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4. Reflections on Gall 1821

PHYSIOLOGICAL LECTURES.

ADDRESSED TO

The College of Surgeons.

BY

JOHN ABERNETHY, F.R.S.

&c. &c. &c.

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TO

THE RIGHT HONOURABLE

SIR JOSEPH BANKS, BART. K.B. &c.

DEAR SIR,

To you, the Patron and Friend of John Hunter, I dedicate this inadequate attempt to delineate his character and labours.

Permit me at the same time to assure you of my great respect, and also of my gratitude for various acts of friendship and kindness which you have conferred on me.

I have the honour to be,

DEAR SIR,

Your much obliged and obedient Servant,

JOHN ABERNETHY.

PHYSIOLOGICAL LECTURES

In the Year 1817.

LECTURE I.

After resolving to write no more lectures, nor longer to praise Mr. Hunter, I break this resolution; yet my conduct seems to need no apology, for if my first decision was wrong, it is creditable to retract it; and if I am now wrong, it is probable I shall soon discover my error, the candid acknowledgment of which would then be far better than ingenious excuses.

I have praised Mr. Hunter for his Theory of Life, because it is a probable one, cautiously and philosophically deduced, and adequate to explain the phænomena. Therefore am I directed by the precepts of philosophy, and also induced by other reasons, which I have partly explained in my first Lectures, to uphold it as a good theory, till a more satisfactory one be discovered. I have praised him, because his perception of the healthy state of the vital processes enabled him to discern and investigate the causes and effects of disorder and disease in a manner and degree that have produced a most important revolution in medical science. I now mean to praise him for the great labour of his life, his Museum; which I may call the principal record of his deeds and opinions.

Hitherto I have endeavoured to make the Anatomical Lectures subservient to the surgical subjects I had afterwards to discuss. Finding myself rather at a loss for such topics, particularly because this theatre is unsuited to anatomical demonstrations, it occurred to me, that it might be useful to represent to my present audience, what were the peculiar improvements Mr. Hunter made in Physiology, and also the degree of perfection to which he brought that science.

No study can surely be so interesting as Physiology. Whilst other sciences carry us abroad in search of objects, in this we are engaged at home, and on concerns highly important to us; in enquiring into the means by which we live, and move, and have our being. To those however, engaged in the practice of medicine, the study of Physiology is indispensable; for it is evident that the nature of the disordered actions of parts or organs can never be understood, nor judiciously counteracted, unless the nature of their healthy actions be previously known.

The study of Physiology, however, not only requires, that we should investigate the nature of the various vital processes carried on in our own bodies, but also that we should compare them with similar processes in all the varieties of living beings; not only that we should consider them in a state of natural and healthy action, but also under all the varying circumstances of disorder and disease. Few, indeed, have studied Physiology thus extensively, and none in an equal degree with Mr. Hunter. Whoever attentively peruses his writings, must, I think, perceive that he draws his crowds of facts from such different and remote sources, as to make it extremely difficult to assemble and arrange them.

I am the more particularly induced to follow Mr. Hunter through the separate examination of the principal vital functions, because I know his notions of life were deduced from considering them severally and conjointly. I hope therefore to be able, by such an examination, to convince you of the truth of his opinions on that subject; for I hear there are some who still say they think them either unintelligible, or inadmissible. If these opinions be not understood, his works, I am persuaded, will remain obscure. They seem to me like writings in a cypher; his notions of life forming the only key by which they can be intelligibly read. Yet, to examine the vital processes, as Mr. Hunter has done, it is necessary to refer to the facts contained in his Museum; and to commemorate his labours as a comparative anatomist, which it is particularly incumbent on some of us to do; for so little have they been revealed to the public in general, that even Professor Cuvier has declared, he knew not that there was such a collection as the Hunterian Museum.

To display the talents and labours of Mr. Hunter in forming his Museum, it seems proper, in the first place, to notice those circumstances which led to this great undertaking: for great indeed must it be accounted, when it is considered, that it was accomplished by the labour, and at the expense, of an individual. Mr. Hunter was the first in this country, and I believe I may say in any country, who studied Comparative Anatomy and Physiology extensively, in order to perfect the knowledge of our own animal economy. I admit, indeed, that Baron Haller was fully apprised of the advantages likely to result from this proceeding, and that he himself had prosecuted the same mode of enquiry, to a certain degree. I am also aware, that many men may have explored the structure and functions of particular tribes of animals even more fully than Mr. Hunter himself has done. I am aware, that when the Count de Buffon engaged in his work on natural history, he might have excited Daubenton to a general investigation of the structure and functions of all the varieties of living beings; and that Professor Pallas might have followed the steps of Daubenton, and traced the subject generally and extensively. But, I am not apprized that any systems of Comparative Anatomy and Physiology were published before those of Professors Blumenbach and Cuvier. Neither can I believe it possible, that such enlarged and interesting views of the structure and functions of living beings in general, could have been formerly contemplated and not displayed by any man except by Mr. Hunter, who experienced such great difficulty in communicating what he knew, was never satisfied with the extent of his knowledge, and who cultivated Physiology, only as preparatory to the still more important science of Pathology. Of late years, many persons have engaged in the study of Comparative Anatomy and Physiology, and they seem to feel like the discoverers of a new path in science, which they pursue with animation and energy, as promising to lead them to some advantageous and commanding situation, from which they may eventually discern the whole order and course of nature in the most interesting part of her works, the formation and functions of living beings. Yet this is the very path which Mr. Hunter trod, unobserved, and in silence, with constant and accurate observation, and profound meditation. It is but just, that some one should say how far he had proceeded, and what were the general results of his observations and enquiries.

Mr. Hunter came to London in the autumn of the year 1748, and was educated to anatomy, during ten years, in his brother's dissecting room. In that time, he made many important discoveries in the structure of the human body, and his attention, from a very early period, being directed to Comparative Anatomy, we find him subsequently asserting, that among other researches in this department, he had in the same interval made preparations of the organ of hearing in fishes, of which he claimed the discovery. Mr. Hunter's biographer, Sir E. Home, mentions, "that his desire to obtain a correct knowledge of the functions of the organs in the human body, first led him to examine the same kind of organs in various animals."

From his brother's elegant and learned lectures, Mr. Hunter must have derived the best physiological information of the time; the facts and opinions of every writer, collected, arranged, considered, and improved by the industry and talents of Baron Haller, together with whatever later discoveries or suggestions had been made in that department of science. When he went abroad as an army surgeon in the year 1760, he had an opportunity of acquiring a knowledge of the animal productions of other countries, and of their surrounding seas. But he had neither time nor opportunity for the collection and display of those facts which doubtless he constantly accumulated. He returned to England, his mind teeming with knowledge, and full of great designs; determining to display the structure, and investigate the functions of living beings in general, both in the states of health and disease. With what extreme and unabating industry he wrought at this great work, his biographer has also told us; he allowed himself but five hours daily rest, during the remainder of his life. His mornings were passed in the Museum, and his days in constant experiments and dissections.

His object in forming the Museum was simple; it was to display the anatomical facts which were the ground-work of his physiological opinions; to exhibit the visible means, by which the vital processes were carried on, in all the varieties of living beings, that came within his cognizance. Mr. Hunter's biographer has told us how anxiously he sought for sources of knowledge. In 1782, Mr. Hunter says, his Museum "had already cost him 10,000*l.* besides the labour required in making the preparations. Of this sum more than 2000*l.* had been expended in the purchase of dead animals only."* Opportunities of examining rare and curious animals were also liberally afforded to him, chiefly through the means of that zealous patron and promoter of science, Sir Joseph Banks; towards whom, he always felt and expressed the warmest friendship and gratitude. Mr. Hunter knew but little of the arbitrary arrangements of natural history. The simplicity of his object induced an equal simplicity of arrangement. The facts are displayed in his Museum, according to the order of the vital processes, which is the method also adopted by Professor Cuvier.

I repeat what I asserted in the introductory lectures, that the preparations in the Museum are records of facts. Mr.

* European Magazine for 1782.

Hunter would have given his money even to his own ruin, to have procured the evidence of any fact warranting an important physiological conclusion; but he admitted nothing into his collection foreign to its general design; and scarcely any thing but of intrinsic value is to be found amongst the real gems in his cabinet. We do not over-rate the value of his preparations, in comparing them with the paintings of an ancient master, which are of high price because they possess a peculiarity of excellence that cannot be equalled. Every object shown by Mr. Hunter is displayed with a kind of elegance, as well as with distinctness and truth. He was not a man of learning, and derived but little assistance from the labours of others. Few perceived the ultimate objects of his pursuit. His inquiries into the structure of the lower kinds of animals, were regarded as works of unprofitable curiosity, and no one felt an interest in them. Therefore, without the solace of sympathy, or encouragement of approbation, without collateral assistance, did he labour to perfect his designs, till death deprived us of so great a benefactor to mankind: an event which happened on the 16th of October, 1793.

In the autumn of the year 1776, Sir Everard Home informs us, that "Mr. Hunter was taken extremely ill, and the nature of his complaints made his friends as well as himself, consider his life to be in danger. When he reflected on his own situation, that all his fortune had been expended in his pursuits, and that his family had no provision but what should arise from the sale of his collection, he became very desirous to give it its full value, by leaving it in a state of arrangement." He therefore was anxious to have a catalogue made, and wrote a little preface to each department of his Museum. These explanations of his designs ought not, in my opinion, to be published; for they appear to be mere sketches of what he meant in future to have finished. To these writings, however, I shall frequently refer, because they show the extent of his knowledge and views at that time; which was more than 20 years prior to the publication of Professor Cuvier's lectures. On his recovery from this severe illness, his time was however occupied in increasing his knowledge, and not in recording what he had obtained; and his catalogue no longer seemed the important object his illness had made it appear. Considerations, deducible from the imperfect state in which he left his Museum, probably influenced his last act; for he would not suffer it to be sold unless altogether; doubtless anticipating, that when it was examined as a whole, his designs and his labours would be fully appreciated. In the pursuit of knowledge, he relinquished that of wealth, so that he left his family no other legacy than his Museum; which, after the lapse of several years, was bought by Parliament, and given to this college. Mr. Hunter's Museum has thus become our Museum; and I trust that every member of this college will feel that interest in it, which is commonly felt for things appertaining to ourselves. Belonging to a commercial nation, we visit every part of the world; and have opportunities of bringing home whatever is rare and curious in Comparative Anatomy. But to know the wants of the Museum, it is necessary that we should know what it contains, and also the general desiderata in this department of science. The latter may be learned from the systematic books lately published, and both will be shown by the lectures of my brother professor, whose extensive and accurate knowledge of Comparative Anatomy, as well as of other subjects connected with medical science, cannot but greatly redound to the credit of his industry, comprehension, and capacity.

