
Burns of face and limbs,	4	Irregularity of pupil,	80
Severe burns of body followed by death,	5	Amaurosis,	66
Slough of the feet from cold,	2	Cataract of both eyes,	15
Large abscess in palm, piercing to the back of the hand,	1	Cataract of one eye,	19
Extensive sloughing ulcer of nose and cheek,	1	Cataract incipient,	30
Malignant ulceration of the tongue and loss of half that organ,	1	Lippitudo,	330
Inflammation of ancle joint,	4	Pterygium,	348
Anchylosis of hip joints and partial do. of knee joints,	1	Trichiasis,	103
Fistula in ano,	9	Entropium,	185
Fistula, enormous,	3	Ectropium,	70
Polypus nasi,	5	Contraction of tarsi,	200
Tumour of lip,	1	Enormous fungus hæmatodes of the eye ball,	1
Tumour of neck, large,	2	Loss of both eyes,	44
Tumour of scrotum, enormous,	1	Loss of one eye,	73
		Loss of one from a wound,	1
			10,140

W. LOCKHART.

Shanghai, 15th August, 1846.

Mr. LOCKHART in ACCOUNT CURRENT with MEDICAL MISSIONARY SOCIETY.

From 1st July, 1845, to 30th June, 1846.

1845—July	10	Balance of last year's account in favour of the Society,	$ 419.60	Expenses from 1st July, 1845, to 30th June, 1846.			
1846—January		Rec'd. 5th Feb.	10.00	Medicines from Hongkong	$	84.30	
February		W. Pyke, Esq.	20.00	and Shanghai,		181.50	
				Servants' Wages,		8.85	
		Total Receipts,	449.60	Patients' Food,		47.06	
		Total Expenses,	361.71	Sundry Expenses on account of Hospital,		30.00	
		Balance due to the Society,	87.89	Rent for Three Months,		10.00	
				Loss by theft,		361.71	
					$		

Audited

T. C. BEALE.

W. LOCKHART.

Shanghai, 1st July, 1846.

Shanghai, 12th October, 1846.

REPORT OF THE CHINESE HOSPITAL AT SHANGHAI,

From July 1st, 1846, to June 30th, 1847.

By WILLIAM LOCKHART, Esq., M. R. C. S.

In presenting a Report of the Chinese Hospital for the last year, it is satisfactory to be able to state, that the expectations entertained of the favorable site of the new Hospital have been fully realised, as shown by the large increase in the number of patients; from the list of cases appended it will be seen, that the number of individuals attended to has been larger than at any former period since the establishment of the Hospital at this place; this most probably results from the greater confidence of the natives in the means of relief, and also from better accomodation being afforded to the in-door as well as to out-door patients, the large hall of the new building being a convenient place for them to sit in, while waiting to be attended to; and much better adapted to the purpose, than the open yard in which they formerly assembled, and where they were much exposed to the weather.

The mode in which the Hospital is managed is this, the building was erected and has been in part paid for, by donations received from England, from the members of the Foreign Community at, and from visitors resorting to this port. The property is vested in trustees chosen by the subscribers, and is rented temporarily to the resident agent of the Medical Missionary Society. At a general Meeting of the subscribers held in the hall of the Hospital in December 1846, it was judged desirable that all money subscribed for the Hospital should be paid to the treasurer of the Committee of the Hospital, he being authorised to pay to the medical officer such sums as are required for carrying on his work; hence a list of the local subscribers does not appear in the money accounts now presented, but the sums received are mentioned as paid by the treasurer, in the same way that grants are acknowledged from the Medical Missionary Society at Hongkong. It is intended that a list of the local subscribers, together with the trust deed of the property, shall be printed in a short time; this was promised at the beginning of the year, but it was eventually postponed for a time, until some final arrangements had been completed.

No particular reference is made in this report to individual cases treated at the Hospital, but the general nature of the diseases prevalent here may be gathered from the subjoined list of cases; almost the whole of the accidents enumerated occurred at the European buildings, and many of the Chinese servants of Europeans have been attended to; thus showing, that although the primary object of the Hospital is to draw the natives generally under instruction and relieve their bodily infirmities, still it is not without benefit to the subscribers themselves, by affording an asylum and means of cure for their sick domestics.

The observations on the temperature of the climate are still kept up, and the results as shown in the following table, may be relied upon as being tolerably correct:—

Range of the Thermometer under shade in the open air.

	Highest by day.	*Lowest by day.*	*Average by day.*	*Average by night.*	*Highest by night.*	*Lowest by night.*
1846.—July,	98 deg.	78 deg.	91 deg.	79 deg.	83 deg.	75 deg.
August,	92 ..	73 ..	80 ..	73 ..	80 ..	68
September,	90 ..	70 ..	80 ..	71 ..	80 ..	60
October,	80 ..	52 ..	71 ..	60 ..	67 ..	46
November,	70 ..	44 ..	69 ..	45 ..	54 ..	28
December,	65 ..	31 ..	53 ..	36 ..	48 ..	26
1847.—January,	63 ..	35 ..	47 ..	31 ..	42 ..	24
February,	63 ..	32 ..	44 ..	31 ..	41 ..	21
March,	77 ..	58 ..	41 ..	41 ..	61 ..	23
April,	86 ..	65 ..	47 ..	51 ..	65 ..	38
May,	83 ..	62 ..	70 ..	58 ..	65 ..	46
June,	90 ..	65 ..	76 ..	67 ..	77 ..	62

Two cases of Asiatic Cholera presented themselves; in one case the patient recovered, but in the other he died; the symptoms were similar to those noticed in persons afflicted with this fearful disease in Europe, namely the coldness and peculiar blueness of the extremities and face, cramps of the limbs, vomiting and rice water dejections, and general sinking of the powers of life. In the cases noticed here, the vomiting and purging were not very abundant, the pathognomic symptoms of the disease, being extreme exhaustion of power, coldness and blueness of the surface, with cramps of the limbs; indeed the purging existed to a very small extent in either case. From what is said by the natives, it is evident that they have occasional attacks of this fearful pestilence, which cause great mortality, and such a visitation is much dreaded; for an epidemic of this nature would make severe ravages among the inhabitants of the narrow, densely crowded streets and lanes of a Chinese city. In England, efforts are made by committees of public health, to clear the streets, open avenues for the admission of fresh air, and to adopt such regulations as tend to increase the salubrity of the towns; but the state of the cities of China sets all such regulations at defiance, and it is surprising that being exposed to so severe a heat, as that which prevails during the months of summer, the inhabitants should be able to live in their small unventilated houses. To take away their fans would be a worse punishment for a time, than taking away their food; without the fan they would be most miserable, and its constant use tends much to the comfort, and consequently to the health of the people. It is amusing to see how the Chinese employ the fan; not in a quick and hurried way, involving much exertion, as is the practice of Europeans usually when fanning themselves, but in a quiet uninterrupted manner, which, while it removes the hot air and answers the purpose of a refrigerator, does not cause any fatigue. When the state of a Chinese city is examined, it is not surprising that the people should suffer much from dyspepsia of various forms, but the matter for wonder is, that in a country, where in summer the thermometer ranges from 80° to 100°, and where the habits of the people both personal and domestic are so filthy, the inhabitants can exist at all without more disease then appears to pre-

vail among them. If the same carelessness regarding public health, joined with equally pernicious practices, were to exist in European towns, there can be little doubt that typhus fever and other fatal diseases would exist to a large extent.

During the whole of the spring, small pox has been very prevalent among the Chinese, both at Shanghai and through the surrounding districts; almost every family has been afflicted, and many children have died of the disease. As is generally the case during an epidemic of small pox, there were many cases of chicken pox, which ran its usual mild course. The only case of small pox among the Europeans occurred in the family of the Medical officer of the Hospital, in the person of an unvaccinated child, but the disease was of a mild type and the child soon recovered. Several Europeans were affected with varioloid, and at Woosung there were two or three cases of small pox in unvaccinated European adults. All the supplies of vaccine lymph both from England and Canton have failed in producing the vaccine vesicles, and it has been impossible to carry on vaccination as it was desired, and thus to have shielded the natives from the infection of small pox. In former reports it has been mentioned, that the Chinese do frequently inoculate their children when three years old, but it would appear that this is not universally attended to, and though by inoculation, the virulence of the disease is in some degree mitigated, the great objections to this procedure ever present themselves, namely that use is made of a most dangerous agency, which may disfigure and even kill the child, and also that a direful disease is thus propagated and maintained among densely populated and ill ventilated dwellings. As was shown on a former occasion two years ago, the Chinese readily appreciate and avail themselves of the benefits of vaccination, and during this year they were most anxious to have this means of safety afforded to their children, but after repeated and constant efforts, the vaccination has not succeeded in a single instance, and the people have consequently been much disappointed.

(September;—since the above was written, some lymph sent from Canton has taken effect, and several persons have been vaccinated and endeavours are being made to keep up a regular supply.)

The religious services at the Hospital are maintained as usual, and thus the spiritual as well as the temporal wants of the people are attended to as much as possible. May these efforts be blessed of him who is our Master in heaven, and may this prople find peace and joy in casting away their idols and all their superstitions, and loving him only with all their heart and soul.

List of Patients attended to at the Chinese Hospital, Shanghai, from 1st July, 1846, to 30th June, 1847.

Intermittent fever,	473	Severe contusions,	6
Tussis,	1,440	Contusion of abdomen, rupture of liver and death,	1
Asthma,	487	Concussion of the brain,	2
Hæmoptysis,	247	Severe wounds,	10
Phthisis,	115	Gun shot wounds,	5
Dyspepsia,	2,024	Dislocation of wrist,	1
Dysentery,	325	Dislocation of ancle,	1
Hæmatemesis,	26	Fracture through base of skull,	3
Jaundice,	33	Fracture os frontis,	2
Ascites,	45	Fracture neck of scapula,	2
Anasarca,	53	Fracture clavicle,	2
Rheumatism,	1,624	Fracture tibia and fibula,	3
Rheumatic enlargement of joints,	22	Fracture thigh,	1
Opium smoking,	40	Fracture radius,	2
Paralysis,	10	Compound comminuted fracture of patella,	1
Surditas,	119	Compound fracture of humerus,	1
Asiatic Cholera,	2	Division of malleolus interior and tendo achillis,	1
Hernia of various kinds,	196	Catarrhal ophthalmia,	383
Hydrocele,	21	Chronic conjunctivitis,	600
Variola,	3	Granular lids,	628
Abscess,	189	Granular lids with opacity,	588
Ulcers,	554	Granular lids with pannus,	414
Ulceration of throat,	6	Leucoma,	245
Enormous ulcers on various parts of the body,	5	Staphyloma,	78
Abscess of digital theca,	6	Ulceration of cornea,	708
Elephantiasis,	72	Conical cornea,	17
Leprosy,	107	Irregularity of pupil,	165
Psoriasis,	185	Closure of pupil,	25
Psora,	418	Hernia iridis,	14
Porrigo,	36	Synechia,	20
Lepra,	249	Cataract single,	41
Porrigo decalvens,	24	Cataract double,	18
Polypus nasi,	19	Cataract incipient,	73
Polypus malignant,	2	Amaurosis,	90
Ganglion of wrist,	6	Pterygium,	384
Excrescences round anus,	42	Lippitudo,	424
Fistula in ano,	35	Trichiasis,	232
Prolapsus ani,	11	Entropium,	248
Soft nodes on bones,	4	Ectropium,	155
Carcinoma testis,	2	Contraction of tarsi,	185
Sarcoma testis,	5	Inflammation of lachrymal sac,	14
Secondary syphilis,	8	Fistula of lachrymal sac,	6
Lupus faciei,	1	Loss of one eye,	57
Osteo-sarcoma of superior and inferior maxilla,	4	Loss of both eyes,	38
Caries of inferior maxilla,	4	Fungus hæmatodes of eye ball,	1
Caries of tibia,	3	Fungus hæmatodes in child,	1
Adipose tumour of thigh,	1	Fungus of eye lid,	1
Tumour of toe, large,	1	Wound and destruction of eye by a shoemaker's needle,	1
Enlarged glands of neck,	6		
Tumour of neck pressing on the trachea in a child,	1	Total	15,217
Severe burns,	8		

W. LOCKHART.

The thanks of the Committee of the Hospital are given:—

To the West London Association of Ladies in behalf of Medical Missions to the East, through Mr. CHARLES, for donations of Instruments, Medicines, &c.

To the Hackney Association of Ladies in behalf of Medical Missions to the East, through Miss KIRKPATRICK, for donations of Medicines.

To Dr. COLDSTREAM, of Leith, for a box of Medicines.

To the Juvenile Missionary Association at Crescent Chapel, Liverpool, through SAMUEL BLACKBURN, Esq., for donations of Instruments, Medicines, and Books.

To the London Missionary Society for a donation of Medicines.

MR. LOCKHART IN ACCOUNT CURRENT WITH MEDICAL MISSIONARY SOCIETY.

From 1st July, 1846, to 30th June, 1847.

			$		$		$
1846—July	10	Balance of last year's account,	87.69	Hospital Sundries: Patients' Food, Oil, Candles, Charcoal, Coal Buckets, Chops, Jars, Soap, Paper, Books, Towels, &c. &c.	44.60		
Nov.	3	Received from the Medical Missionary Society at Hongkong,	100.00				
1847—March	1	Received from Charles Shaw, Esq., Treasurer of the Committee of the Hospital,	100.00	Servants' Wages, ...	184.00		
				Removing to New Hospital,	13.00		
				Purchase of Medicines, ..	42.00		
May	10	Do. do. do.	100.00	Purchase of Medicines at Native Hospital, ...	26.70		
June	30	Do. do. do.	97.25	Instruments from England, ..	21.00		
				Books from England, ...	62.50		
				Ground Rent, ...	6.85		
				Carpenter's Work, ...	84.50		
			$ 485.15		$ 485.15		

W. LOCKHART.

Shanghai, 30th June, 1847.

REPORT OF THE NINGPO MISSIONARY HOSPITAL TO THE MEDICAL MISSIONARY SOCIETY OF CHINA.

By D. J. MACGOWAN, M. D.

On account of unhappy differences among the friends of the Society at the South, and the consequent financial embarassments, the Ningpo Hospital was closed early in the season; since which period, the sick have received medicines from the Chapel of the Mission, and from the Physician's private residence, and to some extent have been visited at their own dwellings. Of medicines, there was not an adequate supply, and the time occupied in visiting the houses of the patients limited very much the number of those who were the recipients of the Society's bounty; thus only 1,970 cases have experienced its benevolence.

Wounded Soldiers.

In the month of October of last year, the inhabitants of the neighbouring city of Funghwa rebelled against their rulers, and expelled them from the city. The insurrection was occasioned by some dissatisfaction, in relation to the payment of the land tax, though the immediate cause of the revolt, was the infliction of corporal punishment by the Chekieu, on one or more literary men, who were pleading the cause of the people. The civil and military authorities of this department, with a force of 1,200 men, marched against the insurgents, but suffered a signal defeat before they reached the walls of Funghwa; the disturbance was subsequently quelled. The loss of the Imperial troops in the encounter was estimated at first at 100 killed and 300 wounded, subsequently it appeared that only 18 were killed, and 150 wounded. The T'ituh or Governor sent his chair for the Physician to see the wounded, whom he had conveyed to one of the Temples. With the assistance of Dr. Yvan of the French Embassy, their wounds were carefully dressed, and such attention paid to them as their respective cases required. With a few exceptions, the injuries were slight, and quickly healed. They were for the most part incised wounds, and bruises, inflicted by spears, arrows, and clubs: no fire arms were used except by the regular army, and then with but little effect.

Among the wounded was the Chihien, or mayor of Funghwa, who was under medical treatment more than two months for an injury received in the action. In the retreat, he was overtaken by an arrow, which entering the lumbar region, pierced him to the spine. His secretary was killed at his side; indeed he appears to have been a courageous officer, and was in the thickest of the fight the whole time, and received in all six wounds. On recovery, he expressed his gratitude in the strongest terms, for the surgical aid which had been afforded him.

Alopecia.

Alopecia, or baldness, is almost a universal affection among the females of this part of the Province of Chekiang. There is scarcely a woman who has attained her 30th year, whose head (with the exception of the parietal, and occipital portion) is not perfectly bald. The affection does not appear under the age of 18 or 20, and is unaccompanied with change of colour, the rest of the hair remaining black until 50 and upwards. It is difficult to assign a cause for the prevalence of Alopecia in this place. In one of the Shetland Islands (where the affection is so common as to give rise to a saying among the inhabitants, "that there is not a hair, between a Fair Isle man and heaven") the cause has been referred to the free use of fish: the same might be suspected to exist here, were it not that the males whose diet is the same, are remarkably exempt from the affection. It cannot therefore be owing apparently to the use of fish, unless the tonsure of the the male acts as a prophylactic. Chinese females spend much time at the toilet, and almost entirely confine their care to the combing and arranging of the hair. They employ a simple mucilaginous liquid, obtained by macerating the shavings of the Lien in water, which gives a gloss to the hair, but cannot from its nature tend to produce baldness. It might be attributed to the practice of wearing the hair drawn back tightly from the forehead, but as this fashion prevailed at one time among our Western ladies, without occasioning Alopecia so far as information can be obtained, it can hardly be attributed to that cause.

Poisoning by Arsenic.

On first arriving at Ningpo, a box of medicines of the value of sixty dollars was stolen by the coolies or boat-men. In the beginning of the year, a theft of the same kind was perpetrated on a smaller scale, but attended with serious consequences. Whilst changing residences, a man employed in removing the medicines purloined one and a-half pounds of arsenic, taking it for foreign flour. The greater part he made into *cakes*, which were caused to adhere by a small admixture of flour. *Ten* persons partook of these cakes, but happily the quantity taken was so large, that in all but one case, it acted as an emetic, and was promptly ejected from the stomach.

A poor old woman however who eat of them sparingly, died in consequence—all the others escaped, but had for some time more or less inflammation of the stomach. The parties took all the blame to themselves, and the matter was soon dropped. Much gratitude was expressed to the physician for the relief he afforded them.

General Health.

The city has been remarkably healthy during the past year. Intermittent fever, and diarrhea have chiefly prevailed, but in mild forms.

The latter complaint frequently attacks foreigners in the summer season, which a few hours sailing among the islands of the Chusan archipelago is almost sure to arrest. Lichen tropicus or prickly heat is a source of much inconvenience to foreigners. Towards the close of the hot season, natives, as well as foreigners, are liable to be affected with boils.