Gratitude to the former of the Museum, and also to the donors of it, equally demand that its value and excellence should be publicly acknowledged and displayed; which consideration has goaded me on to undertake and imperfectly to execute a task, for which I feel myself not properly qualified. It is my design, on the present occasion, not only to show you what were Mr. Hunter's opinions respecting the principle vital processes, but also briefly to exhibit the extent of his knowledge in Comparative Anatomy, and to contrast it with that promulgated of late years by Professor Cuvier. I candidly acknowledge, however, that I have little acquaintance with the subject, except what I derived from looking over the preparations in the Museum, from reading Professor Cuvier's lectures, and from the frank and friendly communications of our highly praise-worthy conservator, Mr. Clift. Permit me to say, gentlemen, though many may know it already, that Mr. Clift resided with Mr. Hunter, and was taught by him to exhibit anatomical facts in preparations; that he does credit to his excellent instructor; that he feels the same interest and zeal that his patron did for the improvement of this department of science; and that he possesses the same candour and simplicity of character. I am, however, aware that I may have attended chiefly to one side of the subject, and that my partiality to Mr. Hunter, may a little mislead me; I wish you, therefore, no further to confide in what I say, than as I confirm my assertions by facts; and to regard me, on this occasion, in the light I appear to myself, as one venturing to come forwards a voluntary advocate in the cause of Hunter versus Cuvier and others, and in this character I may thus address you.

Gentlemen, (of the Jury), I trust I can prove to your perfect conviction, by ample and incontrovertible evidence, that my client died seised and possessed of very considerable literary property, the hard-earned gainings of great talent and unparalleled industry. It is not, however, for the property that I plead, because that is already secured; it is fenced in, landmarks are set up, it is registered in public documents. I plead only, for the restitution of a great and accumulated income of reputation, derivable from that property; which I trust you will perceive to be justly due, and will consequently award to my client and his country. In mentioning our country, think not, that pleader-like, I wish to bias your judgment. Self-love, or nationality, which is but an extension of the same sentiment, is only productive of good when it excites emulation; and on this account alone, would I ever advert to it in the cause of science. Nation should vie with nation in promoting human knowledge and happiness. A desire to obtain the respect of others may warrant us in claiming our due; but we should freely accord to them that tribute of respect and applause to which they also are entitled.

I cannot easily express the gratification I received from reading Cuvier's Lectures on Comparative Anatomy, because, in addition to the information I derived from them, they enabled me clearly to discern the extent of Mr. Hunter's views. Neither can I tell the regret I felt that such a book had not been published during the life of Mr. Hunter, that he himself might have compared the opinions derived from more general and extended observation, with those that had resulted from his own peculiar modes of enquiry and consideration.

In praising Hunter, I by no means wish to disparage Cuvier; on the contrary I acknowledge the industry with which he has collected information by reading; and the great additions he has made to the stock of public knowledge relative to the subjects on which he treats. I admire, also, his clear arrangement, and the genius which is displayed throughout his works. We observe a constant endeavour to discover the series and order of facts; the variety of means employed for effecting the same purpose; attempts to reduce a number of facts to one general principle; in short, the endeavour to discover the causes and nature of whatever we observe; the hope of effecting which, appears to be the most potent incentive to labour, and the accomplishment its most gratifying reward. To shew that Cuvier has not wrought so hard without some animating motive, I quote his own words. "Pourquoi tel animal ne se nourrit-il que de chair, tel autre que de vegetaux? D'où celui-ci tire-t-il la finesse de son odorat, où celle de son ouie! D'où viens que l'oiseau voit egalement bien à des distances si differentes? Quelle est la source de la force prodigieuse des muscles des oiseaux? Cette force comment est elle employée à produire ce mouvement si étonnant du vol? Quelle est la cause de l'étendue, et de la varieté de sa voix? Tel reptile, pourquoi est-il si engourdie? Tel ver, comment conserve-t-il la vie long tems apres etre divisé? Tel zoophyte comment peut on vivre egalement bien quelque parties de son corps que l'on en retranche. Suppose-t-on qu'il puisse exister une histoire naturelle sans ces questions, et des milliers d'autres semblables?"

Believing that no man will ever labour in the strenuous and unremitting manner that Mr. Hunter did, and to the detriment of his own private interest, without some strong incentive; I have supposed, that at an early period he conceived those notions of life which were confirmed by his future enquiries and experiments. He began his observations on the incubated egg, in the year 1755, which must either have suggested or corroborated all his opinions with regard to the cause of the vital phænomena. He perceived that however different in form and faculty, every creature was nevertheless allied to himself, because it was a living being; and therefore he became solicitous to enquire how the vital processes were carried on in all the varieties of animal, and even vegetable existence. In the progress of science, genius, with light and airy steps, often far precedes judgment, which advances slowly, and either finds or forms a road along which all may proceed with facility and security; but the direction of the course of judgment is often suggested, and its actions are excited and acceleratad by the invocations of preceding genius.

Whether truth be discovered by that penetrating foresight which is characteristic of genius, or ascertained by the more laborious methods of experiment and induction, still, when it is once found, each succeeding observation serves but to convince us of its nature and reality. No one could be more scrupulous in admitting propositions to be proved, than Mr. Hunter; yet he was convinced that his opinions respecting life were true, by a course of patient and persevering meditation, on all its phænomena, in a manner I shall endeavour more fully to point out in the succeeding lectures. Yet these opinions, though correspondent to those of the wisest philosophers of ancient times, were so little suited to the modes of thinking of his contemporaries, that it required no small degree of hardihood, in a man of little education, to maintain them, in spite of the apathy or derision with which they were received by persons of greater general learning. Such, however, is the hardihood that conviction produces.

When, however, conclusions are deduced by a course of patient and persevering consideration of voluminous and multifarious evidence, it is scarcely possible to detail the causes and processes of thought by which we have been led to them; and this, I doubt not, made one of the difficulties which Mr. Hunter encountered in communicating his opinions. By investigating the works of nature, we collect facts from which we deduce opinions. On the formation and importance of opinions, I have already taken the liberty of expressing my sentiments before to this assembly, to which I now beg leave to add, that there are many who think clearly, who do not think deeply; and they have greatly the advantage in expressing themselves; for their thoughts are generally simple and easy of apprehension. Opinions immediately deduced from any series or assemblage of facts may be called primary opinions, and they become types or representatives of the facts from which they are formed, and, like the facts themselves, admit of assortment, comparison, and inference; so that from them we deduce ulterior opinions, till at length, by a kind of intellectual calculation, we obtain some general total, which in like manner becomes the representative and coefficient of all our knowledge, with relation to the subject thus examined and considered. In proportion to the pains we have taken in this algebraical process of the mind, and our assurance of its correctness, so do we contemplate the conclusion or consummation of our labours with satisfaction ; and being unable to display to others the different series of facts and opinions, and modes of inference, we express our certainty of the conclusion, by saying, it must be so ; it is absurd to suppose otherwise ; or, as they say Dr. Johnson was accustomed to do, " I know I'm right, so there's an end of it."

Now these ultimate opinions, for so I may call them, as being the last of a series, become primary and elementary in the display of knowledge. These conclusions of thought become principles of science and of conduct. By the prosecution of thought, we are led to observe the very trunk and roots from which the various ramifications of our knowledge are produced, and the nature of the ground on which the whole is supported, so that we become assured of its security, or admonished of its uncertainty. It is then, to certain ultimate opinions, or physiological conclusions of Mr. Hunter, with respect to the vital processes, that I chiefly wish, on the present occasion, to excite your attention; and these are highly important, on account of their re-action, and the bias they impart to our opinions in general, and also to our conduct.

The study of Nature has been compared to the working of an inexhaustible mine, abounding in rich materials; but which require to be assorted, refined, and wrought up, ere they can be converted to useful purposes. Some dig the crude materials from the mine, others assort and refine them; whilst others again, construct, with the wrought substances, instruments of great utility in the future acquisition of knowledge. Surely, I may be permitted to consider opinions as the instruments of intellect, for it both forms them and employs them in its future operations; and when also they are well constructed, they illuminate and render intelligible surrounding objects; but when ill formed, they only obscure and disfigure the face of nature. In adverting then to Mr. Hunter's Museum, by thus circumscribing my designs, I shall not in the least trench upon the province of my brother Professor; for I shall not describe facts, nor detail opinions; I shall not examine the materials, but merely the construction and utility of certain instruments which the hand of Hunter either formed or finished.

When I first had the honour of addressing the members of the College in this theatre, I knew it would be expected that I should eulogize Mr. Hunter; and nothing loth, I declared that he seemed to me to possess that rare combination of intellectual powers which qualified him equally to extend the boundaries of knowledge and to establish principles of science and practice. Of his opinions, I said I knew of none that had not been cautiously and legitimately deduced from the facts before him, and though the progress of science might have since invalidated some, yet most of them, from the same cause, had become more and more firmly established. In proof of the latter part of this proposition, I excited your attention to his opinions respecting life, which the progress of science seems to me to have most perfectly confirmed. The probability of his opinions on this subject is to be inferred from analogy; their rationality from their adequateness to account for all the vital phænomena. As Sir H. Davy's experiments fully prove that electricity may be superadded to, and that it enters into the composition of all those substances we call matter; I felt satisfied with this establishment of the philosophy of Mr. Hunter's views, nor thought it necessary to proceed further, but merely added, "It is not meant to be affirmed that electricity is life. I only mean to argue in favor of Mr. Hunter's theory, by shewing that a subtile substance of a quickly and powerfully mobile nature, seems to pervade every thing, and appears to be the life of the world, and that therefore it is probable a similar substance pervades organized bodies, and is the life of these bodies." I am concerned, yet obliged to detain you by this recapitulation, because my meaning has been either misunderstood or misrepresented.

Mr. Hunter was the first physiologist who placed in clear array the various vital functions before our view, so as to enable us to judge of their nature and probable cause. He told us that life was a great chemist, and even in a seemingly quiescent state, had the power of resisting the operation of external chemical agency, and thereby preventing the decomposition of those bodies in which it resided. Thus seeds may lie buried far beneath the surface of the earth for a great length of time without decaying, but being thrown up, they vegetate. Mr. Hunter shewed us that this chemist, Life, had the power of regulating the temperature of the substances in which it resides. Seeds possessing the principle of life being placed within the influence of the atmosphere, and in contact with moisture, produce heat, form sugar to edulcorate the first nutriment of the young plant, and in short, bring about all those phænomena which characterize incipient vegetation. He further shewed us, that Life, by its chemical processes, could convert a great variety of dissimilar substances, into one kind of generally distributed nutriment, and could also prepare from it a still greater variety of dissimilar substances. Mr. Hunter shewed us that Life was also an architect, that it built up a great variety of curious structures or edifices, in which it continued to reside and execute its future functions. No unprejudiced person can, I think, possibly doubt that it is by the active power of Life such effects are produced. Mr. Hunter shewed that the actions of life are various, that in nerves they are rapid, though not so forcible as in muscles. By such actions he accounted for the sympathies of remote organs, and the instantaneous effects produced on, and by the brain, from and in the remotest parts of the body. He shewed that the most obvious, and in general most surprizing manifestation of vital activity, which is called irritability, was not necessarily connected with a muscular structure; and when apparently connected with the same structure, was subject to considerable variations in its acions. By means of the active powers of life, he also saw how it was possible that fluids should undergo those modifications, that are known to take place, from the affections of the vessels in which they are contained. Having convinced himself of these facts, he inferred that Life was a principle, active in all it's functions, and that by acting in various modes and degrees it produced the diversified phænomena by which it is characterized.