Bandaging the Feet.

Ulcers are very common amongst the poor; the worst form of those that have been treated, were on the feet and legs of women. Bandaging the feet, if not the cause of ulcer, certainly prevents to a great extent their cure: they are also affected with corns and other callosities of the feet. Other evils, the result of this pernicious and cruel practise, might be detailed, if this report were intended for the perusal of professional readers. That a custom so barbarous could be imposed upon a comparatively civilized country, whose inhabitants number by hundreds of millions, is one of the most singular facts in the history of our race, and illustrates the deference which the Chinese pay to Imperial wishes. The custom, comparatively speaking is of modern origin, and owes its existence to the whim of Leyuh, the licentious and unpopular prince of Keang-nan, whose court was in Nankin. He ruled from A. D. 961 to 976, and was subdued and finally poisoned, by the founder of the Sung dynasty. It appears that he was amusing himself in his palace, when the thought occurred to him, that he might improve the appearance of the feet of a favorite concubine. He accordingly bent her feet, so as to raise the instep into an arch, to resemble the *new moon*. The figure was much admired by the Courtiers, who at once began to introduce it into their families. Soon after the province of Kiangnan again became an integral part of the Empire, from which point the new practice spread, throughout all provinces and all ranks, until it became a national custom. Many lives were sacrificed by suicide. Those females whose feet had not been bound, were persecuted by their mothers in law, and despised by their husbands, so much so that many hung themselves, or took poison. About 150 years after the origin of the practice, we find a Poet celebrating the beauty of the "Golden lilies" which he makes just six inches long; from which it would appear that six centuries ago, they were of the same size as those of the present day. According to the theory of Lord Monboddo, and Monsieur Lamark, such continued compression for centuries should have occasioned a material alteration in the structure of Chinese feet, but nothing of the kind is observed; for until they attain their seventh or ninth year, when the painful process of bandaging commences, the feet are perfectly natural, both in size, and figure. This custom, though deeply entwined in the feelings of the people, could be abolished by a single sweep of the vermilion pencil. The present dynasty could abolish the cruel custom with less opposition, than was experienced in introducing that degrading mark of subjection the tonsure.

There have been (and now are) in China those who possess the humanity and moral courage to express their dislike of the practice. Among them may be mentioned Yuen, a member of the Hanlin College, a writer of celebrity in the latter part of the last century. In the most popular of his works, entitled "the Sayings not of Confucius," he represents Prince Leyuh, as suffering in purgatory, for the introduction of such a vile custom, and awaiting with much impatience the expiration of the 700 years, which he had been condemned to suffer, before he could attain to his original state of a Priest in Sungsan; but in profound ignorance of another punishment, which awaited him on the completion of the first period. Authentic history informs us, that a celebrated robber, during the period of anarchy which ushered in the reigning dynasty, cut off the feet of an immense number of women, and made a pyramid of them. The spirits of these women, several myriads in number, are represented by Yuen, as vociferously demanding of Heaven further chastisement upon Leyuh, whom they regarded as being the author of their sufferings, and small feet, to which the robber had an antipathy. Whereupon the prince was condemned to make a hundred myriad of shoes for those women. It may here be added that Chinese females can scarcely stand, and cannot walk without their shoes.

Opium Smoking.

Remarks on the moral, or political bearing of opium smoking are inexpedient in this place; the subject is merely adverted to from the fact, that applications are continually made for relief, by those addicted to the dreadful habit. Indeed it is extremely difficult for a medical observer, to omit noticing a practice so fraught with painful interest to every humane mind, and so intimately connected with the physical interests of this great empire. A typograpical error in last year's report made it appear, that the *tradesmen* of this department were not addicted to the vice of opium smoking, it should have said, that the *agricultural* class was the healthy portion, in consequence of their inability to procure the fatal luxury. So long as the price of the drug is kept up, the *sinews* of the empire will retain their natural power, and sustain only a reflex injury. The highest functionary in the province lately issued a proclamation against vice and immorality, by Imperial authority. Among the prohibitions was the culture of the 罌粟花 *Ying-suh-hwa*, under penalty of death, if the cultivation be not given up six months after the date of the proclamation. A like penalty was threatened against all who sold, or used the article. It is cultivated to some extent in the neighbouring departments, to the south and south west, particularly in districts coterminous with the province of Fokien, where the rulers possess but little power, and want the inclination, or ability to prevent its growth. Twenty years ago, the plant grew wild in waste places; but has gradually become a staple product in many districts. From the capsules of the plant (which are procurable

in the druggists' shops here) it would appear that it is the *Papaver Somniferum;* at least, it possesses affinity to the opium of commerce, and of the Pharmacopœias, and must be a variety of the same family. The concrete juice is obtained in the same manner, and produces the same effects when smoked, though the sensations are less agreeable, and it is therefore used only by those, who cannot procure the imported article, which perhaps owes its superiority to the great care taken in its growth and preparation. A Philanthropic native, deploring the effects of opium smoking on his fellow citizens, issued a handbill containing directions for overcoming the habit. The articles recommended were *Liquorice*, *Honeysuckle* flowers, and half a dozen other articles, equally inert, but sufficiently potent when the accompanying directions were followed, viz: "To refrain resolutely from smoking whilst taking the physic for ten days," if at the end of that period the appetite returned, the physic to be continued. Very few made the experiment, because it was said "the articles were so cheap and common, it could not be that they could effect a great thing." One case came under observation, in which the remedy was successful or seemingly so, for the individual, though a confirmed opium smoker, has not used the drug for four months. Acting on the hint thus given, empirical remedies, addressed chiefly to the imagination, have been administered to a number of applicants, which there is reason to believe have been successful in some of the cases. Among the applicants was the *Chehien* or mayor of Hangchow, who left his opium box, as an evidence of his anxiety to be delivered from his bondage, saying, that if the medicines he took with him failed to effect a cure, he would send for more. Several months have elapsed since his visit, during which time he has not been heard from. Several cases of infanticide, and suicide have come under notice during the past year, and are not regarded as extraordinary events by the inhabitants.

Meteorological Phenomena.

The climatic features of the department in which Ningpo is situated, exhibit great extremes of heat and cold. For three months in summer the heat is oppressive in the extreme. During the present season, the thermometer has ranged from 96 to 102 in the shade, for many days in succession. In winter, though the thermometer seldom falls below 22°, yet the piercing blasts of the north east monsoon (which resembles the "Bize" of Switzerland and the Harmattan of Italy) deprives the body so rapidly of its caloric, as to occasion the sensation of extreme cold. In general terms it may be said, we have a hot and a cold season, of three months each, with intervening agreeable periods of the same duration. On the 15th of last March, there was a fall of dust at Ningpo, apparently of Volcanic origin. It fell also at the same time at Shanghai, but in greater quantities. A vessel about three hundred miles from the coast is reported to have fallen in with a quantity of pumice stone floating on the sea. * If of volcanic origin,

* For a more detailed account of the Phenomenon, see communications

the dust may have been wafted, the wind being fair, from one of the Volcanoes of the Japan archipelago; probably from Mount Fusi, which it is well known is subject to frequent eruptions: ejecting dust, which at Dezima has been several inches thick. The estimated altitude of Mount Fusi is 14,000 feet. At ½ to 4 A. M., on the 4th of August 1846, there was an earthquake at Ningpo, of nearly three minutes duration. A long drought, and excessive heat was previously experienced. The atmosphere was in a highly electric state, and for some days prior to the subterranean commotion, all nature appeared stagnant. The barometer afforded no indication of any approaching change, and at the time of its occurrence, the fall was scarcely perceptible, nor was there any wind. (It may here be remarked that the barometrical variations at this station are very slight. During the whole of last winter Mr. Thom's barometer hardly ever varied more than from 29. 90. to 30°., and during the whole of this summer, it has hardly changed more than from 29. 50. to 29. 60.) The motion of the earthquake was of a rocking kind, and very uniform: causing the beams of houses to creak like the timbers of a vessel, under a press of sail, with a high sea. When the vibration was about half over, there was a loud noise, such as the rushing of a typhoon through a thick forest, might be supposed to occasion: it continued for ten minutes, and moved from the south east, to north west, which was evidently the course of the earthquake itself. The tract of country where the phenomenon was experienced was about 140 miles long and 60 broad; after the earthquake, the thermometer fell to 96 being about 4 degrees; the day was hazy, and at night a small quantity of rain fell. These was but little lightning at the time or afterwards. Intelligent natives say "that in the 8th year, 7th month and 24th day of the reigning emperor, (September 1828) in this fu, Funghwa district, and Fungpu neighbourhood, fire issued from a mountain called Kikia (Pencil frame.) This mountain is exceedingly steep, and quite inaccessible, and has a cone (crater?) in its side, near the summit; on that day great thunder was heard, as if in the mountain, when fire issued out of the cave, which continued to blaze for more than two days, when it stopped. Ashes were thrown in all directions. Men did not know what to make of this affair!!

Medical Lectures.

Unavoidable delays have prevented thus far the carrying out of one of the professional objects, which we have ever had in view, viz: the communication of anatomical, and physiological instruction by means of lectures, to native practitioners and their students. Several native surgeons are waiting with some impatience, the arrival from Paris, of the long expected models, by which the attempt is to be made, of lecturing on the elementary principles of Medical and Surgical Science.

from Dr. Bellot of H. M. Ship *Wolf* and Dr. Macgowan in the Journal of the Asiatic Society of Bengal for 1846.

The chief design of professional labours in this place (and that to which it is hoped all others may be subordinate) has been the dissemination of Gospel truth, and the conversion of idolaters to the Saviour of the world.

Acknowledgments.

Thanks are due to Dr. McCartee of this city, for kindly taking charge of the hospital for a season, when otherwise operations would necessarily have been relinquished; and also to the following individuals:—

Captain Bamfield, 11 Blankets.

M. A. A., for Medicines.

Drs. Lewell, Little and Kowand of Philadelphia, for Books and Medicines.

To Dr. Thompson of New London U. S. A., for a box of Medicines, valued at 100 dollars, shipped by the *Arcatas*, and daily expected.

The Publishers of the American Journal of the Medical Sciences, kindly send a copy of their work to this station.

We are also favored with the N. Y. Journal of Medicine, and the American Journal of Insanity, by their respective Editors Drs. C. A. Lee and A. C. Brigham.

H. B. M. Consul, R. Thom, Esq., kindly contributed to the Society the sum of 50 dollars.

Brief Statement of the Patients Treated at Ningpo, from 1st September, 1845 to 31st July, 1846.

Intermittent Fever,	236
Diarrhœa,	167
Diseases of the Skin,	321
Opthalmia,	414
Wounds, Ulcers &c.,	272
Miscellaneous,	560
Total	1,970

Of these 1,638 were Males and 332 Females.

Ningpo, 22nd August, 1846.

REPORT OF THE DISPENSARY AT AMOY,

For the Year 1846,

By Dr. W. H. CUMMING.

More than a year has passed since Dr. Hepburn's departure left me in charge of the Amoy Dispensary. In the mean time the Society has appointed me to fill his place as its agent at this station, and as such I would give a brief account of the affairs of the Dispensary since June 1845.

During this period the number of patients received has been less than in the preceding year. The monthly average of entries in 1844 was 200, whereas during the past year it has been 70. Making al-

lowance for the absence of Dr. Hepburn, there is still a decrease of 30 per cent, which is worthy of notice. And I am happy to be able to state, that with this diminution in the number of cases received and entered upon the books of the Dispensary, there have been more persons *under treatment* than in any former year. Ignorance of the language, and inexperience of the habits of the people, formerly led us to receive without hesitation, all who were not apparently incurable. Men from a distance sought our aid, and were readily admitted, who could not follow the prescribed course of treatment. Many of these did not return, and many more came for a few days only. Others, knowing that we rejected as hopeless many long standing cases, made false statements respecting the dates of the diseases. Gross falsehood of this kind was occasionally detected, but many were received in good faith whose cases were far beyond our skill. Thus were many names enrolled of persons who derived no benefit from our advice. During the last year a great change has taken place in this respect. The examination of the patients has been more carefully conducted, in order to elicit the truth from the error and confusion of their careless, inaccurate and often wilfully false representations. Cross-questioning is not more important in legal than in medical practice, and while unable from ignorance of the language, to employ this most valuable test, the diagnosis cannot be confident nor the prognosis sure. Many cases have thus been rejected, which would formerly have been admitted. Many applicants not residing in Amoy or its vicinity have been told, that unless they came to the city, nothing could be done for them. Of these some have never returned; others more anxious to be treated have spent weeks or months in Amoy. The majority of these applicants can scarcely be made to comprehend the motive of refusal; they seem to think that a little additional entreaty is alone necessary to ensure their reception. They are often most pertinacious in their requests, and appear unable to see the folly of hoping to be cured in one or two days of long-standing disorders.

Of those admitted, many still fail to fulfil their promise of regular attendance, but in this respect there has been a great improvement. This change has been useful to all concerned. To the patient it has in many cases spared much useless suffering, while to the physician it has given many hours, which must otherwise have been wasted to no purpose. And as the study of the language has demanded and still demands much of the physician's time, it is important that none should be needlessly devoted to hopeless cases. A longer acquaintance with the people serves to show more clearly their unwillingness to undergo the long-continued treatment which many diseases require. Accustomed to consult ignorant pretenders to medical skill, they are ready to take the prescribed remedies for a few days. But if they are then conscious of no improvement, they can rarely be induced to persevere. Yet there are many exceptions to this remark and their number is constantly increasing.

Another fact of interest is, that many of those formerly treated have returned to seek remedies for new disorders, and that they frequently

bring their relatives and friends for the purpose of seeking aid. Should these cases multiply, we may hope to have in Amoy a number of steadfast friends, on whom our influence may be physically and morally good.

Conjunctivitis (ocular),	76	Entropium,	8
Conjunctivitis (palpebral),	37	Blenorragic conjunctivitis,	3
Keratitis,	80	Iritis,	56
Blepharitis,	17	Affections of the lachrymal passages	4
Opacity of cornea,	14	Miscellaneous affections of the eyes	17
Granulated lids,	2	Trichiasis,	5
Vascularity of cornea,	11		
Pterygium,	9		339

In more than two-thirds of the cases of Iritis, the right eye has been affected alone, and in less than one-third of the cases the left eye has been alone diseased. The cases in which both eyes have suffered are only eight per cent of the whole number.

Keratitis, being the disease which offers the smallest chance of mistake, has been selected in order to show the manner in which the Chinese improve the offer of gratuitous treatment. These facts will show at the same time that much time is really wasted by the physician and patient. Of 49 cases of Keratitis admitted, 5 never returned; 16 ceased to attend after two or three days, so that they derived no benefit from the treatment; 24 remained long enough to receive benefit varying from a slight improvement to almost entire restoration; only 4 were discharged cured. It is due, however, to the patients to say, that of the above-mentioned 24, about one-half remained from 20 to 137 days, and we must not wonder that their patience failed after so prolonged a treatment.

Syphilis (primary, secondary, and tertiary),	90	Orchitis,	1
Blenorrhagia,	10	Hydrocele,	4
Epididymitis,	2	Amenorrhea,	1
			108

Of the 90 cases of Syphilis, 46 were affections of the skin, some of them of two or three years duration. The frequency and persistence of this form, and the great variety of the ulcerations of the throat are worthy of remark. I have not yet (during more than four years practice among the Chinese here), seen one case of syphilitic ulcerations of the throat. It would be an interesting inquiry whether this peculiarity is observed in India and other warm climates.

Scabies,	60	Erysipelas,	2
Eczema (chronic),	9	Lichen,	1
Herpes (zoster, circinatus, and phlyctenodes),	6	Lupus (which had completely destroyed the nose),	1
Prurigo,	5	Pityriasis,	1
Ecthyma,	4	Miscellaneous (of difficult diagnosis),	8
Porrigo favosa,	3		
Impetigo,	2		104
Lepra vulgaris,	2		

Lupus seems to be a rare affection here. The above-mentioned case is the only one I have yet seen in or near Amoy. There are some cases

of diseases of the skin here, which seem entirely different from those known in Europe, and of which the elementary lesion seems different from those admitted by classic writers on this subject.

Cough (these cases have not been classified),	30	Hæmoptysis,	3
Asthma,	12	Laryngitis,	1
			46

During the year many cases of tubercular phthisis have been observed, but as nothing could be done, their names were not recorded. There are many cases of hæmoptysis among these, but I have recorded only those that have been admitted for treatment. To-day (Sept. 15) three well-marked cases of tubercular consumption presented themselves. It is said to be more frequent among the rich than among the poor. If this be true, it probably results from the greater mortality among the children of the poor, while the superior hygienic position of the rich protracts the fatal period.

Anasarca generally succeeding intermittent fevers,	10	Tertian intermittent fever,	29
Continued fever,	6	Quartan do. do.,	29
Quotidian intermittent fever,	23	Double quartan do. do.,	1
			98

The quartan fevers have been treated with great success this year. No paroxysm has occurred after the fifth day of treatment; and in most cases none after the second day. Fowler's solution has been invariably employed, usually in doses of from 7 to 10 minims, given three times daily. In a few cases the dose has been increased to 15 minims. In no case has any untoward accident occurred. In two or three cases in which the bowels seemed irritated by its use, an equal quantity of laudanum was added. This completely obviated the necessity of relinquishing the medicine, and the result was equally attained. I enter into these details because many estimable practitioners avoid this remedy, and such statements as these will tend to give them confidence in this much slandered preparation.

Rheumatism,	16	Lumbago,	3
Arthritis (gout),	6		
			25

The last year has presented six cases of arthritis of which four have offered all the symptoms of the classic podagra. Two of these had been and are still addicted to the excessive consumption of ardent spirits. The other two were poor agricultural labourers, and a careful examination could elicit nothing explanatory of the origin of the disease.

Angina,	1	Diarrhœa,	14
Gastralgia,	40	Dysentery,	10
Gastralgia and Pyrosis,	33	Congestion of liver,	3
Pyrosis,	8	Jaundice,	4
Indigestion,	7	Ascites,	5
Gastritis,	1	Miscellaneous medical cases,	36
Enteralgia,	4		
Enteritis,	1		167

These have been for the most part cases of debility following fevers. The convalescence is often very tedious. Though the Chinese pharmacopœia is rich in articles reputed tonic, the high price of those most esteemed keeps them out of the reach of the poor. The American ginseng is much inferior (in public estimation) to the Tartar or Corean plant. As all European experiments of late have been made with the American root, would it not be well to compare this with the Asiatic?