I shall, on the present occasion, add a few words, to what is contained in my former lectures, to shew the nature and probability of Mr. Hunter's opinions respecting Life, because I am unwilling to leave any excuse for saying, that they are either unintelligible, or inadmissible.

The progress of science, since Mr. Hunter's time, has wonderfully manifested, that the sun-beam when dissected by a prism, is not only separable into seven colorific rays of different refrangibility, producing the iridiscent spectrum; but also into calorific rays refracted in the greatest degree, or intensity, beyond the red colour, and into rays not calorific, refracted in like manner to the opposite side of the spectrum beyond the violet colour; and that the calorific and uncalorific rays produce effects similar to those occasioned by the two kinds of electricity; and thus afforded additional reasons for believing that subtile mobile substances do enter into the composition of all those bodies which the sun illumines, or its beams can penetrate. Late observations induce the belief, that even light may be incorporated in a latent state with animal substances, and afterwards elicited by a kind of spontaneous separation, by vital actions, or by causes that seem to act mechanically on the substance in which it inheres.* All the late discoveries in science seem to realize the speculations of ancient philosophers, and shew that all the changes and motions which occur in surrounding bodies, as well as in those which live, are the effect of subtile and invisible principles existing in them, or acting on them.

* See Dr. Hulme's, and Dr. Macartney's papers in the Philosophical Transactions.

Mr. Ellis, who with such great industry and intelligence has collated all the scattered evidences relative to the production of heat in living bodies, and added so much to the collected knowledge, seems to think that all the phænomena of the variations of temperature in them, may be accounted for by known chemical processes. Here, however, I must observe, that Mr. Hunter's opinion of life having the power of regulating temperature was deduced, not only from his experiments related in the Philosophical Transactions, but also from observing, that in certain affections of the stomach, the heat of the body is subject to great vicissitudes, whilst respiration and circulation remain unaltered; and also that parts of the body are subject to similar variations, which appear inexplicable upon any other supposition than that of local nervous excitement or torpor, or some similar affections of the vital powers of the part which undergoes such transitions. His views with respect to this subject are confirmed by the late experiments of Mr.

Brodie.* As the circulation of the blood will continue in warm as well as in cold blooded animals without the influence of the brain, provided respiration be artificially kept up in the former by means of a pair of bellows, Mr. Brodie severed the connection of the brain from the top of the medulla spinalis, which in effect instantly kills the animal, and thereby prevents further suffering in the experiment, and then maintained artificial respiration, and consequent circulation, for more than two hours. Yet under these circumstances the body cooled as rapidly and regularly as that of another animal in whom respiration and circulation ceased upon the division of the medulla spinalis. This experiment shews that the change produced by respiration on the blood is not of itself alone sufficient to maintain the ordinary temperature of animals. Chemical science has not yet explained how the intense heat and light are produced, which are occasioned by the transit

* Philosophical Transactions, 1811. Cromian Lecture.

of electricity through the air. That the powers of life regulate electrical actions is evident; and may they not in this manner produce some of those variations of temperature to which I have just referred? But admitting that the refined operations of modern chemistry should actually shew us the means by which the variations of temperature are in every instance produced, they would not explain the cause of those actions by which such means are rendered efficient; which actions constitute the essential difference between living and dead bodies.

Neither would chemical science, by explaining the regulation of temperature, unfold the cause of the other vital phænomena; for instance, the prevention of putrefaction and irritability. The heat of incubation would hurry on the putrefaction of a dead egg, but the white and yolk of a living one, which we cannot suppose to be organized, do not putrify, though they undergo changes subservient to the nutrition of the young animal they are designed to support. Doctor Macartney, who has of late particularly attended to this subject, gives it as his opinion, "that when fluids change their composition, it is often by some vital action in themselves, instead of a fermentative process, or the mechanical operation of solids upon them, as is commonly supposed."* Were irritability shewn to be an electrical phænomenon, and I consider it already demonstrated that they are electrical actions which cause the various combinations and decompositions so constantly occurring in all parts of living bodies, and upon which their formation and functions so greatly depend; yet the consideration of the vital phænomena proves that such electrical operations are under the influence and control of the vital powers. I am aware that there is an obscurity in my first lectures, arising from my not explicitly declaring my sentiments; which did not then appear necessary, and even now may perhaps be deemed presumptuous and improper. In my opinion, experimental science

* See article Incubation, in Dr. Rees's Encyclopædia.

has not as yet informed us of more than reason has suggested, from the consideration of the general phænomena of nature; which is, that the motions and changes occurring in surrounding bodies, and in our own, are the results of some subtile substance or substances, which enters into their composition, or acts upon them.

But if science were eventually to demonstrate that heat, light, and electricity, are different things, that there are various kinds of subtile substances, then I should be obliged to suppose that there was also a subtile substance belonging to living bodies, a principle of life, which had the amazing power of kindling and controlling the destructive element of fire, and regulating the actions of that still more sudden and powerful agent, electricity. Neither by so doing should I transgress the rules of philosophy; for in suggesting a theory, it should not only be probable, but adequate to explain all the phænomena. I am aware, however, that there may be some contemplative and unprejudiced men, who, perhaps a little elated by the progress of science, may think me hasty, and that I had better have waited to see what her ample page might have eventually unfolded. To them I bow with respect, and assure them, that I would have done so, had the subject been merely an abstract question in Physiology.

Few however are they who contemplate the nature of life "in the calm lights of mild Philosophy;" nor do I affect to include myself among that very small number. In becoming the advocate of Mr. Hunter's Theory of Life, I knew I should irritate what many might consider as a very formidable Party. Formidable, because some of them possess extensive information, are subtle disputants, have words at will to make the worse appear the better argument, and are writers even by profession. Yet I feared them not, because I knew, that words do not make, but merely adorn arguments. Nevertheless I thought it prudent to entrench my subject behind a little fortification made of the most approved rules of reasoning; and neither this outwork, nor the subject itself, has even been assailed. Yet assertions have been made which I am concerned to feel it an indispensable duty publicly to answer in this place. I shall include all the individuals who compose this party, under a general denomination, which I think appropriate to them, and call them the Modern Sceptics.

First then, I am instructed, that I ought to consider life to be a property of certain structures, as gravitation and elasticity are said to be properties of matter. With this injunction, however, I cannot comply, because I can only think or consider in one way. I must deduce rational inferences from the facts belonging to any subject, or from analogies existing between that subject and others better understood. Now there is no analogy between the permanent and invariable properties of gravitation and elasticity, and the occasional and variable properties of life. Therefore, if I judge from analogy, I must think as I have hitherto done, that life is more like electricity or magnetism, because its operations are occasional; it may vary in degree, and admits of being annulled or abstracted, without evident difference in the subject to which it has belonged. My preceptors, suddenly shifting their ground, call upon me to consider life as an effect resulting from the combined action of certain structures. I own I am not disposed to follow such leaders, yet if I do, I discover that they wish me to consider life to be nothing; which I take to be the plain English of the Physiology contained in some late French publications relating to this subject.

When Sir Isaac Newton explained the laws of attraction, and of the motion of those substances we call matter; though he wished only to announce facts, without attempting to account for them, though reluctant to hypothesis, he afterwards felt obliged to suppose that there might be an æther forming a bond of connection and reciprocal action between their distant masses and molecules. In the anatomical lectures which I have had the honor of delivering in this theatre, when speaking of the ultimate fibres of the body, I observed that they varied in the properties of rigidity, pliability, strength, and elasticity; and that such properties could not be considered to be dependent on the quantity of matter contained in the fibres, which would be estimable by weight, to which such properties bear no proportionate relation; and, consequently, that these properties must be attributed to certain powers of attraction and repulsion operating in various modes and degrees, between the atoms of which such fibres are composed. However minute the atoms may be which compose those visible and tangible substances we call matter, Sir Humphry Davy's experiments shew, that each atom is surrounded by electric substances possessing powers of attraction and repulsion; and which substances are not only capable of acting upon the integral parts of bodies, but also upon the largest masses of matter. These electric substances produce decomposition and recombination, and by such means destroy the mechanical properties which had before obtained. Thus we see the toughest wood slowly decay, or suddenly consumed by fire.

So numerous are the phænomena in nature, that suggest and enforce the belief that subtile substances may and do pervade others more gross and inert, and produce effects in and upon them ; that no surprise can be excited upon finding that contemplative men have in all ages adopted and inculcated this opinion. Yet it was not till of late years, by observing the phænomena of electricity and magnetism, that decisive evidences of this proposition were obtained. In considering these subjects, we observe the utmost boundaries of human knowledge, for all our information must be derived from our senses, which can never give us any cognizance of the atoms that compose surrounding bodies. Yet this horizon of our views has been always distinctly seen by long-sighted observers ; and advanced as we are in knowledge, we can see no further. Persons of different characters of mind have thought, and may think differently; for neither can confute the other. One party, considering the more gradual and rapid changes which take place in surrounding bodies, and all the phænomena of motion and of rest, as effects of some subtile, invisible substance or substances pervading all nature, whilst the other may attribute them to inherent propensities in the atoms themselves.

I have led you thus far, Gentlemen, to shew you the rock on which the ancient fortress of scepticism stands erected, and it is evidently so unimpregnable that it has been a secure retreat for ages, and may still continue to be so. Whilst its tenants keep within their own territories, or even demean themselves peaceably abroad, I, for one, would never attempt to molest them, nor prevent them from the full enjoyment of their native apathy and inactivity of mind. But when they make excursions to annoy their neighbours, and in disguise too, it seems necessary to unmask them, and send them home again.

If, however, those professed sceptics, whom I have incorporated under the title of Moderns, really suppose that they have no opinion on certain subjects, they deceive themselves; for by repeatedly thinking that there may be nothing which is not an object of sense, they at last bring themselves to believe that there is nothing, which is a positive opinion, and also a creed found to have various conveniences. Else whence arises their zeal to make proselytes and to refute the opinions of others, who, perceiving the deficiencies and fallibility of our senses, believe that there are many things far more demonstrable to reason than to sight.