Abscesses,	10	Enlarged parotid,	1
Ulcers,	18	Ranula,	1
Panaris,	4	Meliceris,	1
Phlegmon,	3	Hæmorrhoids,	1
Anthrax,	3	Fistula in ano,	1
Hernia,	2	Miscellaneous surgical cases,	15
Polypus nasi,	2		
			62

The Abscesses here recorded are all of the more important kind, either from their situation or magnitude. As the Chinese here do not venture to use any instrument more formidable than an acupuncture needle for giving issue to pus, serious evils often follow simple abscesses. Extensive *fusee's* often occur, followed by atrophy of muscles and fixity of tendons. Panaris is frequent and often makes sad havoc. The cases here recorded had already gone so far as to ensure the rigidity of the fingers affected. Several cases have been treated from the commencement and have not been noted. The case of Ranula was very remarkable. Not only was there a tumour on each side of the frænum, but one near the right submaxillary gland. The former were punctured, but the patient would not allow the last to be opened. Among the miscellaneous surgical cases is one of an operation for the removal of a steatomatous tumour from the neck of a woman. The tumour was superficial and about the size of a hen's egg; the operation involved no organs of importance, yet on the second day, there was such pressure on the œsophagus and trachea that swallowing was almost impossible and breathing impracticable except in an erect position. These symptoms so unusual in superficial wounds of the neck, were relieved by a large dose of eroton oil and did not return. It is an incident worthy of note from its rarity in such cases.

P. S.—Dr. Cumming is now absent on a visit to America, and the Dispensary temporarily closed.

To the Committee and Friends of the

MEDICAL MISSIONARY SOCIETY, HONGKONG,

Communicated by BENJAMIN HOBSON, M. B. London,

Member of the College of Surgeons.

Gentlemen,—My letter to the Secretary, dated July 1845, informed the Society of the arrangements I had been able to make for the conducting of this hospital during my absence in England.

The Rev. V. Stanton, kindly took charge of the premises, disbursed in the most careful manner the monies for the monthly expenses of the hospital, and by a judicious superintendence promoted in many ways the prosperity of the institution.

It is I believe from a representation sent in by Mr. Stanton, that the local government of Hongkong has given a grant of $300 a year, to defray the expenses incurred by the frequent cases of injury and loathsome disease met with on the public roads by the police, to which the hospital has often afforded an asylum, while in other cases received too late for cure, the hospital funds have been necessarily expended to inter the friendless dead.

I have been truly rejoiced to find that the hospital has not been obliged from want of medical attendance to close its doors for even a single day, since it was first opened in June 1843. Many indeed have been the changes during my absence, which are painful to refer to. Two professional brethren who took the deepest interest in this institution, and who generously came forward to relieve me of my hospital charge, are now in the Providence of God numbered with the dead. Alfred Tucker of the *Minden's* Hospital, and Francis Dill, Colonial Surgeon, were both severe losses to this colony, and there are many friends yet remaining who sincerely deplore their sudden and unexpected removal from our midst. I can only say I acknowledge and remember their disinterested kindness and valuable assistance to myself with much feeling and gratitude.

It becomes me also not to forget the long continued and disinterested services which Dr. Balfour has so cheerfully rendered to this Institution since the demise of Drs. Tucker and Dill. From a pure, benevolent regard to suffering humanity, Dr. Balfour regularly attended this hospital to give his advice to all that applied, which demands from me and all the friends of the Society a public expression of our thanks.

For the four years this hospital has been in operation, 12,139 patients have been registered on the books, chiefly men and children from the colony, and from the villages and towns on the main land who have often come long distances, paying their own expenses going and coming, purposely to be healed. The numbers have not been so great as at Shanghai and Canton, the native population here being smaller and more scattered, but in no hospital yet established in China have there

been more in-patients, or more serious cases received. Of course the non-residence of a medical officer for two years has been a disadvantage to the Institution, and from this cause, and also from less sickness prevailing in the colony, the number of applicants has been reduced. The applicants for medical aid are chiefly of the poorer class, and in many instances beyond the limits of surgical skill. From examining the books I find that cases of severe contusion, wounds and ulcers have been frequent. Of cutaneous diseases, Psora, Psoriasis, Eczema, Lichen and Leprosy have been the most common. Fluxes and Chronic diseases of the absorbing and secreting glands, and different forms of fever, periodic and remittent, have been the principal and most important diseases of the internal organs and general system. But the list of patients plainly shews a diminution in the amount of fever cases as compared with the years 1843-44, so that Hongkong, especially the west end of Victoria, is now regarded as a very healthy settlement by the Chinese. Disorders of the visual organs both in this and in all the hospitals on the coast have been, by far, of the most frequent occurrence. And it is a remarkable fact among other strange and peculiar characteristics of the Chinese, that diseases of the eye should be so common and so universally prevailing among them; and that for so long a period this nation should continue ignorant of their nature and mode of cure. For example, the cornea, the transparent part of the eye is without a name to describe it. Cataract is quite unknown to be an opacity of the crystalline lens or its capsule, and the whole internal structure of this admirable piece of mechanism is grossly misunderstood, arising doubtless from want of anatomical knowledge. And so long as it is considered unfilial and wicked to make any breach or wound upon the dead, there is not much hope that this obstacle to improvement will be removed. It is singular however that the Chinese medical practitioners, in their attempts to cure these common ophthalmic diseases, did not hit upon the idea of expanding their knowledge by the study of comparative anatomy. But no. All study of animated nature is neglected and despised; error is preferred to truth, and the ignorant sayings of their ancient literati, before the splendid discoveries of modern experimental science. The time however will come when this abject deference of the Chinese to the wisdom of their sages, this slavish adherence to ancient custom, and dislike to all innovation and change (for it is nothing less than a state of intellectual bondage), must give way to the onward march and superior light of true science and religion. Dark superstition and spiritual ignorance at present rests upon the people; the free exercise of thought and intellect is suspended, and all moral improvement prevented by the withering, benumbing influence of a base idolatry. To raise them from this state is surely a most worthy object of benevolence and mercy. And if we are enlightened and blessed with the knowledge of Christianity, we shall doubtless feel it a pleasure and a privilege to do all we can to extend similar advantages to the innumerable heathen people around us. The liberalizing influence of a Christian education and the benevolent operations of Missionary hospitals are worthy of

all encouragement and patronage; but it becomes us all to remember that it is only by the power of Divine Truth that any great change in the moral and intellectual improvement of this people can be effected.

You will pardon me, Gentlemen, for introducing these sentiments in this short report. It is simply for the purpose of removing any false impression that some may entertain of the indispensable, reforming nature of Medical Practice among the Chinese: and also to afford me a public opportunity of declaring my opinion, that Medical Missions are only valuable in my eyes as they directly promote the extension of Christianity. For no other object surely than this, the noblest of all, could men be found willing to forfeit all secular advantages, and to come hither, just with a bare measure of support, to devote themselves to the service of the Chinese. And yet I have heard it said that the only hope of revolutionizing the moral, intellectual and social condition of the Chinese, is by medical practice and education. I think they are very important and very desirable among a people so exclusive and prejudiced as the Chinese are proverbially known to be; at the same time let us not limit the Divine power, but subordinate all such benevolent efforts to the fulfilling of our Saviour's great command, to teach the Gospel to all nations.

There have been no sectarian views or national prejudices disseminated in this hospital, but from its first opening to the present time, it has been made to combine the two-fold character of a benevolent and religious institution. I have sought to sustain the genius of Christianity by works of mercy, kindness and charity. Religious exercises have been conducted every day in the Canton dialect in the morning, and in Fok-keen or Te-chew in the evening. From these, and from the religious books distributed, a large amount of information has been communicated, not only to the patients but also to their fellow villagers and townsmen, on their return home. A few have expressed a concern to know more of these new doctrines, and some have been willing to become Christians, but without sufficient knowledge to justify Baptism, with the exception of one, whose views and knowledge of Divine Truth are more satisfactory. It is doubtless discouraging to see so little fruit of one's labors; but to prevent a hasty judgement that all such efforts are useless, I beg to state that the uneducated class of the people and the variety of dialects that we meet with here, together with the exceeding apathy and indolence of the native mind, are great obstacles to a ready intelligibility and appreciation of the instruction imparted.

I have now to state in a few words that, owing to circumstances that have transpired since my return hither, I feel it my duty to resign my charge of this hospital. The circumstances are simply these. The London Missionary Society, whose agent I am, is desirous of re-establishing its Mission at Canton, where there is no English Missionary stationed, nor has there been, permanently, since the death of Dr. Morrison. Medical Missions having a natural tendency to disarm prejudice and conciliate the good will of the natives, there is no locality more desirable for their peaceful and benevolent

operations than that city. Much undeserved odium and obloquy have been cast upon the character of foreigners, especally the English, alike injurious to our good name and holy religion, which doubtless we should be rejoiced to see done away, though it is not easy to say how these bad impressions and irritated feelings are to be removed. With the blessing of God I have confidence that moral means judiciously applied will effect what hostilities and arms can never accomplish. These latter may be overruled for good, but it is not in their nature to conciliate angry feelings!

Having stated the above, it only remains for me to say, that I have received instructions to *endeavour* in a quiet and unobtrusive manner, by friendly intercourse with the people and healing the sick, to obtain a permanent locality in the midst of the Chinese in Canton, and so prepare the way for other English Missionaries to settle there. With the present hostile feelings and their strong dislike to rent houses to foreigners, I dare not be sanguine of certain success. It appears, however, my duty to try, and I have already made arrangements through the kindness of a friend to rent part of his house till I can meet with a more suitable and permanent residence in another part of the suburbs.

An offer has been made by the Committee to Dr. Balfour to take charge of these premises, but at present he cannot clearly see it to be his duty to accept of the offer, but kindly proposes to come and visit the sick every day, as before, for a few months to come; after which I trust some permanent arrangement can be entered into by the Committee, to the mutual satisfaction of the friends and supporters of this useful charity in Hongkong.

The property belonging to the Hospital—with a donation of £86 18s. 0d. from "A Friend to the Medical Missionary Society," through Rear Admiral Hope, and transmitted to me by the London Missionary Society—I shall hand over to the Committee of Management.

The usual expenses for each month have been for

Superintendent, ...	$5
Dispensary Coolie, ...	6
Water Carrier, ...	5
Watchman, ...	5
Incidental Expenses of the Dispensary, as, Leeches, Pork-fat, Yellow-wax, Paper, &c., from $3 to	5

For aiding poor destitute in-patients (of which the number is not small), 30 copper cash, (about the value of a penny) to 10 or 14 patients each day, from 9 to 12 dollars a month.

The whole expenses, including an allowance for Native assistants, have amounted on a general average to $50 a month.

I beg to say a few words, before I close this report, on the Medical School which I had hoped to be able to form here. When I proposed the plan to the Medico-Chirurgical Society, it met with a warm reception, and the members pledged themselves to give the utmost assistance in every possible way to the formation of such a school; but two of the most active members have been removed by death, and since

then the Society has ceased to exist. The boys I had mainly depended upon to receive medical instruction, are now in America and England, and those remaining in Hongkong, who are sufficiently advanced to be benefited by it, were previously engaged for other pursuits. The monies I have collected from persons in England, (chiefly personal friends) amount to about £350, part of which has been paid into the hands of the Treasurer of the London Missionary Society; part into Barclay and Bevans' Bank by the Chinese Association in London, and the remainder into the Oriental Bank of this place, the sum being far short of what would be required to carry the original project into effect. From these causes, and from unexpected changes in my own plans, I have been necessarily obliged to abandon the formation of the proposed school. I do not, however, abandon the hope of its practicability some future day, and in the mean time, I have decided to appropriate those donations intended for general use, to the fitting up of an Hospital in Canton—and those which were given specially for education, to that purpose on a modified plan. The total receipts and expenditure of the above, I shall faithfully account for to my subscribers in the proper time.

For the local aid I have formerly received from this Society, first at Macao and afterwards here, to assist me in practising among the Chinese, as a Medical Missionary, I desire to return my sincere thanks. I do not leave this hospital without some regret, nor without hope that one will soon be found to fill my place, who will carry on its varied operations, in a manner more efficient and more worthy of patronage than my own has been.

With cordial good wishes for the increasing prosperity and usefulness of the Medical Missionary Society in China.—I remain, gentlemen, respectfully yours,

BENJAMIN HOBSON.

Chinese Hospital, Hongkong,
1st December, 1847.

REV. V. STANTON IN ACCOUNT CURRENT WITH THE TREASURER OF THE MEDICAL MISSIONARY SOCIETY,
DURING THE ABSENCE OF DR. HOBSON.

			$				$
1845—July	17	Received from Dr. Hobson,..	285.14	1845—		Hospital Expenses for July,	66.97
July	17	Donation of V. Stanton, ..	300.00			Do. do. for August,	62.37
1846—Janv.	24	Received from Treasurer, ..	275.11			Do. do. for September,	66.56
Sept.	30	Do. do. ..	230.00			Do. do. for October,	74.45
June	27	R. P. Saul's Subscription, ..	15.00			Do. do. for November,	61.75
August	10	C. B. Hillier's do. ..	25.00			Do. do. for December,	60.31
1847—Feby.	1	Received from Treasurer, ..	100.00	1846—		Do. do. for January,	61.67
May	7	Do. do. ..	250.00			Do. do. for February,	56.18
March	2	Major-General D'Aguilar's Subscription, ...	25.00			Do. do. for March,	58.94
						Do. do. for April,	65.24
August	25	Lieutenant Fedder's do. ..	10.00			Do. do. for May,	61.75
						Do. do. for June,	76.97
						Do. do. for July,	62.25
						Do. do. for August,	42.22
						Do. do. for September,	35.90
						Do. do. for October,	40.80
						Do. do. for November,	44.63
						Do. do. for December,	38.59
				1847—		Do. do. for January,	39.65
						Do. do. for February,	36.49
						Do. do. for March,	36.60
						Do. do. for April,	31.56
						Do. do. for May,	33.53
						Do. do. for June,	37.67
						Do. do. for July,	38.39
				1846—August	8	Paid to Dr. Cumming's Assy...	209.09
				1847—August	31	Handed to Dr. Hobson, ..	23.44
			$ 1,315.25				$ 1,315.25

Hongkong, 1st September, 1847.

VINCENT STANTON.

Dr. BENJAMIN HOBSON in ACCOUNT CURRENT with the TREASURER of the MEDICAL MISSIONARY SOCIETY, HONGKONG.

1847—Sept.	1	Received from Rev. V. Stanton balance of his account,	$	23.44	Hospital Expenses for August,	$	49.50
					Do. do. for Mason's and Carpenters' Repairs, ..		112.00
	2	Received from Treasurer, ..		100.00			
Oct.	1	Do. do. ..		62.00	Hospital Expenses for September,		35.63
Nov.	1	Do. do. ..		50.00	Do. do. for October,		38.60
Dec.	3	Do. do. ..		50.00	Do. do. for November,		47.75
1848—Jany.	1	Do. do. ..		50.00	Do. do. for December,		39.60
					Incidental Expenses due to former Corresponding Secretary, ...		6.10
					Due to the Society (paid to Dr. Balfour), ...		6.28
			$	335.44		$	335.44

January 1st, 1848.

BENJ. HOBSON.

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Dr. THE MEDICAL MISSIONARY SOCIETY in ACCOUNT CURRENT with P. DUDGEON, Treasurer. Cr.

1845—Dec.	22	To Cash paid Dr. Cumming at Amoy,..	$	150.00	1845—Sept.	30	By Amount of sundry Subscriptions received, ..	$ 275.00
1846—Jany.	24	To Cash paid Rev. V. Stanton, Rs. 624½ *a* 227, ..		275.11	1846—May	30	By Cash received of Robt. Thom, Esq., by Dr. Macgowan, ...	50.00
May	30	To Cash paid Dr. Macgowan at Ningpo by Mr. Thom,		50.00	August	31	By Cash received sundry Subscriptions, ...	930.00
Sept.	30	To Cash paid Rev. V. Stanton,		230.00		31	By Cash received of Mr. Gibb, ...	25.08
Dec.	15	To Cash paid Dr. Cumming at Amoy,..		300.00	Sept.	30	By Cash received sundry Subscriptions, ...	313.00
	28	To Cash paid Dr. Bridgman on account of Mr. Gillespie, ...		10.00	Oct.	31	By Cash received of Col. Chesney,..	20.22
1847—Feby.	1	To Cash paid Rev. V. Stanton,		100.00	1847—May	31	By Cash received H. M.'s Government Subscription for 1847,..	300.00
May	7	Do. do.		250.00	March	15	By Cash received of Dr. Cumming per Mr. Gillespie, ...	281.30
June	29	To Cash paid Dr. Lockhart at Shanghai, ...		200.00	July	31	By Cash received sundry Subscriptions, ...	725.00
July	31	To Balance in hands of Treasurer,		1,354.49				
			$	2,919.60				$ 2,919.60

Hongkong, 1st August, 1847.

P. DUDGEON,—*Treasurer.*

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Balance brought down, ...	$ 269.97
Subscriptions in Canton, 35 at $15 each, $ 525 Do. do. 1 10 10	535.00
	$ 804.97

Hongkong.—Balance in favor of the Society, 17th July, 1845, not handed over, ...	$ 285.14
Shanghai.—Balance in favour of Society, 20th July, 1845, ...	$ 419.46

The MEDICAL MISSIONARY SOCIETY,

in Account with P. DUDGEON, Treasurer, *Cr.*

1847—Augt.	1	By Balance in hands of Treasurer as per Account Rendered, .. Deduct.	$	1,354.49
Sept.	1	Cash paid Dr. Hobson,..	100.00	
Oct.	1	Do. Akee. Repairs of Hospital,	62.00	
Nov.	2	Do. Dr. Hobson,..	50.00	
	11	Do. Jas. Young, Medicines from 1843 *a* 1847,..	233.30	
	11	Do. Hongkong Register Office, Printing,.. ..	90.00	
				535.30
		In hands of Treasurer,..	$	819.19

Pro. P. DUDGEON.
J. H. CANNAN.

Hongkong, 1st December, 1847.

LIST OF LIFE SUBSCRIBERS,

TO THE

MEDICAL MISSIONARY SOCIETY, HONGKONG,

1845-6-7.