Mr. Hunter's opinions may be denied, but cannot be refuted. It is, however, easier to maintain a proposition diametrically opposite to truth, than one originating in any intermediate degree of error. Those, therefore, who attempt to account for the vital phænomena upon any other supposition than the one I have had the honor of advocating in your presence, would lead us into such a maze of absurdity, that reason and common sense forbid us to follow them.

Now, in applying the philosophical opinions of the wisest men tó account for the functions of life, according to the views which Mr. Hunter had taken of that subject, I have been charged with imagining causes of which Physiologists are not competent judges. It has been said, this is not on the record, nor before this court. You know, Gentlemen, that the plea of the incompetency of the court, is often urged when a party suspects a verdict may be given against them. If, however, Physiologists be not competent judges of this cause, no writ of *certiorari* to any other tribunal, can, I am convinced, with propriety be granted. I cannot but smile, when I hear or read of the functions of life being the effect of the vital forces; because the expression seems to me the very *ne plus ultra* of philosophical caution. So flimsy a veil is drawn before the subject, as not to conceal any thing; for every one is convinced that nothing can exert no force, and consequently that these forces must either be the attributes of the atoms which compose an organized body, or of some subtile and invisible substance superadded to, and inherent in it.

It has been said that Comparative Anatomy contradicts Mr. Hunter's opinions respecting life, for where there is no organ, there is no function. If Nature did not design an animal to see, no eye is constructed; but how the want of an organ can affect the general question of what life may be, I am too dull-sighted to discover. It will be shewn, and I think it must be admitted, that life is an organ builder, as well as a performer on the instruments it constructs. That organization alone does not produce the functions which belong to life, must, I think, also be granted. A man may sleep with his eyes open, and his friend stand before him with a light; yet the organization of the retina does not enable the sleeper to perceive the image of his friend, though vividly depicted on its surface. Food may also be received into the stomach, and the circulation in that organ go on as usual, yet its organization does not cause digestion, unless vital actions regulate those electrical operations upon which the preparation of the food-dissolving juices of that organ depend. On the contrary, I may observe, that Comparative Anatomy informs us, the same vital processes of the prevention of decomposition, regulation of temperature, action, assimilation and growth are effected in structures extremely diversified: and further, that observations on disease demonstrate the perverted actions of the same structures to produce a great variety of effects, which is a proof that the actions of life do not depend merely on organization.

I will not condescend to particularize or parry the absurd attempts that have been made to ridicule Mr. Hunter's Theory of Life. I will only inquire why we are to be prohibited from thinking, if we conform to the most approved rules of ratiocination?

Why these sceptics try to ridicule what they cannot refute? and whence arises the irritability they have displayed? The nature of this kind of irritability is, indeed, well known to Physiologists, it is but the common consequence of debility when excited. But what is the exciting cause, what provocation has been given to them? It must be as I surmised; they have opinions and are irritated at any thing contradictory which they cannot oppugn. The very term of superaddition is discordant to their ears; the supposition that there may be any thing which is not an object of sense, or actual demonstration, torments them; they themselves perceive, that the superaddition of life to structure may, indeed, warrant the supposition of a substance having the properties of perception, and volition being superadded to life; and that there may be "more things in heaven and earth, than they in their philosophy dreamt of." Should such opinions gain ground, the privileges of scepticism seem endangered; their proselytes may no longer receive with perfect confidence the assurance of philosophical liberty, the assurance that, because they are sensitive and rational creatures, true philosophy, therefore, consists in gratifying their senses, and acting as their reason dictates, for their own advantage, independently of all other considerations. Wherefore do they tell us, that we know not why a muscle acts, or a nerve feels, and that both are properties of organization? Is it not because they wish to persuade others, as perhaps they may have brought themselves to believe, "that when the brains are out, the man is dead?" Yet surely, it does not necessarily follow, that perceptivity and consciousness are annulled, because those actions have ceased by which they have hitherto been affected or manifested.

I have heard it said that I was wrong in bringing forward a metaphysical subject before this assembly; yet no one can, I think, account Mr. Hunter's Theory of Life to be metaphysical; for we infer no more than we do with respect to electricity, that it is equally probable there is an electric fluid and a vital principle. Permit me to repeat, that I excited your attention to the consideration of this subject, not only because it affords a strong proof of Mr. Hunter's genius and reflection, but because I felt assured, that without understanding his opinions respecting life, no one can understand his general Physiology, or that Pathology which it was my principal duty and desire afterwards to explain. He seems to me to have written under a persuasion that others knew what he did respecting the vital functions, and had thought as he had done, and his merits as a Physiologist, has therefore been less generally perceived from the want of this previous information and reflection.

What Mr. Hunter thought about sensation I know not; what I think, I willingly declare, which is, that it can be neither the result of organization, nor an affection of mere life. In reasoning on the motions of the matter which surrounds us, and also of that of which we are composed, we must grant either that the atoms are motive, or that they are impelled to move. So also in reasoning with respect to sensation, if the atoms be not sentient, it is impossible to suppose that sensation can result from the arrangement or motion of insensible atoms.

If to think and act in this manner be considered as an error, I must be shown that it is one, before I can alter either my opinions or conduct. Till then, I shall glory in entertaining the same opinions as Pythagoras, Plato, Socrates, and a host of others whom I need not mention, have done. It will be my boast and future endeavour to show by Physiological arguments, that in this instance also, what has been perceived by the penetrating eye of intellect, on a distant and general observation, becomes more and more apparent on a close and accurate examination of the subject. I say, it will be my boast, because I know that the opinions I allude to are productive of nothing but good to humanity, individually and collectively I admit, that the belief that man is a machine does not tend to alter his natural and established motions, and consequently, that there have been many good and moral sceptics. But I also know, that the good dispositions will want that excitement and energy which the opposite sentiments produce, whilst the bad will be left without control. It is equally apparent that the belief of the distinct and independent nature of mind, incites us to act rightly from principle; to relieve distress, to repel aggression, and defend those who are incapable of protecting themselves; to practise and extol whatever is virtuous, excellent, and honourable; to shun and condemn whatever is vicious and base; regardless also of our own personal feelings and interest, when put in competition with our duty.

We all seek for truth, and on her approach, and in her presence, are ready to sacrifice, without hesitation or reluctance, our most favorite opinions;—but to exchange opinions for other opinions, as in this case seems required of us, when the barter is so disadvantageous, would be the highest absurdity. We should give up that which is in every respect, and in the greatest degree, useful and dignifying, and what experience has proved to be durable, for that which is pernicious and derogatory, and which evidently cannot last; for the specimens presented to us are composed of such flimsy and ill-connected materials, that they will not bear even common handling and examination.

Whoever considers the operations of intellect, will, I think, perceive, that when conviction is not forced upon the mind, by something resembling mathematical demonstration, we form our own opinions. We think as we have been instructed to think, or as those do with whom we associate. Thoughts become concatenated, and by repetition habitual and established. There is a strongly imitative or gregarious disposition, even in intellect; most people think as well as act with a party, and hence results the good or evil derived from association. That in France, in a nation where the writings both of its philosophers and wits have greatly contributed to demoralize the people, I do not therefore wonder that those of their anatomists and physiologists should represent the subject of their studies in a manner conformable to what is esteemed most philosophical or clever. But that in England, the chief excellence of whose inhabitants is, that they are a thinking people, who consider the probable ends of conduct from its beginning; that in this country, particularly after so arduous an examination, and so rational an explanation of the vital phænomena have been presented to us by Mr. Hunter, the mere opinions of some French anatomists, with respect to the nature of life, should be extracted from their general writings, translated, and extolled, cannot, I think, but excite the surprise and indignation of any one fully apprized of their pernicious tendency.

The education and course of life of medical men tend to make them sober-minded, moral, and benevolent; and their professional avocations equally require, that they should possess such characters and dispositions. On no other terms can they be admitted with confidence into the bosoms of those families which may require their medical aid. Whoever therefore inculcates opinions tending to subvert morality, benevolence, and the social interests of mankind, deserves the severest reprobation from every member of our profession, because his conduct must bring it into distrust with the public.

If what I said in the introductory Lectures has irritated the party of Sceptics, what I now say, may anger them still more. But I fear them not; they can only shoot at me with the shafts of ridicule, or spit at me the venom of their malice; both of which modes of assault I actually laugh at; for the experiment has been tried, and I know, that though these things may tickle, they can never annoy me. To express my opinions on this subject a little technically, I may say, such means have no effect upon sound or naturally defended surfaces; some point must be exposed, or morbidly susceptible, ere they can occasion either pain or irritation. If, however the Sceptics had even the power to injure me, still I should not fear them; because I place between us the undisguised truth, which they can neither conquer nor confront. For truth possesses a power which poets have represented by symbols; like the Ægis of Minerva, or the spear of Ithuriel, it has the power, not only of protecting and maintaining what is right, but of revealing, abashing, and appalling, what is wrong.

LECTURE II.

The propensity to observe and compare surrounding objects, seems natural to man. We find even children pleased with examining and assorting stones, spars, metals, and other specimens of mineralogy; still more gratified with those beautiful objects, flowers; and even in a greater degree with moving beings, which, on that account, claim a kind of alliance with themselves. Yet so diversified are the subjects of nature, in each of these departments, that it requires the constant application of any individual to render himself a distinguished character either as a mineralogist, a botanist, or a zoologist. Linnéus, whose knowledge of natural history was so extensive and exact, perceived the necessity of some system of mnemonics, by which we might remember and survey the whole. He therefore formed an arbitrary arrangement of these subjects, and chiefly from their external characters.

The advantages resulting from this plan were striking. It was perceived how we could thus learn parts in detail, and also contemplate the extreme diversity and extent of the system of nature; as well as how we might arrange any additional knowledge that was obtained, so as to make it a part of one orderly whole.

The minds of men seem to have been fascinated by the method which Linnéus had adopted; for it was applied to subjects where no artificial memory was required. Even diseases were thus arranged; and the attention being directed to their external characters, it was taken from its true object, which should be to enquire into their intrinsic nature. This is a striking though not singular instance, showing, that even grave and learned men, reputed philosophers, have a propensity, like sheep or like school-boys, inconsiderately to follow the leader.

That the arrangement of Linnéus is unnatural, and unsuitable to the purposes of

Comparative Anatomy, is evident; but we need not defame the memory of so great a contributor to general improvement, by supposing that he was ignorant of the advantages and disadvantages of his own scheme, particularly as he has himself so frequently acknowledged the latter. Though he thought it right to arrange the subjects arbitrarily, and chiefly by their external characters, because, those but little informed could then co-operate with the more erudite, he must have known that he violated the arrangement of nature; for even with respect to plants, he separated the individuals of their families, and placed them apart amongst strangers with which they had no natural connection. Of his twelve botanic Classes, there are but two which have a claim to be considered natural; and even in these, it is not unexceptionable. I allude to the classes Tetradynamia and Syngenesia. Surely, too, Linnéus must have perceived that he committed still greater outrages against natural order in the animal kingdom. I would never advise my young friends, to endeavour to raise their own reputation, by attempting to depress that of another; for general observation speedily detects what each has done for the promotion of science; and their respective merits are impartially appreciated by the public; therefore the attempt to undervalue another, becomes an offence against public opinion, and at the same time, "shows a most pitiful ambition in him that uses it."