Sir John Francis Davis, Bart.,	$ 100	Hon. J. W. Hulme,	$ 100
Augustus Carter, Esq.,	100	T. W. L. McKean, Esq.,	100
Wilkinson Dent, „	100	Henry R. Harker, „	100
Hon. Fred. Bruce,	100	Rev. V. Stanton,	300

ANNUAL SUBSCRIBERS.

C. J. Braine, Esq.,	$ 15	J. F. Edger, Esq.,	$ 15
J. Jardine, „	15	David Jardine, „	15
Hon. Major-General D'Aguilar,	25	F. B. Birley, „	15
D. Matheson, Esq.,	15	W. W. Dale, „	15
Dr. Dill,	15	Geo. C. Bruce, „	15
Dr. Young,	15	R. Calvert, „	15
Dr. Kennedy,	15	R. J. Gilman, „	15
John Cairns, Esq.,	15	D. Byramjee, „	15
William Scott, „	15	S. Marjoribanks, „	15
F. T. Bush, „ (U.S.Consul)	15	S. Pounder, „	15
C. B. Hillier, „	15	Hon. Major Caine,	20
Pk. Dudgeon, „	20	Hon. W. T. Mercer,	15
S. Rawson, „	15	Robt. Strachan, Esq.,	15
A. T. Croom, „	15	Geo. Strachan, „	15
J. Stewart, „	15	John Pope, „	15
T. D. Neave, „	15	C. Ryde, „	15
Walter Davidson, „	15	A. Campbell, „	15
John Wise, „	15	J. Crooke, „	15
W. F. Bevan, „	15	W. Leslie, „	15
A. Fletcher, „	15	J. Dent, „	15
D. Fletcher, „	15	J. Rickett, „	15
George Findlay, „	15	D. Burjorjee, „	15
Peter Young, „	15	B. Larobjee, „	15
Rev. V. Stanton,	15	C. Pallanjee, „	15
Wm. Blenkin, Esq.,	15	C. Shapoorjee, „	15
C. Ryder, „	15	N. D. Nuhta, „	15
G. Lyall, „	15	N. B. Fakarjee, „	15
A. Dunlop, „	15	D. Byramjee, „	15
C. S. Compton, „	15	N. Eduljee, „	15
H. H. Smith, „	15	F. Hormusjee, „	15
R. Ellice, „	15	H. Hormusjee, „	15
J. Worthington, „	15	M. Nanabhoy, „	15

DONATIONS.

Edward Pereira, Esq.,	$ 10	C. St. G. Cleverly, Esq.,	$ 10
T. Smith, „	5	Hon. A. R. Johnston,	10
A. Lena, „	5	Robt. D. Cay, Esq.,	10
A. Shortrede, „	5	C. G. Holdforth, „	10
C. May, „	5	W. Pedder, „	5
T. McKnight, „	5	Rev. C. Gutzlaff,	10
J. A. Olding, „	5		

LIST OF OFFICERS.

PRESIDENT,

T. R. COLLEDGE, Esq., M. D., F. R. S. E., *England.*

VICE-PRESIDENTS,

Rev. E. C. BRIDGMAN, D. D.

DONALD MATHESON, Esq.

Rev. V. STANTON.

W. DAVIDSON, Esq.

P. YOUNG, Esq.

W. MORRISON, Esq.

RECORDING SECRETARY,

R. DILL, Esq., M. D.

CORRESPONDING SECRETARY,

B. HOBSON, Esq., M. B.

TREASURER,

T. W. L. MACKEAN, Esq.

AUDITOR OF ACCOUNTS,

T. D. NEAVE, Esq.

REGULATIONS

OF THE

MEDICAL MISSIONARY SOCIETY,

PASSED IN THE FORM OF REGULATIONS AT A GENERAL MEETING

AT CANTON, 21ST FEBRUARY, 1838.

OBJECT.

I. That in order to give a wider extension, and a permanency, to the efforts that have already been made to spread the benefits of rational medicine and surgery among the Chinese, a Society be organized at Canton, under the name of the Medical Missionary Society in China: That the object of this Society be, to encourage gentlemen of the medical profession to come and practice gratuitously among the Chinese, by affording the usual aid of hospitals, medicine, and attendants: But that the support or remuneration of such medical gentlemen be not at present within its contemplation.

OFFICERS.

II. That the officers of this Society consist of a President, Vice-Presidents, a Recording Secretary, a Corresponding Secretary, a Treasurer, and an Auditor of Accounts,—to be elected by ballot, annually; That these officers collectively form a committee of management for performing the business of the Society; That in the absence of the President, the duties of his office be performed by the senior Vice-President, that is, by the Vice-President whose name shall stand first in order on the ballot list; That any vacancy occurring between the annual meetings be filled up by the Committee: And that the Secretaries and Treasurer render every year a Report of the operations of the Society.

MEMBERS.

III. That persons subscribing fifteen dollars annually be considered members of the Society during the period of their subscription: That donors to the amount of one hundred dollars at one time be constituted members for life: And that donors of five hundred dollars at a time be constituted directors for life.

MEETINGS.

IV. That an annual meeting of the Society be held on the last Thursday of September in each year, for the election of officers and the transaction of general business: That the President be empowered to call a special meeting of the Society, at the request of the committee of management, or on the application of five members: And that the committee regulate the times of its own meetings.

LIBRARY.

V. That this association shall have a Library, to be called 'the Library of the Medical Missionary Society in China,' and to be under the control of the committee of management, by which donations of books, &c., may be accepted.

ANATOMICAL MUSEUM.

VI. That this Society form a museum of natural and morbid anatomy, paintings of extraordinary diseases, &c., to be called 'the Anatomical Museum of the Medical Missionary Society in China,' and to be under the control of the committee of management.

TRUSTEES.

VII. That all real estate or other property belonging to the Society be held on behalf of the same by a Board of Trustees, to consist of the President, the Treasurer, and the Auditor of Accounts.

QUALIFICATION OF MEDICAL MEN EMPLOYED.

VIII. That candidates for the patronage of the Society must furnish satisfactory certificates of their medical education, approved of by the Society sending them out,—with testimonials from some religious body as to their piety, prudence, and correct moral and religious character.

DUTIES OF SUCH MEDICAL MEN.

IX. That the Society will not assume the right to control any individual acting under its patronage, or to interfere with or modify the instructions he may have received from the Society sending him out: That it will, however, expect

a strict observance of any general regulations, for the management of its institutions, and a diligent study of some one dialect of the Chinese tongue on the part of those who receive its patronage; And that it will reserve to itself the right of withdrawing its patronage, at the discretion of the committee of management, from any individual who may, from non-compliance with its regulations, or from other causes, incur its displeasure.

HOSPITAL REGISTER.

X. That at each institution under the patronage of the Society, a book shall be kept, in which shall be inserted, in a fair and legible hand, an account of all important medical or surgical cases: And that, in order that this may not interfere with the other important duties of the physician or surgeon, any assistance necessary for keeping such a register shall be defrayed by the Society.

FOREIGN AGENTS.

XI. That the committee of management be empowered to appoint agents in Great Britain and America, to receive and transmit to them any sums that may be paid on behalf of this Society.

BY-LAWS.

I. The Committee shall meet on the first Tuesday in January, April, July, and October, respectively, or oftener if necessary, for the transaction of business.

II. The Recording Secretary, in concurrence with any two other members of the Committee, may call special meetings.

III. Voting by proxy will be allowed to persons necessarily absent from the place of meeting, provided the proxy produce a letter of authority for specific measures, written within one month of the time of meeting.

IV. Five persons shall constitute a quorum for the transaction of business at a general meeting; and three at a committee meeting.

V. At the meetings of the Society and of the Committee, the President, or in his absence one of the Vice-Presidents, following the order of priority on the list of officers, shall preside.

VI. The Recording Secretary shall keep full and accurate minutes of all the meetings, both of the Committee and of the Society—those of the former shall always be vouched by his own signature, and those of the latter shall be signed both by him and the presiding officer.

VII. The Corresponding Secretary shall conduct the foreign correspondence of the committee, except in cases that may be otherwise provided for; and he shall keep a full record of all his correspondence, for the inspection of the Committee.

VIII. Candidates for the Society's patronage must present their credentials to the President, or senior Vice-President, who, with one of the Vice-Presidents, following the order abovenamed, and the two Secretaries, shall examine, and, if they see fit, accept such person,—their proceedings, however, always being subject to the approval of the whole committee, and finally to that of the Society itself if necessary.

IX. All books in the Medical Missionary Society shall be labeled, and a catalogue of them kept by a librarian, under the direction of the committee; and it shall be the duty of the librarian to take care of the books, and to make them accessible to all those who are in the service of the Society.

X. All articles in the museum of the Medical Missionary Society, duly labeled, shall be placed in charge of a person, appointed by the committee for that purpose.

XI. The occupancy of the buildings, the use of instruments, &c., belonging to the Society, with all disbursements of money, shall be under the control of the committee for the time being.

A

GENERAL REPORT

OF THE

HOSPITAL AT KUM-LE-FAU,

IN CANTON,

From April 1848, to November 1849.

BY B. HOBSON, M. B.

Canton.
PRESS OF S. WELLS WILLIAMS.

1850.

INTRODUCTORY REMARKS.

HAVING been appointed, with Dr. Lockhart, in 1838, by the London Missionary Society, a medical missionary to Canton, I arrived the following year in China, and landed at Macao. Hostilities had then already commenced between the Chinese and the British authorities; and Dr. Lockhart, who had opened the Medical Missionary Society's hospital at Macao some months before, had left China for a temporary residence at Batavia, where he expected to meet me on my way out, and detain me until affairs in China should assume a more favorable aspect. The hospital was then temporarily placed under the care of the Rev. E. C. Bridgman, D.D.; and as there was no opening at Canton, my original destination, I took up my residence in it, and after a few months reöpened the Institution for the reception of patients. The following general summary will show the number of the patients, and the nature of the diseases treated during the year 1840-41.

Ophthalmic diseases	342
Cutaneous diseases	191
Pectoral diseases	63
Abdominal disease	75
Urinary diseases	51
Uterine diseases	10
Wounds	41
Contusions	35
General and local diseases, not classified	725
Total,	1533

In 1841, the late Mr. J. R. Morrison invited me to visit Canton, and endeavor to open there a hospital for the reception of the sick and wounded, after the city had been attacked by the British forces, Dr. Parker being at that time on a visit to America. I acceded to his advice—but no building for the purpose could be obtained. Application was made to Howqua, the rich hong-merchant, but without avail; though the solicitation was backed by influential English and American residents, and though he was under some obligation to myself for cheerfully and promptly attending, when suddenly summoned on his nephew, the chief manager of his commercial affairs, who was struck by lightning. At that time no one ever thought of attempting to rent a house out of the precincts of the foreign factories, and if the attempt had been made it would inevitably have been a failure. Thus, there being no opening at Canton, I was compelled to remain at Macao, and pursue my hospital duties there.

The Report of the hospital in 1842 shows the number of patients registered (including those only who appeared for the first time) for the twelve months preceding, to be 3826. The report goes on to say: "When the Institution was first opened for the admission of in-patients, there was some reluctance and timidity in accepting the offer; but latterly, since the character of the hospital has become established, its regulations known, and its advantages understood, there is not only a willingness, but a solicitude on the part of many to reside within its wards. During the present annual term, there have been rather more than 300 in-patients of both sexes, who have conducted themselves with much propriety, and in willing acquiescence with the rules of the hospital." From that date up to January 1843, when the

hospital premises were disposed of to furnish funds for the erection of a hospital in the new British colony of Hongkong, upwards of a thousand more patients were treated, making a total of nearly 7000.

My report to the Medical Missionary Society for the year 1843-44, gave a favorable account of the prosperity of the new institution at Hongkong, considering the short period since its commencement, and the task of gaining the confidence of the natives of those parts *de novo*.

The number of patients received, was

From June 1st	to Aug. 31st	1311	out-patients,	106	in-patients
Sept. 1st	Nov. 30th,	963		132	
Dec. 1st	Feb. 28th,	592		150	
Mar. 1st	May 5th,	482		168	
Total number of out-patients,		4348		556	in-patients

The religious services at the house were chiefly conducted by the native Christian Agong, under the direction of the Rev. Dr. Legge. The patients were daily reminded that the healing of their physical maladies was designed to exhibit to their own experience some of the practical benefits of Christianity, and from these to direct their minds to the contemplation of God their Creator and Saviour.

The Report of the hospital from June 1844, to June 1845, states that the number of new patients registered amounted to 3307, of which number 1200 were in-patients. With respect to the religious instruction of the sick, I stated in that Report that I had "endeavored to make the hospital an efficient auxiliary in spreading a knowledge of Christianity among its inmates;" and further, "That this is not forced upon them, for it is a voluntary act for them to attend the religious services that are held in the lecture-room every day, in the morning in the Canton dialect, and in Chinchew in the

evening. The average attendance at the former service is forty, and at the latter twenty. These services consist of singing a short psalm, and reading and expounding the Sacred Scriptures, with prayer; and visitors have often expressed their surprise at the good order and marked attention of the hearers."—"If the patients have not given satisfactory evidence that they feel or are influenced by the moral truths inculcated, the fault has not arisen from want of opportunity to learn them, or persuasion to practice what they hear; the fault lies rather in their own innate apathy and indifference to religion generally. Much knowledge however has been diffused, and it may bring forth fruit after many days." The Rev. Mr. Lechler, a German missionary, mentions a pleasing and encouraging fact respecting this hospital. He states that he met with a most hospitable reception from the natives of a large village in Fuhkien province, which he says he soon traced to the fact that several of the inhabitants had been my patients in the hospital at Hongkong, and spoke with feelings of gratitude of the attentions they had received. He has also recently informed me that one man has been baptized, and is a very promising character, who dates his first religious impressions to the instructions he formerly received there.

In August 1845, the hospital was placed under the care of the native assistant Apoon, who was educated by myself, and who was fully competent for his duty, under the supervision and with the occasional assistance of Drs. Tucker and Dill, who kindly promised their aid to enable me to accompany my family on a visit to England for the benefit of their health.

On returning to China in 1847, in my Report dated Dec. 1st of that year, I acknowledged the long continued

and disinterested services of Dr. Balfour, who, in addition to many other duties, had during my absence, generously and cheerfully rendered every assistance in his power to the institution, after the demise of Drs. Tucker and Dill.

PROPOSAL TO ESTABLISH A MISSIONARY HOSPITAL IN CANTON.

In my report to the Medical Missionary Society at the close of 1847, I informed the Committee that the London Missionary Society was desirous of re-establishing their mission at Canton, where no English missionary had been permanently stationed since the death of Dr. Morrison. The Rev. W. Gillespie happily succeeded in 1845, in renting a house on the river side, in the Eastern Suburbs, and had everything in a fair train, with the assistance of Liang A-fah, the Society's native Evangelist, to conduct his mission under very encouraging circumstances, when he was obliged by the illness and return to Europe of Dr. Legge, to relinquish his post for a time, and return to Hongkong to take charge of the missionary station there; during his absence a disturbance took place at the house which prevented its being again rented.

Medical missions having a natural tendency to disarm prejudice, and to conciliate the goodwill of the people, I considered there was no locality more desirable for their peaceful and benevolent operations than this city, where there is so much opposition to foreigners. I therefore resigned my charge of the hospital at Hongkong, and with it my connection with the Medical Missionary Society, that I might endeavor in a quiet and unobtrusive manner, by friendly intercourse with the people, and the healing of the sick, to obtain a permanent locality in the midst of

the Chinese in Canton, and help to pioneer the way for other English missionaries to settle there. Knowing the hostile feelings of the people, and their strong dislike to rent houses to foreigners, I did not dare to be sanguine of certain success, but I considered it my duty to try, and I informed the Committee that I had made arrangement through the kindness of a friend (a missionary of the American Board) to rent part of his house, till I could meet with a more suitable and permanent residence in another part of the suburbs.

My colleague Dr. Herschberg, a Member of the London College of Surgeons, and educated at Berlin University, afterwards took charge of the institution at Hongkong.

RENTING HOSPITAL PREMISES.

In April 1848, after considerable difficulty in meeting with a house, one was at last obtained in an eligible situation, and at a moderate rent (for Canton) of 35 dollars per month;* in the District of Kum-le-fow, about a mile and a quarter northwest of the Foreign Factories; without the city walls (and not *within* them, as has been reported in the Medical Times), in the midst of a large and respectable family neighborhood; with a good water entrance in front, and a constant thoroughfare in the street at the back. As considerable repairs were necessary before it could be rendered habitable (for it had previously been used as a *pack-house*), only a part of the house was rented at first on trial, as a Dispensary, by which plan the fears of the people were not suddenly excited, and their goodwill

* 420 dollars a year on a lease of ten years, paid by the London Missionary Society.

was obtained. In June, the house was taken possession of, and no trouble arose out of it, except that at a subsequent period my landlord's son, a subaltern in the army, was beaten by his superior officer, for not promising to expel me. He refused to comply, asserting that he had only acted up to the letter of the Treaty, and that the people around were quite favorably disposed towards me. His superior officer gave him ten days to think upon the matter, and threatened further punishment on non-compliance. The poor man showed me the marks of the bamboo on his thighs, and he and his mother intreated me to send in a remonstrance to the British Consul, to prevent his receiving further indignity from this unprincipled officer. The Consul then acting thought it proper to refer the matter to H. E. Seu, the Governor, as a violation of the Treaty, and required that not only should my landlord's son be left alone, but that the officer in question should be punished. Seu in reply gave a very unsatisfactory excuse for the conduct of this military officer, whom he said he had examined. This interference had the effect of establishing me more securely; but as I expected, my landlord's son was punished for another alledged offense, and cashiered the army—another specimen, among thousands, of the injustice of the Chinese government.

RELIGIOUS AND MEDICAL DETAILS OF THE HOSPITAL.

I now proceed to give some account of the working of this institution for the last year and a half. Having found from past experience that the relation of facts and incidents illustrative of the character, the opinions, and habits, as well as of the health of the people with whom we are brought in contact, affords the most satisfactory information to those interested in missionary and medical operations, I have taken, with this object in view, some extracts from my note-book, in the order in which the occurrences took place.

On the 1st of April, 1848, a Dispensary was opened for the first time in the western Suburbs of Canton, and was visited every alternate day for two months; the first day there were but four patients; the second, upwards of twenty; and after that never less than a hundred.

Finding the experiment to be successful of commencing with a dispensary, I had the premises fitted up for a dwelling-house, chapel, and hospital, and on the 8th of June I removed into it with my family, in the open day, without opposition or difficulty. On the first Sabbath following, the little native church was assembled, and the day was sanctified by prayer and by the celebration of the Lord's Supper. There were four male and six female communicants; Liang A-fah conducted the service, and it was felt to be an interesting and solemn season.

Arrangements were now made to receive patients three times a week, viz., Mondays, Wednesdays, and Fridays. Tuesday was appointed to be the day for surgical operations. The average attendance of new and old cases

on these three days, during the whole of June and July was 200 each time.

The second Sabbath was observed by the public preaching of God's word by our aged Evangelist, Liang A-fah; 230 persons of both sexes were present, the females sitting on reserved seats by themselves. There was much coming in and going out, talking and smiling at the strange sight of preaching, singing, and praying to an invisible Being, without priest, altar, or sacrifice. Many, however, were attentive and listened with approval.

The third Sabbath was rainy, and only fifty persons were present. On the fourth there were about two hundred, who were quiet, and listened with some degree of attention to the doctrines delivered. The fifth was also well attended. On the sixth Sabbath, July 16th, there was a very full congregation; there were about sixty women, of whom fully a half were of the more respectable class. Most of the women sat in a side room with Mrs. Hobson and child. Altogether, including those who only remained a short time, there were from two hundred and fifty to three hundred persons present. There was more noise than usual this day, caused by the chattering of the women, the crying of children, and playing of some boys at the door. Some were very quiet and attentive, but the greater part came evidently from curiosity alone to see the foreign lady and child, for several of the women who were not in the side room were raising their heads high to look over the blinds, or through the crevices to get a sight of them. To give a single illustration of the ignorance and indifference of the people to what appears to us so sacred and important:—on one occasion a woman, during the time of preaching on the Sabbath-day, held up her child to the reading-desk, and in a loud voice requested medical aid for her child at

once, and could not be easily persuaded to sit quietly down and wait awhile, till the explanation of the sacred Book should be concluded. Her sudden intrusion and earnestness much amused the congregation. The child had nothing seriously the matter with it. Others would occasionally stand up and peep over our shoulders to observe what we were reading, look about with a staring gaze, smile, and then sit down. Others, if any tracts were on the table, would make a rush to seize them. On another occasion some small-footed ladies walked in during service, and I rose up to beckon them to a seat as they passed by; in a moment they moved away from me under evident alarm, their trepidation and awkward motions occasioning a laugh.

On Monday, July 17th, at half past six A. M., there were already several patients waiting for medical advice, and at half past nine when we began the day's duty by the Evangelist addressing the sick, there were then a hundred and twenty persons. Two hundred tracts were distributed, also a form of prayer (specially prepared for them) was given to each patient. The women and men were admitted alternately, fifteen or twenty at a time. The chief diseases prevailing were, acute and chronic ophthalmia, and their sequelæ; rheumatic neuralgia; cough; fever; dropsy, and various forms of scrofula. The inspection was completed after six hours. Whilst I was healing in the dispensary, the native preacher was exhorting and distributing books in the waiting-room. The total number of applicants, new and old cases, was 284:—160 women and 124 men.

July 18th. (1) Removed a large adipose tumor from the nape of an old man's neck. Incision entirely healed by the first intention. The patient was very thankful and pleased. (2) Operated for a hare-lip on a girl of ten

years of age. (3) Operation for cataract by couching, extraction being found unnecessary, and impracticable from want of knives, or a cutler to set them. This man had been blind for four years. The cataract of the left eye proving soft, was broken up, and the patient dismissed to his home near by very grateful. (4) Operations for trichiasis and entropium. (5) An obscure case of apparent disease of the hip joint in a girl of 13, but resembling in the form and length of the limb a dislocation at the foramen ovale. (6) A case of large inguinal hernia could not be reduced from adhesion of omentum. —This day an interesting old lady, a Roman Catholic, called to see Mrs. Hobson. Tea and fruit were presented, after which I had a long conversation with her on religious subjects. She was baptized at the age of sixteen. Her husband was not living; she expressed herself deeply grieved that during life he cared not for the true doctrine. She hoped, however, that the cleansing of fire in hell would render him fit for the service and enjoyment of heaven. She asked for an explantion of the difference between our religion and the "Tien-choo Kiaou"—the term used by the Roman Catholics for the Christian religion—which was given. She asked, did we read, or rather repeat the *King*—the Sacred Book? I explained the nature of our private, social, and public worship. She asked, had we many converts?—I said, very few. Why?—Because the Chinese were very hardened and wicked, and because we did not baptize any without some good evidence that they were true Christians. She strongly confirmed the truth of the first point, deeply regretting that it should be so, and highly approved of the second. She asked about confession; she said she confessed once a year to a spiritual father, a foreigner from Macao, who dressed in Chinese costume—did we

do so? I said we confessed daily, not into the ear of man but unto God, the Searcher of hearts and the Pardoner of sin; the Scriptures taught us so. We then conversed on the Sacraments—our term for the Lord's Supper she did not understand: she had another term. I described the ordinance as we read it in Corinthians, and justified the use of wine. She took the cake once a year. She knew five native priests, who she said were all good men; she called them *shin foo*, spiritual fathers. They had no church or chapel in Canton, they had wished to build one, but the neighborhood would not suffer its erection; the one formerly in use had been pulled down by the authorities. She did not know how many Catholics there were in Canton. Her son was studying English to become an interpreter; he was not an idolater, but could not become a Christian, he said, and continue in business. The old lady can read her religious tracts a little, sometimes attends our services on the Sabbath-day, and is in many respects superior to the generality of her countrywomen.

July 19th. Liang A-fah, the Evangelist, was out of spirits this morning, and said he had no heart to preach to the sick people to-day. I took him aside and inquired the cause of his depression. He said his wife was sick; that the Chinese were very wicked; that the native Christians were not so united as they ought to be, &c. I mentioned how much the foreign teachers had to bear from the Chinese; how hateful many of their ways were to us; how often we felt discouraged at their spiritual insensibility and disinclination to receive the gospel, at their contempt for foreigners and everything pertaining to them; all which was sufficient to dispose us at times to abandon the mission and return home: but still we persisted, and wished to continue, for it was not to glorify ourselves but

the Lord's name for which we came here; and although the Chinese should not repent and believe the gospel, were we not fulfilling our duty in at least attempting to teach them to do so? If these were the feelings, wishes and principles of foreigners, surely a native preacher, and an experienced man like the Evangelist, should not lose heart in urging his countrymen to abandon their idols and worship only the Lord, the true God. Then I reminded him how much provocation, insult and contempt, Jesus, our Savior patiently endured; that when the Jews said, "Thou hast a devil;" he meekly replied, "I have not a devil, but I honor my Father, and ye do dishonor me." "When he was reviled, he reviled not again." So ought men to act towards the heathen, and in following Jesus and praying for help, God will succor us. This conversation had a good effect. The old man was nerved to renewed effort, and spoke better and more earnestly to the patients than I remember to have heard him before. He specially exhorted the women to put no trust in Kwanyin, the Goddess of Mercy, who had already deceived them too long. He said this was the anniversary of her festival day, and much honor would be paid to her; but the Chinese mythology shows her to be only a woman and a very licentious one: worship her not, but worship God, the Savior of men.

At six A. M., many women had arrived, and when we opened the dispensary a hundred persons had assembled. Distribution of books and religious teaching as usual. The principal diseases were those of the eye; dyspepsia; scrofula; ulcers; abscesses; cough; rheumatism. The most important cases were: (1) a deep chronic abscess of the thigh in a girl of twelve, which had been long treated in vain by internal medicine. The lancet evacuated upwards of a pint of pus to the astonishment of all

present. (2) Incipient disease of the hip joint in a boy of ten. (3) Chronic enlargement of the liver with ascites; the abdomen was tapped twice, and with the aid of salines and alteratives, great relief afforded. (4) Cases of cataract, entropium, and closed pupil from effusion of lymph, and a case of divided palate, were remanded for operation on the 25th. Opened the dispensary at half past nine A.M.; closed at three P.M.; 250 patients, 140 women, 110 men, chiefly of the poorer class.

July 21*st*. 234 patients; 112 women and children, 122 men. Four children were dismissed as incurable cases of blindness; one of these was the son of a respectable tradesman, who said, that hearing of my celebrity he brought his son to have his sight restored. A single glance showed that both eyes were irretrievably ruined, and I regretted that so fine a boy should be doomed to continued darkness. I told the father that if he had brought the child when first affected with the inflammation, instead of spending his money to no purpose upon quacks, the eyes might have been saved. "But can you do nothing?" says the father; "I have heard of your great skill, and by cutting the eye would not there *some* sight be obtained? even a little would be better than total blindness." I said the eyes were destroyed, totally lost, and not any surgeon on earth could afford the least benefit; God alone could create, I could only heal—without new eyes, his child could not see. I exhorted the father to endeavor to make up for the loss of the organs of vision by enlightening the eyes of the mind with wholesome and careful parental instruction.—Among eye diseases, chronic ophthalmia, and ophthalmia tarsi.—Among cutaneous diseases, psoriasis; psora; leprosy; elephantiasis, were the most numerous.—Tinnitus aurium, excessive cerumen, and discharge of the outer ear; lupus of the face; ex-

traction of a piece of ivory bodkin from the arm; acute and chronic abscesses; enlargement of the testes; dropsy from enlarged spleen, and a great many cases of chronic cough, dyspepsia, rheumatic neuralgia, and slight fever, received medical aid and treatment. The dispensary opened as usual with an address from the Evangelist at half past nine, and closed at three.—This morning two interesting young men, natives of Hainan, connected with the public office of the prefect of Canton, paid me a visit. We discussed the subject of religion, the state of things at Hainan, &c. I read with one, a part of the 15th chapter of I. Corinthians. It was with difficulty I could make him perceive the difference between the sacred Book, the Bible, and what *he* called his sacred books. His book said nothing of the resurrection; our's did, because it was a revelation from God to man. I showed them some specimens of anatomical models and the human skeleton, and after giving them some books they took their leave.

I had also a visit from a military officer, a captain in the army. We conversed on various subjects, especially among others, the superiority of the Christian religion. He remarked that he had read some of our books, and was convinced that the doctrines were good; they were despised by his countrymen because they were not known. I lamented their disinclination to receive anything from the despised foreigners, and the wickedness of the people in not restraining their children from vice, and in teaching them to behave so rudely to strangers. In the hospital, for example, all styled me "*Seen-shang*," Doctor; or "*Sze-yay*," Venerable Teacher; but when they see me on the water or in the streets, they call me "a foreign devil, whose head should be cut off."

Another visitor, a young man, very intelligent and good mannered, a merchant, was entertained by me for some time. We spoke chiefly on medicine; compared Chinese and European theories and practice; showed the fallacy of the pulse as treated of in Chinese medicine. We spoke of vaccination; he said it was chiefly confined to Canton, but he thought that here nearly all children were vaccinated; he knew several native doctors who practiced vaccination, charging from 50 cash to $1 for each patient. He wanted to bring a young man to me who wished to study medicine, but I declined at present. He also offered to teach me Chinese in the evening, if I would give him some lessons in English, which I also declined.

July 24th. The dispensary closed at half past four, all feeling exhausted after the hard day's work. The number of new and old patients was 281;—160 women, 121 men.—The cases were chiefly dyspepsia; flux; chronic cough; dropsy; abscesses; diseases of the joints; rheumatic neuralgia; ophthalmia; ulcers; &c. The two most important cases were fungus hæmatodes of the maxillary sinus of the right side, and a very large vascular tumor projecting from the abdominal walls, which latter case was remanded for operation.

26th. The services with the patients as usual. The chief diseases were necrosis of the femur, a long splinter from which was drawn out; osteo-sarcoma of the right sinus of the maxillary bone; osteo-sarcoma growing from the lower jaw within the mouth, removal of which was followed by copious hemorrhage, only suppressed by the patient fainting, with caustic and pledgets of lint steeped in tincture of benzoin; contused and lacerated wounds in a watchman by thieves.

27th. Removed the tumor alluded to above. It commenced growing seven months ago, and is now the size of a child's head of two years old. The whole surface is ulcerated and bleeds freely on being pricked. Its attachments are four inches long and one deep. The integuments at the neck of the tumor were pressed between the fingers, a bistoury was then passed through its base, and divided the left and right attachments; five arteries were secured. The tumor weighed 1*lb.* 9*oz.*, of a solid sarcomatous texture. The cut surface soon healed over, and he returned to his home very thankful.

August 11*th.* 230 patients. Most important cases were (1) Aneurism of the popliteal artery, as large as a goose egg. It commenced two months ago, at first very small, but increasing daily to the present size. Neither he nor any of the assistants were at all aware of the nature of the disease. One proposed opening it by the lancet. Age 57; by business a cake maker; native of Fatshan. He was admitted an in-patient. (2) Aneurism of the aorta, projecting from the chest on the right superior part of the sternum, attended with asthmatic breathing and congested bloated features. (3) Large carcinoma of the left breast, affecting the glands of the axilla; it commenced eight months since. Right breast healthy, and well supplied with milk for her child four months old. (4) Acute dropsy in a child. Immense ascites in a woman of 40, admitted into the house. (5) Cancer of the tongue; with numerous cases of dyspepsia, ophthalmia, affections of the skin and ear.

14*th.* Patients prescribed for amounted to 243.

15*th.* Various operations on the eye. Tapped two cases of ascites at the special desire of the patients, and extirpated some encysted tumors.

18*th.* Patients, 235. A boy of 12 was brought with extensive emphysema about the chest, with much excite-

ment in the breathing. The cause was from a wound by the side of the left scapula, which communicated with the lung. Expiration, when the mouth was closed, expelled air in a strong gust through the wound. The boy had fallen from a tree the day before, and either a branch, or something sharp on the ground had penetrated the chest. Bandages were tightly applied, and salines adminstered, and in a few days the lad was quite well.

The case of aneurism previously mentioned in the popliteal space was operated by tying the femoral artery. It is too long to detail in this general report. It will be sufficient to state that in consequence of the aneurism having suddenly burst in the evening at nine P. M., the operation was soon afterwards performed by candle-light, which was a few hours in advance of the time that had been previously appointed for the operation. Dr. Rowe (then assisting Dr. Marjoribanks) kindly came from the Foreign Factories to my assistance, and soon brought the patient under the influence of chloroform, which though at first producing restlessness and incoherence, was soon followed by a perfect calm and deep sleep. The artery was secured without difficulty about the middle of the triangular space, and all pulsation in the tumor immediately and completely ceased. The limb was carefully bandaged with flannel, and elevated; the next day the symptoms were very favorable, the foot only was cold. On the fourth day unquivocal symptoms of mortification showed themselves in the foot, then in the leg, and the patient died on the 24th, the evening of the same day on which he was taken home. The friends expressed their gratitude for the attention which had been paid to him while in the hospital.

21*st*. The number of tickets issued this day was 304—159 women and 145 men.

27*th*. The Sabbath; there was a good congregation, about one hundred and eighty persons present, for the most part orderly and quiet. Addressed from the 17th chapter of Acts, a discourse peculiarly appropriate to the Chinese, who in this particular, resemble the A thenians in their contempt for everything not harmonizing with their philosophy and superstitions. The Lord's supper was administered in an upper room to the professing Christians. The Evangelist described in a feeling manner the love of Christ, and the duty of his disciples to love one another.

Sept. 1*st*. 12 patients. A tyfoon this day, which did fearful mischief to the ships and boats on the the river.

2*d*. Sunday; about 200 persons present; congregation addressed by Rev. Dr. Legge.

4*th*. Patients 251:—113 men, and 138 women. At the latter part of this month, being exhausted by the excessive heat, and succession of severe attacks of intermittent fever, I was obliged to leave for change of air and relaxation at Macao, and returned in three weeks comparatively well.

Oct. 20*th*. to *Nov*. 25*th*. The average attendance has been 100. The Evangelist now takes a short tract, or a portion of the Sacred Scriptures, and plainly and faithfully explains it to the congregation; we then sing a Psalm of praise, and he concludes with prayer for the sick people before him, and for the physician, that strength and ability may be given him to heal their diseases.

Death from Stabbing.

Nov. 21*st.* Was sent for in a hurry to see a patient who had been wounded the night before in the abdomen, by a person unknown, with whom differences had arisen from his accidentally tripping his foot. When I saw him 12 hours after, a large portion of the bowel, of a dark congested appearance, and filled with fluid and air, protruded from a longitudinal wound about an inch long in the right umbilical region. It being impossible to reduce the strangulated bowel, a blunt pointed bistoury carefully divided the internal fascia and muscular fibres, and the intestine was then readily returned, and much relief afforded. The patient was a large and powerful man. He said he had lost much blood at the time of receiving the wound. He had been carried when he fell down into that house (which I heard afterwards was not a reputable one), and its inmates immediately fled; it was near the temple of Longevity. A large concourse of people had assembled near the door, when they heard that a foreigner was inside; on coming out of the house into the street, some of these low fellows seemed disposed to offer insult and make a disturbance, but they were immediately checked by others who informed them of my business. My assistant and myself were then allowed to go quietly to our chairs, which were waiting for us at a little distance. The patient was again visited in the even ing, but he was then dying from inflammation and loss of blood.

Nov. 25*th.* A large sarcomatous tumor was removed by Dr. Rowe, from the left side of the neck in a patient from Shuntak. It was of ten years' growth, and very unsightly. It weighed 1¼*lb.* This man has since brought many friends for operation and treatment.

Insanity.

Considering the phlegmatic temperament and temperate habits of the Chinese, it might be anticipated that this malady is not of frequent occurrence; and I think future inquiry will prove that insanity prevails to a much less extent in China than in Europe. It has been rarely mentioned in the lists of diseases treated by the medical missionaries, and on referring to the Golden Mirror of Medical Practice, a standard work in China, I find a very meagre description of the symptoms, cause, and treatment of this disease. Idiocy is properly distinguished from lunacy, and this latter is divided into two kinds *kwang* and *tien*; the first (*mania*) belongs to the *yang* principle, with an excess of fire or excitement; the second (*dementia*, incoherent madness) partakes of the *yin*, with fluidity in excess, a state of depression; there may be a transition of one into the other.—Lunatic asylums are unknown in China.