Mr. Hunter knew nothing about systems; when he met with an animal he had never dissected, he cared but little by what name it was called, to what family it belonged, with what others it was associated, either by natural or artificial ties. He chiefly wished to know, how its food was digested: how its blood circulated; how it respired; what were its feelings, instincts, and habits; how it secured or defended itself from injury; how the multiplication of its species was effected and insured. Yet, by noting the facts relative to these subjects, it surely must be interesting to observe, how much his arrangement and exhibition of structures correspond to those lately displayed in systematic works; in which also will be found an arrangement of the animal kingdom, more suited to the purposes of Comparative Anatomy, than that of Linnéus.

In asserting the claims of Mr. Hunter, I should not omit to mention that he was a very candid man, and freely divulged whatever he knew or thought, as far as his powers of communication enabled him. His biographer says, "his disposition was candid and free from reserve, even to a fault; for it sometimes made him appear harsh." Doctor Hunter, in his Lectures, frequently mentioned his brother's opinions on different physiological subjects. Mr. Hunter himself began to give lectures in the year 1770. Since the year 1785, the preparations in the Museum have been arranged as they now are, and publicly exhibited. That Mr. Hunter's facts and opinions respecting physiology in general, have gradually become known to the nations on the continent, have been adopted and incorporated with their knowledge of that science, is to me very manifest. I mention only one instance in evidence of this proposition. In some late foreign systems of Physiology, the nerves are called organs of calorification; though without adequate reasons being assigned for so novel a denomination. That his facts and opinions, relative to the comparative structure and functions of animals, should have travelled in like manner, and met with a similar reception, does not seem improbable. Both professors Camper and Blumenbach were in London, and were, as I believe, well acquainted with Mr. Hunter's labours. Such were the circumstances that promoted the diffusion of Mr. Hunter's discoveries and opinions. No one could be more fully aware of the uncertainty of knowledge than he was; and this occasioned his tardiness in publishing either his discoveries or opinions; which may have given a seeming priority to the works of others, and prevented the knowledge that flowed from him from being traced to its proper source by the public in general.

On the contrary, however, I cannot but suspect, that the great illumination which Comparative Anatomy and Physiology have of late received on the continent, has in a considerable degree resulted from reflected light, originally emanating from materials which Mr. Hunter brought together, and from his brilliant physiological discoveries.

In advocating the cause of Mr. Hunter as a comparative anatomist and physiologist, all I can do is to tell when I think he first ascertained certain facts, or drew certain conclusions. Yet I know it is difficult to prove these propositions, and as I have said*, I shall be often obliged to refer to his writings, in 1776, to show the extent of his information and views at that time. If, however, I fail to prove his title to priority of discovery, or opinion; still I feel persuaded that what I shall say of him will not be deficient in interest, for I cannot suppose any one will believe, that the unlettered John Hunter borrowed his evi-

* Lecture I. page 12.

dently original opinions; or that the works of his own hands were copied from those of others. If others preceded him, he will still appear like Ferguson the astronomer; who, whilst a shepherd's boy, drew accurate charts of the Heavens, knew the course of the planets, was acquainted with the nature and application of the mechanical powers, constructed various time-keepers, planned and executed sun-dials in different aspects for his neighbours; and when at length his fame attracted the notice of the surrounding gentry, and a subscription was raised to send him to Edinburgh, that such rare talents might not remain uncultivated; he was, as he said, surprised to learn that all he knew and much more had been already known. Both instances will serve to show the extent of knowledge which rarely-gifted individuals are capable of acquiring by their own observation, ingenuity, industry, and reflection.

In the first department of his Museum, Mr. Hunter displays the firm and rigid parts of vegetables and animals; the substances or joints which connect them; and the powers which move them; as if he had thought it proper to define what living beings were, before he proceeded to show how they were formed, and what processes were carried on in them. Mr. Hunter thought that there was a principle of life in vegetables as well as in animals, and noted the identity of the vital processes in both. He adverted also to the similarity of their morbid processes; to the thickening of the leaves in vegetables, from the irritation of insects; and the growth of excrescences from the same cause. How extremely beautiful is the nest formed by the increased, but not unhealthy actions of life, for the young of the Cynips Rosæ (Linn.)? He observed how exactly correspondent to the processes of animal life is the exfoliation of the dead leaf in the autumn. If the leaf and stem equally and simultaneously perish, if a branch suddenly wither, the leaves tenaciously adhere by cohesive attraction; the detachment of the dead from the living parts being apparently the consequence of vital actions in the latter. There is one experiment of Mr. Hunter's I may mention, because it displays the reflective character of his mind, and the persevering industry with which he prosecuted every subject that excited his attention. Having set beans in a tub filled with earth, which had perforated apertures in various directions, he contrived mechanism to keep it constantly revolving round an axis, to show that the ordinary operation of gravitation had no effect in producing the extremely varied course which the young plants took in order to arrive at the surface.

Specimens of some plants, parts of which undergo sudden motions, stand first among the preparations in the Museum. Respecting this subject Mr. Hunter observes in his MS. in 1776, "All plants are not endowed with evident motions, yet in some, such motions occur in parts of them, and apparently from the application of particular stimuli, as the rising and setting of the sun, &c. Some also are affected by touch, so as immediately to be put in motion by it. Of the nature of the organization subservient to these motions, we are ignorant. We know not whether they may arise from organs formed purposely to produce them, or from all the neighbouring parts being joined in consent to occasion this effect. It seems probable, however, that the power is analogous to the irritability of muscles."

Next are exhibited the nutritive fluids both of vegetables and animals, and also the fatty substance which makes so considerable a part of the body in the latter class, because all their different structures must be formed from these nutritive materials. The nutritive fluids, or blood of animals, and the sap of some vegetables spontaneously coagulate; but in other vegetables, the addition of acetate of lead is necessary to produce coagulation. The nutritive fluid, or blood of insects, and the lower kinds of animals, is shewn to be colourless, with the exception of that of some worms which have red blood; and that in reptiles and fish, the red colour which is so generally considered as characteristic of that fluid begins to be added. Though blood is so subtile a fluid as to be capable of permeating the minutest vessels of the body, yet that part which spontaneously coagulates, becomes very firm, tough, and unsoluble; often also assuming a fibrous appearance. From the exact similarity of these fibres to those of which muscles are chiefly composed, which Mr. Hunter has taken great pains to exhibit in preparations you will observe in the Museum, he inferred their identity; an inference which modern chemistry has since established.

With respect to animals, Mr. Hunter observes in M.S. 1776, "In the more imperfect animals, it is very probable that there are no fixed parts, but that all parts are irritable and have motion, like the urinary bladder or an intestine. As animals become complicated, and have various motions, especially the progressive, then such motions are more divided or partial; for which purpose it is necessary there should be substances whose firmness and structure, and mode of connection, should divide and determine the motions to particular parts. These structures are differently placed in different animals. In the earth-worm, caterpillar, and nereis, the firm structure is the skin, which is divided into rings, all of which have motion on each other, and into these are muscles inserted, so that a variety of particular motions is produced. In insects, spiders, and lobsters, whose firm parts are more complicated and answer a greater variety of purposes, we find the fixed parts still more dense. In the two former they are of a horny, and in the latter of a calcareous nature. These parts also make a covering for the animal, but there are processes of them going deep for the attachment of muscles. In tortoises, lizards, snakes, &c. though they have firm external coverings, yet there is an internal apparatus for motion, which is principally bone. In the more perfect animals, external firm parts are rarely found. They have an internal osseous skeleton, so that the muscles and their attachments are reversed; and thus we find them arranged in the fish, fowl, and quadruped." Mr. Hunter adds, " shell is a substance made use of in the animal kingdom, chiefly as a defence against accidents, serving the purpose of a retreat!"

This extract convinces me that there is scarcely any thing in Professor Cuvier's Lectures, relative to the construction of animals, with which Mr. Hunter was unacquainted; and it must be interesting to observe the correspondent views which these highly informed men have taken of the same subjects. As Mr. Hunter's object was Physiology, or an enquiry into the functions of Living Beings, he has not been solicitous to exhibit all the facts relating to their construction. Professor Cuvier, has, on the contrary, devoted his first seven Lectures to display the latter subject, in so ample and satisfactory a manner, as cannot, I think, fail to gratify the reader. Some animals are soft and undefended; some inhabit shells; some may be said to have an external articulated skeleton, serving also as a defence; and the rest an internal skeleton. He remarks, it is curious, that insects, having an external articulated skeleton, possess such a combination of motive powers, that some of them walk, run, leap, swim, and fly with as much facility, as beasts, birds, and fish, exercise one or more of these faculties. Professor Cuvier thinks that they are indebted for these advantages, to the numerous articulations which their case or skeleton possesses. It might strike a person who had not considered the subject, that there were animals possessing both an internal and external skeleton, as those of the reptile tribe. The muscles of insects, however, act upon the external case, which is therefore similar to the skeleton. The shells of tortoises are to be considered merely as armour, as defences against injuries, which the animals have neither the power to oppose, nor agility to avoid. Even amongst the higher order of quadrupeds, some wear this kind of armour as the rhinoceros; and many have such thick hides, as protect their possessors from trivial injuries; hides like the leathern doublet of Hudibras, which

"Though not ball was cudgel proof."

In the construction of animals, we find nature proceeding upon an uniform plan, and by variation of the same means, contriving to produce beings extremely diversified in form and faculty. It has been observed that Comparative Anatomy furnishes abundant facts to the natural theologian, shewing that intelligence must have operated in the construction of living beings, by the evidence it affords of design, and of the adaptation of means to ends. This observation is however more perfectly verified by human, than by Comparative Anatomy; for so well is man acquainted with his own wants and desires, and with the structure of the human body, that he must be a dull, inconsiderate, or perverse character, who can contemplate the organs and structures which compose it, without a feeling of admiration. The very reverse however happens in Comparative Anatomy. Many of the animals we dissect, are, when living, concealed from our view; they are hid beneath the surface of the earth, or the waters; they fly aloft in the air; or secrete themselves in the recesses of the forest; so that we have little acquaintance with their habits, or peculiar wants and desires. We cannot, therefore, so well perceive the reasons of those varieties of formation we discover, nor judge of their adaptation to the peculiar exigencies of the being that possesses them. In many instances also the organization is extremely obscure, and in some it is probable that it never can be developed.