Several young and grown up persons idiotic from their birth, have been brought for treatment, some of them with remarkably formed heads, flattened on one side, smaller than natural, or conical; but during eight years of practice among the Chinese, I have had an opportunity of witnessing only two cases of insanity. They were both men about 40 years of age, one residing in the suburbs near the northern gate of this city, and the other on the river side. The former case exhibited the usual symptoms of incoherent madness. He was chained by one foot and hand to a large block of granite; and his wife and mother were in the greatest terror when I proposed he should be unloosed for a time, for the chains were evidently galling to his flesh. They said he would kill them, or set

the house on fire; he had been mischievous when his hands were free, and was often furious if displeased. He was incessantly chattering to himself; his chief theme was money and the gods. It appeared that his mind had been much depressed by losses in trade, and the death of his children. When questioned by me mildly and firmly, he gave a rational reply, but immediately after relapsed into his usual state of incoherency. He seldom took food, and still more rarely slept. His mind seemed wholly absorbed with a succession of confused and imperfect ideas unconnectedly expressed. His head was hot, general circulation languid, and body emaciated. He was visited twice, and under treatment a month, but with no permanent benefit. Large doses of opium were borne at first with advantage.

The second was a mild case of Mania. He was occasionally furious, but had little to say. In reply to questions, he would sometimes answer rationally, at other times he would only move his head significantly at his irons. Purgatives and blisters had a very happy effect; after a few days he was quite restored to his usual health. By trade a cannon founder, and addicted to free living.

Amputations.

On June 8th, 1849, a man was brought into the Hospital from Fatshan a few miles distant, with a shattered hand and comminuted compound fracture of the bones of the right arm with much contusion, from the bursting of a piece of cannon. Assisted by Dr. Startain of H. M. Steamer Phlegethon, the arm was removed by a flap operation above the elbow. The patient had lost much blood, and was speedily brought under the influence of chloroform. He was fearful of pain, and when he

awoke from his pleasant slumbers, he was astonished and delighted with the welcome news that the operation was completed. On the third day after, he was able to cook his own rice, and on the twentieth day left the hospital very grateful for the life which had been saved. He has since shown himself in excellent health.

Nov. 5th. A woman aged 40, much worn down by long continued disease of the bones of the hand and arm, was admitted. On the 6th, assisted by my pupil Awing, the arm was removed by flap operation; four arteries were tied. The chloroform affected her immediately, and rendered her quite insensible to pain. The bones of the hand were found greatly diseased with deep and foul ulcers extending up beyond the elbow, on seeing which her husband was quite satisfied that the removal of the arm by amputation was the only hope of cure.

On the 13th, the patient was doing well in all respects; on the 23d, the incisions were entirely healed, and the next day she left the hospital much improved in general health.

Tumors.

I have no statistical tables to guide me, but I much doubt whether the opinion commonly expressed is a correct one, that Asiatics are peculiarly the subjects of unnatural enlargements and large growths. In the West, tumors are removed by operation almost as soon as they appear, and are never heard of; still, a large number come under the care of hospital surgeons, and are reported in the medical archives. In the East—I speak more particularly of China—the excision of tumors by the knife of the native practitioner is scarcely, if ever practised; I have never heard of a single case. The consequence is that the tumors go on increasing both in

number and size from year to year, and from their position and unnatural proportions excite attention, and produce the conviction of their greater frequency among this people. The reports of the medical missionaries also naturally foster this opinion. I can bear my testimony, however, since I have resided in Canton, to the great frequency of encysted tumors, and tumors of the glands, especially scrofulous enlargement of the lymphatic glands. Of goitre, I have only seen a few cases. Ovarian tumors, and chronic enlargement of the liver and spleen with ascites, are of common occurrence. During the last year and a half, I have had three cases of aneurism under treatment; one of popliteal aneurism already referred to, and two of the arch of the aorta projecting through the sternum, attended with great dyspnœa.

I here mention three cases of operation for tumors, as illustrative of the different effects of chloroform and of Chinese quackery.

In July, a man was admitted with non-malignant scirrhous gland situated deep in the submaxillary space, about the size of a man's fist. A Chinese doctor had applied medicine to it which produced a deep ulcer and slough, followed by a fetid discharge which of course only served to add to rather than to lessen the disease. The patient begged to have it extirpated by the knife. The tumor was carefully dissected out, and though attended with some hemorrhage, only one artery required to be tied. He could not be brought under the complete influence of chloroform. He was restless; but still he afterwards said that he was not conscious of suffering, though it must have been otherwise a painful operation. It healed over by granulation, for no integument could be secured owing to the Chinese doctor's handiwork.

In October, a boy aged fourteen was brought by his

father from the country to have a large tumor excised from the outer and upper part of the thigh, from which it hung pendulous, attached to a base of eight inches in length, and about two in breadth. The weight and size of the tumor seriously incommoded the boy's motions. It commenced growing when he was four months old, caused, by the father's account, by the frequent whippings which he received from his mother. There were a few cicatrices upon the surface of the tumor, the result of ulcerations produced by escharotic plasters * designed to remove the enormous growth. The boy was instantly affected by chloroform, and after the integument surrounding the base of the tumor was dissected back for flaps on both sides, the whole mass was excised by an amputating knife in a few seconds. The hemorrhage, chiefly venous, was by no means considerable for so large a surface exposed. Four arteries were tied. The parts were brought together by suture and plaster, and the patient put to bed. He was quite insensible to the operation, and continued in a partial state of syncope and insensibility for half an hour. The tumor was composed of adipose tissue, and weighed eight pounds. On the second day after the operation, the boy was greatly alarmed by a fire which destroyed a great number of wood and mat buildings opposite us, and he fled into the street. This interfered with the adhesive inflammation, and postponed the healing process considerably. The incisions are now (four weeks since the operation) nearly all healed over.

Oct. 29th. The third case is that of a Chinese teacher a native of Hiangshan, near Macao. He appeared three months ago with a large, round, fibrous tumor, attached to the deltoid muscle. The patient was in excellent health,

* These plasters owe their escharotic property to the presence of arsenic and blister fly.

and the tumor free from all malignity. He was advised to have it removed, but said he dreaded the pain. He was told of the wonderful effects of chloroform, and promised to return, with his bedding in a few days. He did return, but not till the above date, and then so altered, thin and care-worn, that I did not recgonize him. On exposing his arm, the tumor, which before was covered with a healthy integument, was now entirely ulcerated and continually secreting a fetid discharge. There were also large and deep sloughs round the arm to the elbow. His pulse was extremely feeble, face pale, and whole body much emaciated, with loss of appetite and wretched nights. On inquiring the cause of all this mischief, the poor man cried out, "alas, alas, how have I been deceived! I did not believe your words; I feared the knife, and therefore went home and put myself under the care of a native surgeon, who promised to remove the whole mass without any cutting. I agreed to give him twelve dollars, and paid six in advance, and was to pay the remainder when the cure was effected. He applied his drugs day after day, and you see the result. I am nearly a dead man, and am now come to throw myself upon your kind care." The next day the attachments of the tumor were speedily divided by a large bistoury; the sloughs were also removed from the arm, and the whole dressed and bandaged.

Nov. 14th. It is now nearly healed by granulations. The patient has been improving in health daily, and both he and his friends are very grateful for the assistance rendered. He could not be induced to inhale the chloroform long enough for it to affect him, but threw it away from his face immediately the linen bag was applied, but he was glad then to endure anything to get rid of his loathsome disease.

Hernia.

Cases of large inguinal and scrotal in men, and umbilical in children, are abundantly recorded. I have met with only one case of strangulated hernia, which was reduced by the taxis after the use of tartar emetic and hot fomentations. Owing to the want of skill in manufacturing steel, trusses can not be made by the Chinese; those that are sent from Europe are too expensive to give away. Hence many can get no help for this infirmity. The size to which they attain in certain cases is prodigious. The Chinese doctors make no distinction between hydrocele, sarcocele, scrotal hernia, and chronic enlargement of the testes; they are all called by one name, and treated alike.

Poisoning by Opium.

Applications to rescue persons from suicide by opium have been very frequent. Unfortunately, however, they are often made too late. When I arrive with all speed at the house, by chair, by boat, or on foot, the patient is usually just dead, or in articulo mortis. An affecting case occurred last month. At 10 P. M., I was urgently requested to go to a street in the sixth ward, distant about one mile and a half. A sedan was provided, and I was carried there with great haste through the narrow streets, with torches leading the way; when we met with any impediment, the chair-bearers called out—"make way! very important business! saving a man's life!"—on which the foot passengers moved away right and left. All the hurry, however, proved of no use. The young man had expired. His wife with tears and lamentations intreated me on her knees to save her husband's life, and she could scarcely believe that he was really dead, though the strongest

ammonia put into the eye made no impression upon it. This young man had swallowed a large dose of the extract of opium to relieve himself from the misery of seeing his wife and son dying before him for want of food. He was by trade a silk weaver, and had latterly been quite unable to get any employment.*

Record of Four Cases that were Recovered.

One was an old lady, the wife of one of the official linguists, who had swallowed in a fit of anger a quantity of opium to prove her innocence of a charge that she was the cause of her daughter-in-law's hanging herself the day before (to whom I had been called, of course too late to save life). The pump was promptly applied, which removed the opium from the stomach, and in a few hours the old lady was as well and blithe as ever.

The second case was that of a young woman who had swallowed a large dose of opium from jealousy. She was quite insensible when I reached the house. The use of the stomach pump was completely successful, and its effects much astonished the bystanders. Some said I was a second *Wa To* (an ancient physician now deified), and that I had the hand of a Budha.

The third case was a man about thirty-five, who in the absence of his brother had broken open his money-chest, and stolen out of it 200 dollars which belonged to another party, intending to replace it by the gains he expected to realize by gambling with it. He however lost the whole during one night, and in the morning, from vexation and chagrin, determined to destroy himself by opium. He dissolved half an ounce of the strong extract in a little hot

* His having taken opium was discovered by a few parting kisses and words to his son, which his mother-in-law in another room overheard.

tea, and secretly swallowed it. When I saw him, his face and lips were livid, pulse feeble, respiration low, pupils almost insensible to light, and it was scarcely possible to rouse him to sensation. The stomach was soon emptied of its contents, the pump being kept in operation till colorless fluid was ejected, which, with the injection of warm water with a few drops of ether in it, restored color to his face, and in a few minutes he could answer slightly when violently roused, and swallow a little tea. It was evident from his soon relapsing into the lethargic state that a considerable portion of the opium had been absorbed into the system; by careful watching for some hours, dashing water on his face, keeping him roused by dragging him about between two men, and other expedients, torpor at length disappeared.—This man was bent on self-destruction, and I heard some days after that he had drowned himself in the river.

I may here refer to a spectacle that I witnessed in Macao, the impression of which will not soon be erased from my memory. Before me, in a small room of a house of ill fame, among the Chinese settlements, was a tall, well dressed man lying upon a bed quite dead; near his side lay a young woman in a partially insensible state, who, on our attempting to introduce the tube of the stomach pump, violently resisted, and with her hands firmly grasped the clothes of the deceased man, and all our efforts were unavailing to induce her to relax her hold, or to swallow the least portion of fluid containing emetic sulphate of zinc. Her eyes were red, face flushed, and pulse quick. She had vomited most of the opium; the rest had been absorbed into the blood, and produced this state of mania. After a time, the stimulating and narcotic effects of the drug passed off, and she was restored to her usual health. It appeared from her account, that early in the morning

they had each dissolved 2 drachms of extract of opium and drunk it off—finding they could no longer live together on earth, they had resolved to die together, hoping to be reunited in the other world. The man left a wife and six children,

The fourth case was that of a young woman, whom my assistant Awing restored. He was called early, and succeeded in expelling the poison by the use of the stomach pump—a fact which it is very pleasing to record.

I apprehend we should find that suicide among the Chinese is very frequent. Feuds and jealousies in families, and distress and poverty among the working classes, are the chief causes. Woman usually resort to hanging, and and men to opium.

Epidemics.

Canton, considering its population, seems peculiarly free from severe continued and intermittent fever. I have heard recently of several deaths from cholera morbus, among the first of which was the father of a child who was under my case. He was seized with cramp and the other usual symptoms at two P. M., anddied two hours afterwards. The malady is called in this dialect *Chow kan ching*, meaning, a drawing up of the tendons.

The mortality among children from small pox is every year very great, and the amount of blindness or leucoma resulting from it, is painful to refer to. The benefits of vaccination appear chiefly confined to Canton, and here there are multitudes who have a prejudice against it. There is also reason to fear that the virus has degenerated. Attempts are now making to renew the supply.

Acute Inflammations of the Viscera.

These rarely come under observation. I have attended but one case of acute peritonitis, and not more than half a dozen cases of acute dysentery. Fluxes are common enough, but active inflammation of the brain, lungs, heart, bowels and kidney, are certainly not the diseases to which the Chinese are most subject.

An encouraging instance of confidence in foreign medical skill has just been exhibited by a patient laboring under acute dysentery, from Fatshan. This individual whose surname is Au, was left when young with a large fortune by his father. Six years ago he was induced, with other sinful pleasures, to try opium. He soon became habituated to its use, and when I first saw him a year ago, he was smoking an ounce and a quarter of opium a day, which cost him, with apparatus and attendants, two or three dollars daily. He was then affected with spasmodic asthma, which was greatly relieved by the inhalation of ether. Two months ago he was attacked with acute dysentery, and a fortnight afterwards he hired a large passage-boat, usually called a flower-boat, at considerable expense, and came to put himself under my care—mooring his boat by the river entrance to this house. At first there appeared little prospect of curing my patient, for there was much reason to fear that ulceration of the bowels had commenced. He was visited twice a day in his boat. He took the medicines with scrupulous exactness, and carefully observed the regimen laid down for him. One grain of calomel with opium every night, with small doses of rhubarb, ipecacuanha, Dover's powder, soda, and cinnamon oil, three times a day, and a pill containing one grain of sulphate of copper,

steadily pursued in, with occasional injections of starch, laudanum, and sulphate of zinc, had a very happy effect. Muriate tincture of iron was afterwards substituted for the sulphate of copper. Tartar emetic plaster and flannel roller to the abdomen. The tormina, sanguineous and mucous discharges gradually ceased, and healthy secretions returned. It is remarkable, with the great susceptibility of the Chinese to the effects of mercury, that his gums were but slightly affected, though he was under its influence for several days in succession. He reduced the quantity of opium smoked, but he was afraid to diminish it beyond a certain amount, lest the dysentery should return; but he promises when stronger to give it up if possible altogether, and he now curses the day when he was first tempted to try it. He wanted to know, on leaving, how he could repay me. I said the best way to do that would be to give a donation to the hospital to aid in purchasing medicine and rice for the poorer patients. He promised to send a contribution in a few days.* He returned home expressing himself deeply sensible of the favor and benefits he had received both to his mind and body.

Pectoral affections are very common, especially chronic catarrh, asthma, and hæmoptysis, this last being often the precursor, as in Europe, of tubercular disease of the lungs.

Native Assistants.

Reference has been already made to Liang A-fah, who was baptized by Dr. Milne thirty-three years ago, and ordained to the Christian ministry by Dr. Morrison

* He has since presented 14 dollars to be used in assisting needy in-patients with rice and fuel.

some years afterwards.* He has this year lost his wife and her mother. They both died after a few hours' illness, within a few weeks of each other. They had made a profession of belief in Christianity, and were members of a native Christian church at Canton.

Liang A-wo, by profession a schoolmaster and a physician, baptized by the Rev. J. F. Cleland in 1847, assisted me in the hospital for a year, and received instruction in ophthalmic surgery. He is now engaged as a stated preacher and tract distributor by the London Missionary Society, and is under the direction and instruction of the Rev. W. Gillespie, and his colleagues the Rev. Messrs. Cleland and Gilfillan, and proves a valuable laborer.

* This good man is an interesting link of connection between those who commenced Protestant missions in China and ourselves who are their successors; and it is gratifying to have such a favorable testimony born to the excellence of his character and capability as a Christian teacher by one who has long known him, as is contained in the following remarks from the pen of Dr. Parker, in whose hospital he assisted for three years, and from whence he was only withdrawn when the London Missionary Society established two stations which necessarily occupy all his time and strength:—"His preaching is characterized by great sincerity, and often by pathos. With much humility he frequently tells his audience that he has been a student of the gospel for thirty years, and understands it a little. It is with great force that he informs them that he was once an idolater, and was as strong in his prejudices against Christianity as others, and equally sceptical as to anything after death. But he explains it all on the ground of his ignorance of the Gospel. Heavenly light had not then illumined his dark mind. His prayers are most fervent, his Christian views strictly evangelical, his illustrations of the Scriptures are clear, and his appeals frequently powerful in their impression upon his auditors. It was once remarked by a Christian traveler who attended one of the services, that he did not understand a word of Chinese, but still he knew, from the tones and gestures of the Evangelist, that he was even eloquent."

Lo Ting-sheen, was baptized by the Rev. W. Gillespie in 1847, and resides in the hospital with his family. He is supported by the London Tract Society. His duty is that of a colporteur, for which he is well adapted. He is engaged three days in the week in the hospital, and three days in the neighborhood around, besides which he conducts a religious exercise with the in-patients and servants, four evenings in the week. I feel much pleasure in bearing testimony to the excellence of his character, and his growing fitness for the work appointed him.

Chan Awing has been with me nearly two years. He is now tolerably well skilled in ophthalmic surgery; has operated for cataract with success; and cases of pterygium, entropium, small encysted tumors, harelip, divided lobes of the ear, extraction of teeth, superficial abscesses, &c., are all committed to his care. He frequently visits patients in their own houses, and has a considerable amount of manual dexterity. He is a diligent student and of correct moral habits.

Lau Ashu, a well educated youth, was with me six months. He was obliged to flee from the presence of his father, whose wrath he had excited by taking the part of his mother, who had unjustly fallen under the suspicions and ill treatment of her husband from the slander of a young concubine whom his father had recently purchased as his third wife. He is now asssisting Mr. Wade, Chinese Secretary, as a copyist at Hongkong. A young man from the Theological Seminary at Hongkong, baptized by Dr. Legge, is expected to take his place at the end of this year.

Chan Apoon, already referred to, now called Aching, resides near the Foreign Factories. He occasionally prescribes for the sick, but at present his chief attention

is given to business. He is an interpreter to a native firm, for which he is handsomely remunerated. I still entertain hope that he will relinquish trade, and again devote his talents and the knowledge he has gained, to that department for which his education designed and prepared him; in which case I shall be happy to render him every assistance in my power.