There are minute animals, the motions of which are extremely vivacious, and in which all the processes of life are carried on with great celerity and vigour, yet no organization can be detected in them, even by the aid of the microscope. We are, therefore, obliged to conclude either, that there may be organization which is wholly undiscernible; or that life can execute its functions unconnected with those kinds of organization which we observe in animals in general. Whatever may be the structure of animals, we cannot however but perceive, that each possesses means of procuring sustenance adequate to its wants; so as to ensure its perfection of health and growth, and powers to continue its species, which seems to be the consummation of animal existence. Neither can we avoid remarking, how admirably the perceptions and faculties of animals are adapted to the situation which they occupy in the graduated scale of existence. As far also as we can discern, we perceive the same evidences of design and admirable contrivance; and the facts we learn from the examination of the structure and functions of living beings in general, may indeed be said, "to come more home to every man's business and bosom," than any we collect from the study of Nature in other departments of science.

You find displayed in the beginning of the Museum, many forms of the moving powers or muscles; and also the uses of elastic ligament are shewn, which sometimes produces motion, and sometimes retains parts in certain positions, by its mechanical properties, without the expense of muscular exertions. It is this substance which keeps open the valves of shells and the claws of lobsters, so that no power is exerted but in closing them; it is this substance also which supports the head of animals, without muscular effort, whilst they are grazing.

I remind you, gentlemen, that Mr. Hunter, who did not consider life to be dependent on organization, was I believe the first who clearly ascertained and publicly announced the fact, that muscles, after contracting to their utmost, might gradually acquire a new sphere of contraction. This fact was first ascertained by the following case, which I relate, because I believe it is not generally known. A lady who had both knee pans broken and greatly retracted, came to London many years after this accident, and consulted Mr. Hunter on her case. Almost every other surgeon would have considered it hopeless. He, however, who was constantly thinking about the reparative processes, began to enquire whether the long union which had taken place between the distant portions of the bone was of a ligamentous and unyielding nature. To ascertain this point, he endeavoured to force the upper portion still higher, and found that the lower followed it, and that a motion of the leg was thus produced. The muscles were however unable to move the retracted part of the patella, because they had already withdrawn it to the utmost extent of their original power. Mr. Hunter saw no reason why muscles, thus circumstanced, might not acquire a new sphere of contraction, yet he saw no mode by which they were likely to do so, except through the influence of the will of the patient; and to persuade persons to will what must appear to them an impossibility, was the chief difficulty he had to encounter in his endeavour to ascertain the proposed subject of enquiry. He persuaded his patient to sit on a table, and suffer her legs to swing backwards and forwards. This they did in the same manner and from the same causes that a pendulum does. She could indeed retract the limbs further under the table than their pendulous motion would carry them, by the agency of their flexor muscles, but she could neither check their motion in this direction, nor prolong it in the opposite one, by any exertion of the extensors. Mr. Hunter urged the patient to sit at intervals for an hour or more a day, wishing the exertion of such powers might take place; and she promised to comply with his request. After a time, she became persuaded she had in a degree acquired her object, and thus encouraged, her will became more energetic, and the muscles more obedient to its mandates; till it was evident to others that she could check the receding motion of her limbs, and prolong the advancing one. Mr. Hunter then attached weights to her feet, to increase the demand for muscular effort, and thus, by degrees, did the patient acquire the power of extending the legs on the thighs, and the consequent ability to stand and walk. That muscles may acquire a new sphere of contraction, was afterwards fully proved by other cases; and Mr. Hunter has put up in his collection of anatomical facts, illustrative of the vital functions, the biceps muscle of both arms of the same subject; the one, which is of its natural length, measures eleven inches; the other, which has become contracted in consequence of the arm being broken, and the bones overlapping, measures only five inches. Nevertheless, in this state, the bones having become firmly united, the shortened muscle acquired a new sphere of contraction. The particulars of this last case are recorded by Sir Everard Home, in a Cromian lecture, published in the Philosophical Transactions for 1795.

Mr. Hunter next displays the anatomical facts relating to the formation of bone, and exhibits specimens of that variety, the black periosteum of the silk fowl of Guinea. He also shews the various kinds of joints and substances by which the bones are connected. The formation of shell, and the growth of horns, are likewise exhibited by various preparations. As these subjects have been already considered in this theatre, I have no wish to say any thing about them on the present occasion, except in reference to one particular.

Every one at all acquainted with the mind of Hunter must be assured that he could not fail to be much interested with the facts relating to the annual renewal of the stag's horns. Those of other animals last for life, and yet the large and curiously-branched horns of the stag, though formed of equally durable materials, are cast off annually, and replaced with a celerity of growth that would scarcely be credited by any Physiologist who was not well acquainted with the fact. Of Mr. Hunter's observations on this subject I shall speak hereafter; at present I only wish to mention that he particularly noticed the fact at that time not commonly known or attended to, that, if a stag be castrated, the horns, which are shed annually, are not afterwards renewed; so that the animal having lost the male powers, no longer exhibits their external characters. We do not find, however, Mr. Hunter drawing any inference from this fact, for it warrants none other than the want of the beard in man, would do, from a similar cause, provided he also became bald-faced annually. On the contrary however, we find him much excited by observing, that when the sexual character is annulled by age, the appropriate external signs are not only discontinued, but sometimes opposite ones exhibited. He really seems interested in observing, that old women sometimes become bearded, and that the old hen pheasant forms and displays the beautiful plumage of the male bird.

In some late works on Physiology, I find it suggested, that the formation of one part or organ, creates a necessity for the formation of another; and therefore it happens, I presume, according to this mode of reasoning, that men become bearded and stags wear horns. Yet these writers have not suggested any reason for the occasional exhibition of the delusive signs to which I have been referring, and I suspect that the consideration of this subject in general, has been omitted, in drawing such conclusions as I have just referred to.

According to Mr. Hunter's notions of life, those occurrences which denote the sexual character are to be considered as the effects of sympathies existing between remote parts of the body; which, like other instances of sympathy, are liable to occasional failure and considerable variation. That such sympathetic actions are the effect of unknown laws, he could never have doubted; but he thought he perceived a spirit and design in these laws very different from those which produce results in dead matter. In the latter the results are immediate and uniform, so that they may be predicted; whilst in the former they sometimes do not take place, and appear more like the effects of option than necessity; they also are subject to considerable varieties; neither is their result in many instances immediate; yet the actions tend to produce some remote effect or good to the individual in which they occur. That such were Mr. Hunter's ideas of the vital actions may be inferred from his unphilosophical language, which imputes design to unintelligent agency.

Mr. Hunter seems first clearly to have perceived that we could not judge of the vital actions from other subjects, and therefore that the zoonomia must be made a separate study and pursuit by comparing the vital processes with one another in the same animal, and in all the varieties of living beings.*

Under the influence of these notions, we cannot be surprised that he is interested in recording the facts, which seemed to him to shew that when age has annulled the principal sexual powers, their appropriate external evidences are not only discontinued, but sometimes those of an opposite character are displayed. †

The difference of form and character between the male and female of most animals

* If, indeed, all the phænomena of life were produced by the super-addition of a subtile substance, or substances capable of causing chemical composition, decomposition, variations of temperature, and actions, according to the suggestion contained in the first lecture, page 35, without being regulated by any other vital energy, but acting in conformity to pre-established laws; still the results are so different from what we observe from the operation of the same causes in matter in general, that the laws of life must be peculiar, and, therefore, require to be made a separate study.

† Mr. Hunter's paper on this subject will be found in the Philosophical Transactions for 1780.

is in general considerable and striking, and denoted by circumstances very diversified, but not reducible to any general rules. Yet this difference does not seem a consequence of necessity, for there are some species of animals in which it scarcely can be said to exist, and in others the female is the larger and stronger, partaking more of what we usually deem the masculine character.

That the characteristic signs of either sex are in general deficient, in proportion to the deficiency of the most essential and important of the sexual organs, must be admitted. Yet as the cases denoting this fact in the female, are not common, it may be proper to refer to some of them. Mr. Pott removed the ovaries of a woman which had been protruded from their natural situation into the groins, like hernia in common. The uterus never afterwards menstruated, the breasts wasted, and the body became muscular and robust. Mr. Pears relates the case of a woman born without ovaries, in whom the other sexual organs were formed, though they remained in a dwarf and inefficient state. She never manifested any of the attributes of the feminine character. She was broad-shouldered, and small round the hips, like a man.*

How fond Mr. Hunter was of animals, how closely he observed their form, habits, modes of action, and progression, Sir E. Home has already told us in this theatre. He preserved the skeletons of most of the animals he had dissected, and there are probably 300 specimens in boxes, which he had no room to display, neither is there space enough in this building. That he was an observant and accurate comparative osteologist is also apparent from his last papers in the Philosophical Transactions, containing a commentary on fossil bones, found in caves near Bayreuth, and elsewhere. Mr. Hunter has, however, exhibited and contrasted some of the skeletons of animals, and preserved specimens of those of rare and curious forms; he also

* Philosophical Transactions for 1805.

collected the heads of persons of different nations. Yet still I am aware that the Hunterian Museum may by some be considered as deficient in the department of osteology, and, as has been before observed, the minute examination of the form of animals did not come within the scope of Mr. Hunter's designs.

Having derived much gratification from reading professor Cuvier's remarks on this subject, and believing that there is much food for meditation even in a skeleton, I shall put together some observations on the form and mechanism of that of the human subject; for as anatomy is chiefly taught as the ground-work of medical and surgical knowledge, such observations are not in general incorporated with systematic treatises on that subject.

The head is formed into the bony cavity, which contains the brain, called the cranium; and the face, which is the seat of four of the senses, that are situated near the organ of sensation, volition, and other faculties. In proportion to the size and complexity of the brain, with reference to the size of the nervous system, do animals appear to possess various kinds and degrees of perception and intelligence. Camper and Hunter, at the same time, attended to the apparently descending series in the construction of the heads of animals. The head of the African does really in some degree, and in some individuals more particularly, approximate in form to that of the monkey; in the sloping direction of the forehead, the size and depth of the temporal fossa, in the flatness of the nose, the projection of the teeth, and the diminution of the chin. We also observe this approximation in other parts of the African skeleton; in the length of the loins, and in that of the fore-arm and leg, compared to the arm and thigh; in the flatness of the foot, and projection of the heel. In the head of the monkey we distinguish the same things, but in so aggravated a degree, that we at once recognize the head of a brute, possessing little cranium and much face, a mere approximation of form to the human head, a mockery, with which, in general, we are more disgusted than pleased. In the quadruped, the forehead is nearly an horizontal continuation of the face, and the jaws, so greatly extended, that the cranium is but little apparent, and the face constitutes the chief part of the head. In the bird and in the fish we observe the same circumstances, but in a much more striking degree. So greatly did these observations interest Sir Joshua Reynolds, that, in his portrait of Mr. Hunter, he has left his portfolio open at that part where this descending series is sketched.