Chan Atsung. The case of this young man is extremely melancholy! He was rescued by me in 1841 from the habit of opium smoking. Possessing good ability and a knowledge of several dialects in Chinese, he promised to be an efficient native assistant. He accompanied Dr. Parker to America, and in 1844 returned to me in Hongkong. He was not benefited, as it was hoped he would be, by a temporary sojourn in the West. He became a gambler—and on account of this and other vicious habits, he was dismissed from the hospital. The late Mr. Lay employed him as an assistant interpreter at Fuhchau fu, and he also was obliged to dismiss him on account of bad conduct. He now resides near me, in the western suburbs, and has repeatedly begged to be allowed to return. He supports himself by practicing among the Chinese; but his habits are still vicious, and his dark, emaciated countenance gives every evidence of his being a confirmed opium smoker.*

Sun A-oan, by profession a native doctor, baptized in 1846, supported some time by the generosity of J. Henderson, Esq., of Glasgow; assisted in the surgery for rather more than a year, and distributed tracts three days in the week. Owing to the want of early education,

* Since the above was written, he has died from the combined effects of opium and poverty.

united to a natural indolence of mind, and an imperfect acquaintance with the dialect of Canton, there seemed little hope of qualifying him for the work of a medical missionary. He has since left to return to his native country in Cochinchina.

It will be seen from the above that something has been attempted in the way of medical education, though at present extremely small as to the results. High expectations must not be raised, for though experience has shown that it is a practicable thing, yet with so many other duties engaging the time and the strength of a medical missionary, it is confessedly a very difficult undertaking, especially when these four impediments are considered:—1st. The difficulty of teaching in the Chinese language. 2d. The want of means to demonstrate by dissection or experiment. 3d. The want of suitable text books in Chinese on the first principles of medical science. 4th. The false theories and mode of practice that prevail.

Chinese Theory of the Pulse.

To illustrate the last point, I will describe briefly the Chinese theory of the pulse, which is the foundation upon which the whole superstructure of their medical practice rests. Demolish this, and substitute in its place the true knowledge of the circulation of the blood, and the first step is laid for future improvement.

Extent. One inch, or three fingers, placed side by side on the right or left wrists.

Division. Into three parts:—1st, called *tsün*. 2d, *kwan*. 3d, *chih*.

Pulse of the left wrist.

Tsün	external	side belongs to	the heart.
	internal		small intestines.
Kwan	external		liver.
	internal		gall bladder.
Chih	external		kidneys.
	internal		bladder.

Pulse of the right wrist.

Tsün	outside	belongs to	the lungs.
	inside		great intestines.
Kwan	outside		spleen.
	inside		stomach.
Chih	outside		gate of life.
	inside		membranes of the viscera.

There are four kinds of pulse:— 1st, *Fau*, the strong full pulse. 2d, *Chin*, deep, feeble, small pulse. 3d, *Che*, the slow pulse. 4th, *Söh*, the quick pulse.

The three places of the inch pulse may each have a different pulse. The *kwan* may be *fau*. The *tsün* may be *söh*. The *chih* may be *chin*.

Besides the above, there are other varieties of pulse; but they scarcely admit of explanation, and in practice are confessed by the Chinese themselves to be unimportant and confusing. For example, the *chih* on the left inch pulse in a woman when *hung* (i. e. rising and swelling like a flood), shows that the child in the womb is of the male sex; when the *chih* is *hung* in the right wrist, the fœtus belongs to the female sex! This unphilosophical theory of the nature of the pulse will demonstrate to every intelligent reader two undeniable facts:—1st. That the true circulation of the blood, and with it the complicated and wonderful vascular system in man, is certainly unknown to the Chinese. 2d. That the practice of medicine with these views prevailing, must be empirical as well as deceptive.

In our attempts to introduce a sounder system of medical knowledge and practice, there seems to be no better or more hopeful plan, next to the opportunities afforded to medical pupils of witnessing and treating disease in the hospitals, than that of furnishing good elementary treatises on anatomy, physiology, chemistry, materia medica, and surgery, with drawings to illustrate and render them inviting. A work also on the wisdom, goodness, and power of God in creation, on the plan of Paley's Natural Theology or Dick's Christian Philosopher, would be a valuable addition to the literature of China, and calculated to be of the highest service to the missionary cause.

I must here say a few words concerning the money I collected for educational purposes when in England. The greater portion of this money is still untouched. Some of it has been used in purchasing a phantasmagoria lantern, which has proved highly attractive to the Chinese; great numbers have come to witness its exhibition, and they must have acquired much new information concerning the first principles of astronomy, and the anatomy of the human subject, which it very accurately illustrates. The Chinese Association has been requested to appropriate another portion to the purchase of wax models of the eye and ear, with a papier-maché preparation of human anatomy. The Chinese are capable of observation and reflection, and experience has shown that an appeal to their senses by maps, drawings, and works of art, &c., is the readiest mode of bringing their indolent minds into operation, and I conceive nothing would excite greater interest, and in its way do greater good, than the establishment of a polytechnic institution, if such a thing was practicable.

With respect to the formation of a medical school, I stated in my medical report, dated Hongkong, Dec. 1st,

1847 that the moneys I had collected in England (chiefly from personal friends) amounted to upwards of £300, part of which had been paid into the hands of the Treasurer of the London Missionary Society, part into Barclay and Bevan's Bank by the Chinese Association in London, and the remainder into the Oriental Bank at Hongkong. The sum being far short of what would be required to carry the original project into effect, I was obliged to abandon the attempt at present. I did not however relinquish the hope of its practicability at some future period, and in the meantime I considered it best to appropriate such of the donations intended for general use, towards fitting up an hospital at Canton, and those which were given specially for education to that purpose on a modified plan. The total receipts and expenditure I engaged to account for to my subscribers at a future time. The money account at the end of the Report will show what I have received and expended up to present date.

Comparison between the Years 1848 and 1849.

The average number of old and new patients in the summer of 1848 was 250 each receiving day. The number of applicants in the winter months from Nov. to the end of April was about 100. The average attendance during the past summer will be seen from the annexed tabular view of one month (which is a fair specimen of the five months preceding) to be about 150 patients each reception day.

October.	1	3	5	8	10	12	15	17	19	22	24	26	29	31	T
Men	79	83	96	85	93	93	104	76	107	104	96	78	98	96	1296
Women & Children.	56	64	67	57	67	68	63	55	54	55	75	26	54	56	817
Total.	135	147	163	142	160	161	167	131	161	157	171	104	152	15	103

If it be asked how is this falling off to be accounted for, I can assign four satisfactory reasons for it.

1*st*. The notion of my healing powers was rated extravagantly high. Many came with the expectation of being cured at once, as if by some miraculous means, by a look, or a word. Or if they had no such thoughts, they entertained the opinion that I possessed profound knowledge of the pulse. For nothing was more common than for my patients, especially the women, to place before me their hand, first the right and then the left, for me to feel the pulse, and then ask me, Doctor, what is my complaint? When shall I be well? What is to be my diet? These were posing questions, and the reader can imagine the disappointed hopes of many, when honestly told that this disease was beyond my skill, that that malady required some months of persevering treatment, that I could make no rash promises of certain cure in so many days, &c. This disclosure, and the subsequent discovery of the incurability of many of their chronic diseases, cooled down high expectations, and gradually lessened the number of applicants for medical relief. I am now seldom teazed with these questions, but a firmer confidence on the part of many is increasingly manifested.

2*d*. Many applied with some slight ailment to satisfy their curiosity, and to afford the man opportunity of passing a learned judgment on the foreign doctor's practice to their friends.

3*d*. The delay which many are subjected to, is often not compatible with their views or their time. Those that come first, are first attended to. They must all take their turn; no difference is made, all are placed on the same footing, and receive equal attention.

4*th*. Another cause is in the disinclination of some to hear what they call *kong-shu*, *kong-ku*, a discourse upon religious books and ancient customs; the erroneous idea generally prevails that we merely teach foreign doctrines which are unsuited for them as well as unnecessary, since they have the sublime doctrines of their own sages; the humbling truths of the Gospel are likewise distasteful to their self-righteousness.

In the year 1848, the female patients greatly out-numbered those of the other sex. This year it has been the reverse, the male having exceeded the female patients. Formerly there used to be noise, talking, and laughing during the religious exercises. This year there has been a pleasing change; the numbers have lessened, but the good order and quietness of those who attend are now habitual. The same remarks apply to the public service held every Sabbath morning. The congregations have diminished to 130, to 100, and sometimes to 80, and on wet days there not over a dozen or two; but there is now, usually, as much order and stillness as in a country congregation in England.

Concluding Remarks.

From the foregoing account it will be seen what has been attempted in this hospital for the eternal as well as the temporal benefit of the Chinese; the manner of its performance and the future results are known only to the Searcher of the hearts of the children of men.

On looking back upon the past sixteen months, there appears much to be grateful for. A missionary living with his family among a heathen population, and surrounded by so many that are viciously disposed,—the preservation experienced of life and property, and the freedom likewise from all molestation and harm—are surely to be attributed to the gracious protection of God. Thousands of the poor and wretched have been healed of their sicknesses; many have received sight and hearing; pain has been assuaged; fears of a life of misery have been removed, and much suffering has been prevented by a timely operation. The institution has proved a benevolent one, and is in some measure appreciated, we hope, by the multitudes who have received the gratuitous aid that it affords. To the afflicted poor (and for them it is chiefly designed) it has been, and it is hoped, will be an unspeakable blessing. Many faithful discourses have been preached; frequent religious conversations have been held, and thousands of copies of Christian tracts have been put into circulation.

But we yet wait to see any great results follow these endeavors. Two only out of the long list of patients have publicly confessed Christ to be their Lord and Savior. These, with a few hopeful inquirers after truth, may appear to be a very small and inadequate return for the amount of religious instruction imparted; for, in addition to the regular attendance and cheerful assistance rendered by Liang A-fah, the sick are now, and have been for some months past, favored with the faithful and impressive preaching of the Rev. W. Gillespie, who is well able to command their attention and excite an interest in the truths delivered. Still, though we wait for the early and the latter rain to fructify this barren soil, it yet is cheering to hear the glad tidings of salvation intelligibly and earnestly made known from week to week, and to believe that in fulfilling the command of our Lord to heal the sick, and say to them that the kingdom of God is come nigh unto them,—the labor bestowed shall not, ultimately, be in vain. May the Lord crown these humble and imperfect efforts of his servants with greater success, to the glory of his name, and the welfare of the idolatrous and benighted people around us.

It has been said that *some* fruit has already appeared in the conversion and baptism of two of the patients, and that hopeful changes show themselves in the conduct of others.

One of these is named Yu Awei. After trial as a catechumen for eight months, having been a hearer for twelve months, he was baptized by the Rev. W. Gillespie, in the month of July of the present year; and in the presence of a large congregation he was not ashamed to own his faith in and attachment to Jesus Christ, the Son of God. And he has not belied his Christian profession since. He is a diligent student in the Scriptures, and his increase in the knowledge of Christian truth is fully apparent. He continues in his business—that of a modeler and coral cutter; and, wishing to be useful, has assisted in the dispensary, and in the distribution of tracts.

The other convert is an individual who was operated upon for cataracts in both eyes—one of 15 years' stand-

ing. They were couched, and there was every prospect of his having good vision, when his impatience and curiosity proved the ruin of one of them. He raised up the bandage, and was overjoyed to be able to read some characters—an inscription on a tablet in the chapel; violent inflammation followed this act of imprudence, from which the eye never recovered. He remained in the hospital three months, during which time he was frequently admonished and conversed with by his Christian teachers, which added to the knowledge he had previously acquired from other missionaries both in Macao and in this city. After frequent solicitations on his part, he was baptized, by the Rev. T. Gilfillan, in the month of October last.

The object of writing this report is explained in a few words, and no apology is offered either for its length or its peculiar character. It was necessary that acknowledgement should be made of the contributions received, and an account given of the expenditure; and it seemed desirable at the same time, for the purpose of imparting information to those interested in the Chinese mission, as well as to aid in maintaining that interest, to give some account of the formation and operations of this newly established Missionary Hospital, in its twofold character of a medical and religious institution.

LIST OF DONATIONS.

PAID INTO THE TREASURY OF THE LONDON MISSIONARY SOCIETY AS A RESERVED FUND FOR EDUCATIONAL PURPOSES IN CONNECTION WITH THE MEDICAL MISSION IN CHINA.

	£	s.	d.	
Rev. G. Cullen, *Leith*	20	0	0	
Sir George Staunton, bart.	10	0	0	
J. Dryden, Esq., *Glasgow*	17	0	0	
H. Marshall, Esq. *Bridlington*	10	0	0	
A. R. per London Miss. Society	10	0	0	
J. Parratt, Esq., *R. A. Surgeon*	5	0	0	
Hon. A. Kinnaird	5	0	0	
Thomas Matheson, Esq.	5	0	0	
G. C. Tuting, Esq. *Beverley*	5	0	0	
Friends at Sunderland	8	13	8	
Friends at Wellingborough	2	7	6	
Capt H. D'Aguilar, *Grenadier Guards*	5	0	0	
Miss Toomer		10	6	
British school girls, *per Mrs F. Wills*	1	12	6	
Professor Millar, *King's College*	1	0	0	
Professor Bowman *Do.*	1	0	0	
Dr. R. Farre	1	0	0	
Mr. Goldsmith, per *Miss Morrison*		10	0	
T. Halcro, Esq. *Sunderland*	1	0	0	
Mr. Gibbon, *Surgeon*	1	0	0	
Mr. Stevenson, *Rainton*	2	0	0	
Mrs. Pullan, *Yorkshire*	1	0	0	
J. Crossley, Esq. *Halifax*	5	0	0	
Miss Scarfe, *Yorkshire*	1	0	0	
Rev. W. Swan and friends, *Leith*	3	0	0	
Rev. Dr. Urwick and friends	2	0	0	
R. A. Macfie, Esq., *Liverpool*	10	0	0	
A friend, Mrs. S.	5	0	0	
S. Prust, Esq. *Bristol*	1	0	0	
Rev. B. Hobson, *late of Welford*	3	3	0	
Miss Bishop, *Welford*	2	0	0	
Miss Burman, *Do.*	1	0	0	
Mrs. Abbot, *Do.*		10	0	
H. Godwin, Esq. *Newbury*		10	6	
Dr. Taylor, *Huddersfield*	2	0	0	
A friend, *per Dr. Taylor*	1	1	0	
A friend, *per Miss Morrison*	5	0	0	156*l.*

Paid into Messrs. Barclay and Bevans' Bank, London, through the Chinese Association, for the same object:—

Chinese Association, London	£50	0	0
T. W. L. Mackean, Esq.	25	0	0
P. Dudgeon, Sen. Esq. *London*	5	5	0
P. Robertson, Esq. *Do.*	5	5	0
Robert C. L. Bevan Esq. *Do.*	10	0	0
James Matheson, Esq	6	6	0
Dr. Wilson, Inspector of Naval Hospitals	5	0	0
Professor Quain, *University College*	2	2	0
	107*l.*	17*s.*	

DONATIONS FOR THE GENERAL PURPOSES OF THE HOSPITAL.

Miss Harford, *Bath* £1.—M. R. M. £5—Miss J. Wills, 15*s.*	6	15	0
A Surgeon at Rainton 5*s.*—Dr. Dill, *Brighton* £1.—Dr. Wilson £1	2	5	0
Mrs. Price, *Brighton* £1. Mrs. Mackintosh £1.—T. H. Do £1.	3	0	0
Mr. J. Smeeton, *Welford* £3. Mr. Burman £1. Mr. Pell £1.	5	0	0
Mr. Ward, *Welford*, 10*s.* Mr. Eady, £1.; other friends 10*s.*	2	0	0
Dr. Caldwell per London Miss. Soc. £10.—G. H. Ditto £10.	20	0	0
Rev. W. Wild, *Guernsey* £1.1.—Dr. Omond, *Edinburgh* 10*s.*	1	11	0
J. Bell Esq. 1*l.*—B. Bell Esq. 10*s. Edinburgh*	1	10	0
Miss Watson, *Birmingham* £5.—Miss M. Burman £1. per London Miss. Soc	6	0	0
Proceeds of sale of fancy articles presented by friends through Mrs. Coldstream, *Leith*, and of others presented through Miss Kirkpatrick, *London*	58	0	0
Donations of Dr. Alison, G. Harvey Esq. and other friends of the Edinburgh Medical Miss. Soc. transmitted per Messrs. Jardine, Matheson & Co.	11	5	0
Donation of Dr. Colledge, £5.—J. Wright Esq. £5.—Rev. M. Wright £5. *Cheltenham*, through Messrs. Jardine, Matheson & Co.	11	5	0
Total receipts to the end of 1848	£132	6	0

1849.		Exchanged into dollars at 4*s.* 2*d.*	$635	04
Jan.	24	Donation of Rev. G. Cullen, 10*l.*; Messrs. McLarin and Son £10 *Edinburgh*, per H. Moul Esq.	100	00
Aug.	20	Donation of M. C. Morrison Esq. $230, less expenses $1.15	228	85
Sep.	17	M. C. Morrison Esq., second donation $125, less expenses, .62	124	38
Oct.	1	Donation of Rev. G. Cullen, per Messrs. McLarin *Edinburgh*	25	00
		Donation of Henry Moul, Esq., *Canton*	50	00
		Donation of Mr. Summers, *Hongkong*	5	00
		Sale of a few articles per Miss Morrison	4	40
		Dollars	1172	77

ACCOUNT OF EXPENDITURES

IN THE HOSPITAL AT KUM-LE-FAU, CANTON, FROM APRIL 1ST, 1848, TO OCTOBER 31ST, 1849.

1848.	Towards purchasing Westley's Phantasmagoria lantern for illustrating anatomy and astronomy, &c.	$84	00
	Paid to Dr. Hunter for a portable medicine chest	32	00
	For a larger one with common bottles	16	00
	Advertisement in the Patriot Newspaper, acknowledging donations in 1847	8	00
June,	Flooring, whitewashing, and fitting up dispensary and receiving rooms	40	00
	Boat and coolie hire for conveying Dr. Williamson's library, &c	5	00
	Chinese medical books for native assistants	1	70
July,	Paid to mason for repairing roof of dispensary, &c.	8	00
	Thirteen bed-boards and stands for in-patients.	4	62
Aug.	For opening a skylight over dispensary	2	00
	Room for native assistant	2	50
	A press for medicines	8	00
	For flagging six rooms for the use of the assistants	7	50
Nov.	Forty yards of calico for surgery	3	00
	Fitting up a reading-room for Awo	4	00
	Paid to watchman and the constable of the neighborhood for nine months	4	50
	Allowance to medical assistant Awing from March to Dec. 31st. ten months	50	00
	Medical assistant Awo for the same period	50	00
	Wages to dispensary coolie for nine months	27	00
	Incidental expenses of Dispensary, viz. pork fat, paper, charcoal, rhubarb, wax, leeches, brushes, pots, brooms, &c., for nine months	31	25
1849.	To printing notices of the hospital days	1	55
	To fitting up an additional room for a married assistant	4	40
March,	Burial expenses of a patient who died suddenly.	1	50
May,	Paid for additional room for female patients, five years' rent in advance, at the rate of $1 per month, being part of Mr. Cullen's donation	60	00
	For an electro-galvanic machine, $20, less by donation of $5 from Dr. J. H. Young	15	00
June.	To mason and carpenter for sundry repairs of patients' premises, a second dispensary, new cook house, &c.	40	00
	Amount carried forward.	511	52

	Amount brought up,	$511	52
	Expense of drainage in patients' cook-house.....	3	50
Aug.	Flagging the ground floor occupied by the assistants.	9	50
Oct.	Painter's and carpenter's bill for sundry repairs in the dispensary.....	4	00
	Magnifying eye glass for surgery.....	2	00
	Sign-board over hospital door	2	00
	Two lamps for evening service.....	3	00
	To a new plank jetty for landing.....	3	00
	To mason's and carpenter's account for repairs of patients' buildings.....	7	34
	Clock for dispensary and chapel.....	3	50
	Allowance to medical assistant Awing for ten months, three months being at $6 per month.	53	00
	Allowance to medical assistant Awo, seven months,	42	00
	Dispensary coolie ten months, $3,25 per month..	32	00
	Medical assistant Asun, 6 months.....	16	00
	Dispensary doorkeeper, 2 months.....	5	00
	Watchman and street magistrate nine months....	4	75
	Dispensary expenses for ten months, including wax, charcoal, brushes, paper, pots, pork fat, two bamboo tables, water-jars, &c.....	30	00
	For 1800 leeches.....	1	80
	Allowance to a few needy in-patients.....	5	00
	Dollars	738	91

Receipts.....	$1172 77
Expenditures.....	738 91
Balance on hand	$433 96

Canton, November 26th, 1849.

ACKNOWLEDGMENTS.

To the Chinese Association in London for two separate supplies of medicines received in 1849, valued at 11*l.* and 20*l.*—Also for a case of eye instruments and a surgical pocket case, a supply of chloroform, Liston's Surgery, Solly on the Brain, &c.

To Mrs. Williamson for the medical library of the late Dr. Williamson of Leeds, including Hunter's Anatomy of the Gravid Uterus, two papier-maché models of the abdominal viscera, and a number of drawings.

To the Committee of the Medical Missionary Society at Hongkong for the stock of medicines belonging to the late Dr. James.

To Mrs. F. Wills and friends for a box of articles to Mrs. Hobson, designed for presents to Chinese female visitors.

To the Edinburgh Medical Missionary Society for a copy of the Lectures on Medical Missions.*

To a friend for the presentation of a pulpit.

To Dr. Morrison, colonial surgeon, for a present of vaccine from England, and Wilson's Anatomist's Vade Mecum.

* A work deserving to be put into the hands of every medical student in Great Britain.

On two new Ceylon plants related to Sciaphila *of Blume.*

By Capt. J. G. Champion, *95th Regt.*

[Communicated by G. Gardner, Esq., M.D.]

[The two little plants, descriptions of which my friend Capt. Champion has communicated to me for publication in this Journal, are certainly very distinct from anything of the kind hitherto described, and are, as he states, evidently related to the little known *Sciaphila* of Blume, a native of Java, the Flora of which Island bears very intimately on that of Ceylon. It is now nearly two years since I accompanied Capt. Champion to the locality where these plants grow, and was then struck with the resemblance which they bear in habit to some small plants, natives of Brazil, which a few years ago, I formed into a distinct family under the name of *Treuridaceæ*. Capt. Champion alludes to this resemblance, but nothing is known of their seeds, and the economy of the male organs is totally different from that of the present plants. Capt. Champion believes that they ought to form the type of a distinct order, but I can find no marks by which they are to be distinguished from *Artocarpaceæ*, except, indeed, their habit, which certainly forms a great contrast to that of such trees as the jack and bread fruit, but that of itself is not sufficient to exclude them from the order, of which they will constitute a section. The numerous carpels of these little plants would seem to form a distinction between them and the *Artocarpus* tribe, but in the latter they are not always solitary, two being generally found in *Brosimum*.

Capt. Champion does not state where the point of attachment of the seed is within the utricule. In *Hyalisma ianthina* I find it to be at the upper part of the parietes as in *Artocarpus*, not, however, as in it on the side which bears the style, but on the opposite one. The embryo I find lying on the outside of a thin fleshy albumen, or but very slightly covered with it, on the side of the seed opposite to the raphe, nearly straight, and with the radical directed towards the hilum. The radical is short, conical, and of a brownish colour: the cotyledons elliptical, compressed, and white.—G. G.]

I enclose descriptions of two minute but interesting plants, with which I have been acquainted for some time, but which do not appear to have been known to the botanists who had

previously explored the Southern Province of Ceylon, possibly because they are so minute as not to be readily observed, and also from their being restricted, as far as my observation goes, to particular localities. I do not think, that any botanist can read the description of Sciaphila, as described by Blume, without feeling convinced of the very near affinity of it to my genus Aphylleia, and it is with Sciaphila, I feel but little doubt, that my plants range. Endlicher arranges Sciaphila after Artocarpeæ, amongst the "genera vix nota," adding "affinitas plane obscura," and the difficulty of its classification is increased by Blume's not having mentioned the structure of the seed, which, if resembling that of my genera Hyalisma and Aphylleia, would bring his plant nearer to the Moreæ than to the Artocarpeæ. From both Moreæ and Artocarpeæ, these plants may, however, be entirely separated, because they are not lactescent, and it seems to me, that it will be more natural to form of them a new group than to place them amongst either of two orders, which, with the exception of Dorstenia, are all shrubs or trees of large size, and very different habit. From Urticaceæ Proper they are readily separated by the stamina, which are so remarkable in the Nettle tribe for being inflexed when young, and when older for the irritable and elastic mode of their development; in habit they are nearer to Urticaceæ than to either Moreæ or Artocarpeæ.

Amongst the Moreæ I do not recognise any genus resembling the plants under consideration. Dorstenia is probably nearest, but very different. Amongst the Artocarpeæ, Brosimum is remarkable for having stamina which burst after the same method. The lateral style is peculiar, but common both amongst Moreæ and Artocarpeæ. That of Sciaphila is said to be sessile and punctiform, which is more after the fashion of Urticaceæ.

I shall therefore not feel surprised to find botanists ranging Sciaphila, Hyalisma, and Aphylleia, next indeed to the

Moreæ, but in a new group, distinguished from that order by its being elactescent, and by its having a more perfect development of inflorescence, viz. the regular calycine Perigonium found in Urticaceæ proper, whilst in the numerous utriculi of its fruit, aggregated on a common receptacle, it agrees with the Moreæ. Hyalisma and Aphylleia being very minute plants, there are one or two points which are not mentioned in the description, but which having come under my observation, it may be as well to mention. The seeds are very minute and difficult of dissection, and the embryo is so small, that it requires to be seen under a microscope, and it is then hard to say whether the cotyledons are one or two. The radicle is slightly curved and pointed towards the hilum. The albumen, which is originally liquid, becomes hard as the seed ripens, and usually causes the testa to burst on the side opposite to the raphæ. The bracteoles arise from near the root, and are there either alternate or occasionally nearly opposite. This construction seems to occur in both Hyalisma and Aphylleia. In male flowers of Hyalisma I have seen one anther burst, whilst the other three were unexpanded: this is interesting, as proving that they are not two stamina with the cells disjoined, as occurs in the American Triuraceæ, upon which Dr. Gardner has written an excellent paper, entitled 'Description of Peltophyllum,' and which in aspect has some resemblance to the plants I am describing. Hyalisma has a right to be called polygamous, as in poor specimens the flowers are all male, but whenever the plant is properly in season, it is usual to find it monœcious, with the female flowers below and the male above, and it is generally when the first scape has withered and the second is in flower, that male flowers alone are produced.

In Aphylleia the flowers are all hermaphrodite; when first blown, the stamina are conspicuous and the ovaries minute; the lateral style is at this period best seen. As soon as

the stamina are withered they are nearly obliterated by the growth of the ovaries, and the styles are so compressed by the same cause as to appear like a point between the ovaries, showing only the multifid stigma. The utriculi of Aphylleia remain much longer on their receptacle, without bursting, than those of Hyalisma; they dry without bursting, whereas if the fruit of Hyalisma is nearly ripe, the utriculi always open upon being dried. Having found specimens of Aphylleia in which all the flowers bore fruit, I feel pretty certain that I am right in considering it to be an hermaphrodite genus. The stamina of Aphylleia entirely disappear when the fruit is ripe. With respect to the structure of the stem of Hyalisma, it consists of cellular tissue without pith or concentric zones, and the skin is so slight that the stem is perfectly hyaline and the cells are distinctly visible with a small magnifying power: they are elongate and occasionally contain raphides. This cellular structure is to be expected in such a minute herbaceous plant. Having had abundance of opportunity of seeing these plants, in their different stages, I am certain that at no season of the year is a stem developed bearing leaves; the plants always consist of scapes which wither after fructification. Neither are they parasitic plants, but are found in rather moist soils in hilly places, under the shade of trees.

Hyalisma. Genus Novum.

(Plate IV.)

Flores monoici—*Perigonium* 8-partitum, lobis divergentibus—Fl. masc. *Stamina* 4, laciniis perigonii alternis adnata et opposita: *filamenta* brevia: *antheræ* peltatæ bilamellatæ, lamellis toto ambitu solutis apertæ. *Ovarii* rudimentum nullum—Fl. fæm. *Stamina* nulla. *Ovaria* plurima, receptaculo sub-convexo imposita. *Stylus* lateralis, obliquus, linearis: *stigmate* acuto. *Utriculi* plurimi, basi verticaliter

dehiscentes, membranacei, glandulis pillucidis tecti. *Semen* nudum, ovoideum basi apiculatum: *testa* dura, fragilis, reticulata: *raphæ* notata. *Embryo* inter albumen minimus: *radicula* hilo proxima.

Herba *pusilla, Ceylanica,* 6-8 *pollicaris aphylla, tenerrima, hyalina:* scapo *erecto spiciformi, sæpius dichotomo:* floribus *minutis, purpurascentibus.*

1. Hyalisma *Janthina, Champion.*

Hab.—Near Galle, Ceylon. Flowers in December to April.

Descr.—A minute *annual* plant, throwing out a mass of fibres from a root deeply seated in the earth, and after that a flowering scape which withers after fructification and is succeeded by a second scape; frequently having the two scapes together. Leafless and not lactescent; the scape furnished with alternate ovate bracteoles; the flowers spiked and in verticels of two to three flowers together, subumbellate; pedicels longish and bracted at base. *Scape* angled; bracteoles and bracts about a line long. *Flowers* minute, about a line to a line and a quarter in diameter; the lower usually female, the upper male; and in poor specimens, the flowers are occasionally all male. *Limb* of the Perigonium purple, patent, divided into 8-linear ovate segments.

Male flowers.—Stamina 4, opposite the alternate segments of the perigonium and attached to them by the filament: *anthers* large, peltate, whitish; when young somewhat 4-lobed, but when bursting spuriously 2-celled, and open their whole extent: *pollen* spherical. *Disk* fleshy and extending between the anthers. *Sterile ovary* none.

Female flowers.—Ovaries very numerous, seated on a convex disk, purplish and covered with pellucid glands, obovoid: *style* lateral, half as long again as the ovary, attached to its base, linear persistent: *stigma* pointed. *Fruit* the enlarged ovary, at length bursting from bottom to top and showing a naked seed. *Testa* hard, brittle, reticulated, one of the sides indurated by a prominent raphæ. *Embryo*

minute, lying next to the hilum at the apex of somewhat corneous albumen: *radicle* conical and somewhat curved.

APHYLLEIA. *Genus novum.*

Flores hermaphroditi: *Perigonium* 6-partitum, lobis reflexis. *Stamina* 6, laciniis perigonii adnata et opposita: *Filamenta* brevissima: *antheræ* peltatæ bilamellatæ, lamellis toto ambitu solutis apertæ. *Ovaria* plurima receptaculo subconvexo imposita. *Stylus* lateralis, obliquus: *stigma* peltatum, radiatim multifidum. *Utriculi* plurimi basi verticaliter dehiscentes, membranacei, glandulis pellucidis tecti. *Semen* ovoideum: *testa* dura, fragilis: *raphæ* notata. *Embryo* inter albumen minimus: *radicula* hilo proxima.

Herba *pusilla, Ceylanica,* 3-4 *pollicaris aphylla, tenerrima:* scapo *erecto tereti, spiciformi, simplici vel dichotomo:* floribus *minutis erubescentibus.*

1. APHYLLEIA *erubescens, Champion.*

HAB.—Near Galle, Ceylon; in damp woods. Flowers from December to April.

DESCR.—A minute *annual* plant, with the root fibrous and bearing either one or two scapes, which are only three or four inches high and several flowered. Leafless and not lactescent, the scape furnished with several alternate and minute bracteoles. *Pedicels* moderate, arranged alternately on the scape and bracted at base. The *flowers* nodding, minute, from $\frac{1}{2}$ to $\frac{3}{4}$ of a line in diameter, with the limb 6-cleft. *Segments* of the *limb* subulate, reflexed when in fructification, persistent, purplish coloured. *Stamina* six, opposite the segments of the perigonium: *anthers* when young bilobate, when the pollen bursts opening right across, white. *Style* linear, lateral. *Stigma* peltate, black, radiately cleft. *Ovaries* and *utriculi* ovoid, sanguineous red and covered with pellucid glands. *Utriculi* bursting from the base upwards: *seed* solitary, hard striated, marked by an elevated raphæ, naked. *Embryo* with the radicle next the hilum at the apex of rather hard albumen. *Bracteoles* ovate, half a line long.

GALLE: *June* 1*st*, 1846.

EXPLANATION OF PLATE, No V.

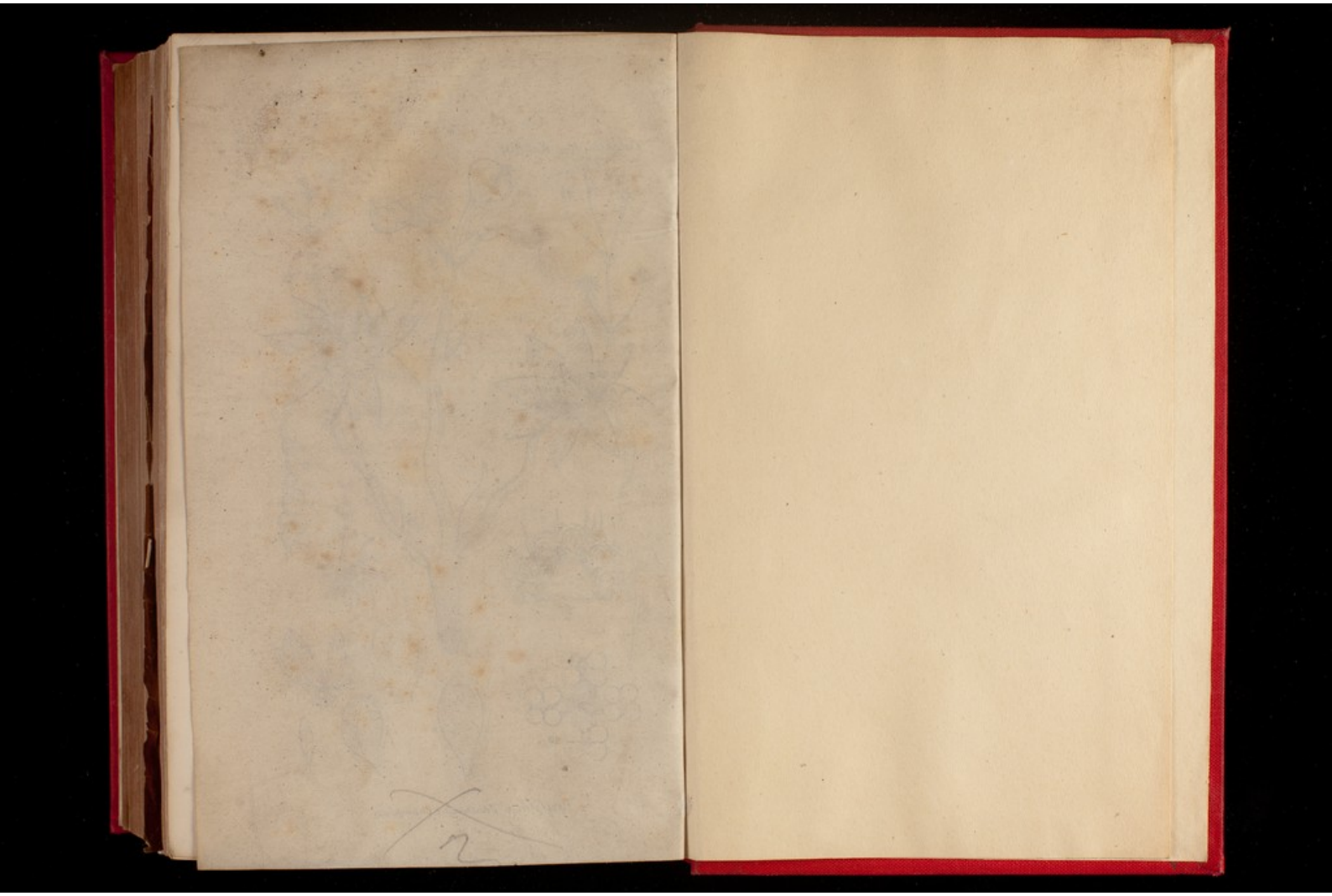
HYALISMA JANTHINA.

1. A specimen with male flowers only, showing the root.
2. A specimen with both male and female flowers.
3. Part of a flower much magnified.
4. An utriculus much magnified.
5. Ditto ditto burst.
6. A style much magnified.
7. A seed magnified.
8. Ditto ditto section showing the embryo.
9. Section of the fruit much magnified.
10. Anthers of a male flower previous to their bursting, also much magnified.

BISHOP'S COLLEGE PRESS.



Hyrelisma Xanthina Champion



PAMPHLETS

65

65