This is the first time, on the present occasion, that I have to call your attention to the very curious and problematical concatenation which exists in all the works of Nature. In the African, we perceive a link connecting the human form with the extremely diversified forms of the brute creation. I cannot forbear to add, that though there is an approximation in the form of the African to that of brutes, there is none in his nature; for well educated Africans have displayed great powers of mind.

Camper also remarked, that the heads of persons of intellect, were generally characterized by a large and prominent forehead; and that in the Greek antique head, the forehead is made to project beyond what is natural, or has been ever observed. It has, I believe, been a question among artists, why we are so fascinated by the sculpture of the Greeks. The intellect of the Greeks seems superior to that of most other nations; their philosophers, poets, orators, and designers, have all left us models difficult to imitate, almost impossible to surpass. With a kind of intuitive perception of the *το καλον*, of whatever is excellent or beautiful, they formed an ideal perfect head, and have exaggerated those circumstances in which the human head differs from that of a brute; yet with a delicacy that leaves the excess beyond what is natural to man, not readily distinguishable. The head of a brute has its forehead oblique, or declining towards a horizontal line, drawn from the top of the face; and the sides of the forehead converge from the orbits, so as to make it narrower at the top than at the bottom. The Greeks made the human forehead advance a little before a perpendicular line, and they raised it to an uncommon height. They made it also diverge from the orbits, so as to be broader above than below. The eyes of animals are placed at the sides of the head, so that they see laterally, and some even behind them. The human eyes are made to look forwards; whenever they glance to a side, they indicate either fear or distrust. The Greeks seem to have paid attention to this point; the eyes are made to look strait forwards, and the outer edge of the orbit is so wrought up, as seemingly to preclude a contrary vision. The eyebrow is a feature peculiar to the human face; and I think it must be regarded chiefly as an organ of expression. In the antique head, this part is finished with much labour and skill.

The bridge of the nose is also peculiar to the human face; it is represented very prominent, or raised much above the level of the orbits. The Greeks thought it most beautiful when it proceeded in a strait line from the forehead, whilst the Romans preferred it arched. The nostrils are formed as little like a snout as possible; they are apertures for respiration, and for smelling, in the human subject, and their motions contribute to expression. The orifice of the mouth, though occasionally used for eating, seems chiefly constructed in the human face, for the articulation of our words; and the motions of the lips are also strongly indicative of our feelings. The Greeks represented the mouth according to these views of the subject. They made it as little like a devouring aperture as possible. They made the orifice of small dimensions; the lips thin, but muscular and expressive; and they sometimes even flattened the arch of the jaws in an excessive degree. The chin, which is peculiar to the human countenance, they made to project very considerably, and in the males they represented it broad. I forbear to say more, because this is a subject rather of taste than of science; yet design all this, effect but this, and you will form the front of Jove himself.

Doctors Gall and Spurzheim tell us that brutes have a forehead and hind-head, but they want the middle part of the head, which is peculiar to man. Man is a long-headed animal; there is a great extent of brain between the fore and hind parts. The top of his head is arched, and in some individuals, in a peculiar degree, so that the hair falls to either side, and hence results the naturally parted forelock; and it is there that our new cranioscopists believe they can discover signs indicative of moral sentiments and excellence. Perhaps some spice of vanity may be perceived in Milton's description of the head of Adam, for it seems to be copied from his own.

> His fair large front and eye sublime declar'd
> Absolute rule; and hyacinthine locks
> Down from his parted forelock manly hung,
> Clustering;

Doctors Gall and Spurzheim further tell us, that the instincts or propensities of brutes may be judged of from the form of their heads, and assert the same with regard to the human subject; which latter assertion does not appear discordant to general observation. For if the human head be more produced in those parts peculiar to man, so does its possessor frequently appear to have more of the intellectual character; or if in those parts common to him and brutes, so has he more of the propensities in which he participates with animals in general. Even this was observed by the Greeks, who, to use Dr. Spurzheim's own expression, "never committed such an absurdity as to put the head of a gladiator on the shoulders of a philosopher, or the reverse."

The speculations of these gentlemen appear to me very ingenious, and calculated to unravel some of the intricacies of the human character, as well as to establish a just distinction between the faculties of animals and those of man. The peculiar original dispositions and talents which certain individuals possess, must either be ascribed to original qualities of mind or to causes which may produce them. To me, who think it absurd to suppose that perception and volition are the result of organization, or an affection of mere life, and consequently who believe them to be properties of something distinct, it is even pleasing to perceive how any thing essentially perceptive and possessing consciousness and volition as the natural and seemingly necessary adjuncts of perception may be variously affected, and consequently prone to certain actions. To me, the plurality of our senses has always appeared a strong argument for the individuality of mind. I see, I hear, I am variously affected. I am more delighted with the objects I behold, or more charmed with the melody I hear.

If Doctors Gall and Spurzheim tell us, that in consequence of certain conformations of our brains, we have propensities, such as brutes also possess, productive of good or evil according to the degree or direction in which they are exerted, they only attempt to account for facts of which we are all conscious. Men are by nature brave or fearful, generous or covetous, candid or cunning, fickle or determined; and these original qualities, though they admit of being controlled and suppressed, cannot be altogether annulled. Our great student of human nature and conduct, whose representations of them must ever render him the delight, admiration, and glory of his country, has also metaphorically pourtrayed that mixture of good and evil which belongs to the human character. "Our web of *brain* is as a mingled yarn, the good and ill together; our virtues might be proud, if our vices whipp'd them not; and our vices would despair, were they not cherished by our virtues."

There is nothing in the assertions of Drs. Gall and Spurzheim contradictory to the results of general observation and experience. It is admitted that the superior intellectual faculties can and ought to control the inferior propensities. It is admitted that we may possess organs, which, nevertheless, may be inactive, from natural torpor or want of education. General observation and experience proclaim, that susceptibility is the chief incentive to action, that it is the source of genius; and that the character of man greatly depends upon his education and habits. We educate our faculties; what is at first accomplished with difficulty, by repetition is easily performed, and becomes more perfect and established by habit. Trains of perceptions and thoughts also become firmly concatenated, and occur in succession. Even our feelings undergo the same kind of education and establishment. Casual feelings of good-will, by repetition, strengthen and produce lasting friendship; whilst trivial sensations of disgust, in like manner, may occasion inveterate hatred. When the remembrance of our perceptions recurs, they are often concatenated with other perceptions, modified by reflections, and associated with feelings; and it is by means of the repetition of such trains of perceptions, thoughts, and feelings, that habits of thinking and acting are acquired and established. Yet such reflections and associations are produced and regulated by the actions of our own minds; and it is therefore evident, of whatever materials Nature may have made us, she has at least given us great powers of forming and fashioning ourselves. Had the dispositions and powers of our minds been similar, human life would have been dull and monotonous. Their variety enables us by education to attain different kinds and degrees of excellence, and to be useful to one another.

The very supposition of the organs which are said to form the distinctive characters of the human race, appears to me extremely ingenious. Every one knows that some individuals are more prone to the accurate notation of facts; others to their comparison, and to forming judgments from analogy; others to the investigation of causes; and others to those sportive combinations of similar and dissimilar things productive of wit and humour; which facts are attributed to the organization of the brain being more active or developed in different parts. I need not tell you, gentlemen, that I went to school a long while ago, and that what I was there taught has become established by repetition and habit, so that I cannot readily express my meaning, without the use of the old terms, cause and effect; it seems proper, therefore, to explain what I wish to express by them.

In several medical books published of late, I read, that we have no knowledge of cause or effect, save what results from the continued observation of the priority of the one, and the consequence of the other. I was however taught to believe that we had by enquiry attained a rational assurance of the nature of cause and effect in a great number of instances, and might, by a continuance of the same endeavour, probably obtain it in others. All our knowledge is derived from our perceptions, and they inform us, that if one body in motion impinges on another free to move, the latter receives part of the motion of the former according to the degree and direction in which the force has been applied. If, therefore, I push a bullet contained in a tube, in a horizontal direction, I infer that it moves for the same reason, or from the same kind of cause. But if I put the tube in an oblique or perpendicular direction, I find the bullet move with different degrees of velocity and torce from another cause, gravitation. If I explode gunpowder in the lower part of a tube held in a perpendicular direction, containing also a bullet, I find the ball forced upwards for a time by one cause, and then it decends in consequence of another. My senses may indeed inform me of the appearances of light and shade, in the surfaces of spherical and many-sided figures; but if, after having studied all that human ingenuity and industry has discovered relative to these subjects, I am able, in the absence of the object, to represent upon paper a spherical or many-sided figure, do I not manifest a knowledge of the causes of light and shade beyond that which my perceptions alone would have produced? If also, I can at will present the angle of a prism to a luminous body, so as to produce the regular exhibition of the rainbow colours, do I not exhibit a knowledge of the causes of such effects? If indeed the retailers of such sentences as I have been commenting on, merely design to inform us that we have no knowledge of the precise means by which a cause produces an effect, they surely need not have exhibited so much parade in shewing what is constantly seen and acknowledged. If however they mean to insinuate, that we have no knowledge of cause or effect beyond that which results from mere observation, they publish at the same time, a libel on the human understanding; a prohibition to rational inquiry, and a most severe satire on themselves.

Should the result of our general enquiries, or attention to the subjects proposed to us by Drs. Gall and Spurzheim, eventually induce us to believe that the peculiarities of our feelings and faculties were the effects of variety of excitement transmitted through a diversity of organization, they would tend to produce mutual forbearance and toleration. We should perceive how nearly impossible it must be that persons should think and feel exactly alike upon any subject. We should not arrogantly pride ourselves on our own virtues and knowledge, nor condemn the errors and weakness of others; since they may depend upon causes which we can neither produce nor readily counteract. The path of virtue is plain and direct, and its object distinctly before us; so that no one can miss either, who has resolution enough never to lose sight of them by adverting to the advantages and allurements, with which he may be presented on the one hand, or the menacings with which he may be assailed on the other. Yet no one, judging from his own feelings and powers, can be aware of the kind and degree of temptation or terror, or the seeming incapacity to resist them, which may have induced others to deviate. Now though, from the foregoing considerations, I am pleased with the speculations of Drs. Gall and Spurzheim, I am however quite incompetent to give any opinion as to the probability of what they have suggested; because I see no mode by which we can with propriety admit or reject their assertions, except by pursuing the same course of investigation that they themselves have followed; a task of great labour and difficulty, and one which, for various reasons, I should feel great repugnance to undertake.

After these general observations on the form of the human head, the mansion of the mind, and the index of its character, I proceed to describe that of the teeth, which commonly make a part of the skeleton. In man, they must be regarded chiefly as the means by which he masticates his food; yet Mr. Hunter did not, in my opinion, consider the teeth of animals in general as subservient principally to this purpose, but placed them in his Museum, for reasons that will hereafter be explained, among the instruments and weapons that are allotted to animals.

The four front teeth, in man, have their edges overlapping each other, like the blades of a pair of scissars, and seem well calculated to cut in slices the food which admits of such a division. The side front teeth, which correspond to those teeth in animals, called tusks and tushes, fangs and venom teeth, are in the human subject, round in front, flattish behind; they increase in size as they project from the gum, till having attained their greatest magnitude, they become suddenly and obtusely pointed. They have long roots inserted deeply in the jaws, and the pointed termination of their bodies projects a little beyond the level of the line made by the edges of the other teeth. These teeth seem well calculated for breaking into small pieces hard substances, and thus preparing them for the action of the grinders. All the back teeth in the human subject are grinders, and there are two small and three large on either side, in each of the jaws.

That nature meant man to grind his food by means of his teeth, is to be inferred, not only from their form, but from the mechanism of the joints of his jaws, from the great strength and various actions of his muscles of mastication, and from the lever formed by the coronoid process to increase their power. I do not know, however, that we are warranted to infer from the teeth alone what kind of food nature designed us to live on. Some vegetables and animals are peculiar to certain districts, and will not thrive in other situations; whilst other kinds of vegetables and animals, are found more generally distributed over the surface of the globe. Grass and corn thrive every where. Man also seems an universal animal. He can and does live in some places upon vegetables only, whilst in a Greenland winter, his chief sustenance is derived from oil and fish. Nature may have given man means to grind his food, that he may extract the greatest quantity of nourishment from a deficient supply of it; and he can by mixing different kinds of food qualify substances for trituration, which by themselves would be unsuited to that process. It is also one of his characteristics, and in which he seems much to delight, that he is a cooking animal. The human teeth are also of great use in the articulation of our words.

I should certainly not fulfill one of my objects in these Lectures, which is to display, to the extent of my ability, the merits of Mr. Hunter, were I to omit in some part of them, to notice the surprising labours he bestowed, in investigating the structure and functions of animals of the whale kind. In all the works of nature, we perceive extreme variety. The teeth are not only various in their formation and re-production, but also in the substances of which they are formed, and the purposes which they serve: and as some of the whales present a very curious instance of this sort, I trust I shall be excused, if I introduce the subject on the present occasion. In Mr. Hunter's paper relative to the structure and functions of animals of the whale kind, there is abundant evidence of the pecular character of his mind. We see the student of nature on the most extended scale, solicitously enquiring into all those particulars which adapt these animals to the peculiar situation they occupy in the scale of existence. The horizontal direction of the tail, so different from that of fish, and the cause of the peculiar strength of the flexor muscles, analogous, as he says, to the lumbar muscles of animals, is shewn to be calculated to raise the most prominent part of the animal, where the blow-hole is placed, above the surface of the water for respiration; whilst the horizontal motions of the tail are equally adapted to depress it to the depths of the ocean in search of food. The motions of the tail cause these animals to move up and down in a curvilinear direction, which makes them appear hump-backed, and thus the dolphin is generally represented. We see this in porpoises when they swim slowly and near shore, alternately respiring and grubbing along the bottom. Yet these creatures can, with their powerful tails, scull themselves forwards in a strait direction with surprising speed, passing a ship whilst she is going at the rate of ten miles an hour, with the same apparent celerity, as if she were lying at anchor.

The back bone of this tribe of animals, is formed as in quadrupeds *; it has not the flexibility nor lateral motion of that part in fishes, neither have they side oars or fins, and therefore they are unable to pursue the quickly varied and versatile motions of the finny tribe. They say, however, that a squadron of porpoises will encompass a shoal of herrings and drive them into a small bay to devour them. Though many of the whale tribe have teeth, they probably chiefly feed upon medusæ, sepiæ, shrimps, &c. which they find on the shores and depths of the ocean, or when pressed by hunger, they may destroy and devour one another. Mr. Hunter found the eye of some kind of whale undigested in the stomach of the grampus. We cannot consider them as predacious animals, for these in general, are suspicious, cunning,

* Mr. Hunter has put up a preparation of the intervertebral substance, which is similar to that of quadrupeds in general.

and solitary, whilst the whale tribe have an opposite character. The porpoises accompany our ships on the voyage, and they say the dolphin has been known to come to the shore when called for food he had been accustomed to receive; observations and stories of this kind may have formed the basis of different poetical fictions.

For so monstrous a creature as the great whale, when thus constructed to obtain a supply of food for its vast bulk, would appear to us, were we ignorant of the means which nature has contrived, a subject of the greatest difficulty. But she has made his mouth an enormous trap, and has given him whalebone teeth, the fringed edges of which form a finely meshed net to encompass his prey. We must suppose him groping along the bottom of the ocean, his jaws extended, his mouth a vast chamber, twenty or thirty feet in length, and ten or twelve in breadth, filled with water, containing medusæ, sepiæ, shrimps and small fish, when gently closing his jaws, they are encompassed in a net formed by the decussating fibres of the fringed edges of the whalebone teeth. The tongue, which is soft like a feather bed, and very thick, being applied to the roof of the mouth, the water is expressed through the apertures of the net, and then the food is swallowed. Thus is the most powerful Leviathan obliged to obtain his livelihood by the exercise of the wily arts of the fisherman.

Mr. Hunter supposes, that the oil and spermaceti which these animals form in such abundance, not only serves to give them buoyancy, but also proves a storehouse of nutriment in cases of failure in the ordinary supply of food; for he found the cells that contain spermaceti empty in some instances, which, he thought, indicated that the animal had been for a long time without food. The whole of the whale tribe have also complicated stomachs like those of ruminants, which enable them to extract the greatest quantity of nourishment from whatever food they may obtain. I must not pursue this subject further, but merely recommend those who wish to do justice to Mr. Hunter, and form a fair estimate of his labours and merits, to peruse this p per with consideration.*

* Philos. Trans. 1787.

LECTURE III.

The head is placed on the top of a column of bones, which, from their having in general a kind of turning motion on one another, are called vertebræ, and the whole pile is called the vertebral column. The base of the column rests upon a wedge-shaped bone, interposed between the side-bones of the pelvis. Each vertebra has belonging to it, a part called its body, which is of an oval or circular form, and presents two plain surfaces to the bone above and below, which are cemented together by the intervertebral substance. The bodies of the vertebræ appear in front of the pillar, laid one upon another, like the stones with which a column is erected. They chiefly support the weight of the head and trunk, and regularly and considerably increase in size, as they descend, because the weight is proportionately augmenting.

The intervertebral connecting substance is composed of concentric layers, of tough, strong, and unyielding ligaments which extend for about a quarter of an inch from the circumference of the body towards its centre, when the connecting substance appears softer, and is manifestly elastic; which appearance continues till it approaches the centre, when the still connecting matter becomes pulpy and inelastic. The exterior concentric layers of strong unyielding ligament serve for security. The quantity of elastic substance interposed between the several vertebræ, is not so great as to occasion any insecurity in their connexion, yet the aggregate elasticity of the whole, renders the vertebral column very springy; so that the head rides upon its summit, undisturbed by jars, and as upon a pliant spring. The central inelastic matter admitting of a ready variation of form, though not of bulk, serves as a pivot facilitating the motion of the vertebræ on one another. Doctor Maclaurin in his lectures delivered more than half a century ago, was accustomed to illustrate its use by comparing it to a bladder partly filled with water, and placed between two trenchers; in which case, the water would readily diminish in bulk as the circumference of the trenchers became approximated on the one side, and would occupy the increasing space on the other. As the exterior ligaments are unyielding, this variation of form in the central pivot could never have taken place, had not an elastic substance intervened between them.

It is interesting and creditable to human intellect, which thus penetrates into the designs of nature, to know, that in the great fish, the squalus maximus, or basking shark of Pennant, this, then merely suppositious, structure is actually found. There is in the centre of the intervertebral connection, a bag of water, and so great is the elasticity of the substance by which it is surrounded, that when Mr. Clift cut into the bag, the expansion of the elastic matter, projected the fluid to the height of four feet in a large and perpendicular stream, compressing the bag into a small compass, and forcing its sides into numerous wrinkles.

Behind the body of each vertebra there is a bony ring, and these rings, when opposed to one another, constitute a canal for the protection and transmission of that important part, the medulla spinalis. From these rings, seven processes are continued, four of which serve to make joints, connecting the vertebræ with one another. There are two ascending and two descending articular processes. Two processes also stand out laterally, and are called transverse, and one backwards, which, being in general pointed, is named spinous. These latter processes chiefly serve to give attachment to the muscles which support and move the vertebral column.

Upon the form of the articular processes, the degree and kind of motion which takes place between the several vertebræ, seem entirely to depend. In the neck, the opposing surfaces of the articular processes are smooth and oblique planes, a form which admits of a limited and equal degree of sliding motion forwards and backwards, from side to side, and also of a turning or vertebral motion of one bone on another. We know that the vertebral column in the neck, admits of an equal motion in these different directions, so that we can touch the breast with our chins, the back with our hind head, and the shoulders with either ear. We can also turn the neck, so as to describe with our face a complete semicircle. In the last motion, the effect is, however, augmented by the peculiar turning of the first vertebra upon the second, which will be separately described hereafter. In the neck we find the spinous processes short and horizontal, so as to afford no obstacle to the extension of that part, and we find them formed in a similar manner, in all animals which have long necks and carry their heads far backwards.

In the back, we find the articular processes formed into perpendicular planes, which preclude any motion either forwards or backwards, or any turning of one vertebra upon another; a form which allows only of a motion from side to side, to which, however, the ribs present an insurmountable obstacle. In the back, we find the spinous processes sloping considerably downwards, and absolutely locked together, by a sharp ridge of one being received into a groove of the other. We find, also, the rib connected to the transverse processes, so that every circumstance concurs to prevent any motion, save that which results from the elasticity of the intervertebral substance. It seems, therefore, evidently the intention of nature, to make the vertebral column, in the back, a fixed support for the ribs to move upon.

In the loins, we find the articular processes very differently formed from what they are either in the neck or back. The descending ones are shaped like half an oval, the convex surface of which is received into a cavity of corresponding figure in those which ascend, which form is admirably adapted to admit of the suddenly turning horizontal motion which takes place in this part of the vertebral column. It also freely admits of motion from side to side, but does not allow of it in any considerable degree either forwards or backwards. Indeed had such motions been permitted beyond a certain extent, the abdominal viscera would have been injuriously compressed by the ribs. Neither is much motion, in this direction, requisite, because we can carry forwards and backwards the trunk of the body, by moving the pelvis upon the rounded heads of the thigh bones. The spinous processes of the loins extend horizontally, so as not to interfere with one another in the turning motion, but their great breadth is prohibitory of extension beyond a limited degree.

The head is joined on to the first vertebra, (which, from supporting this globe on its shoulders, is generally called the atlas,) by two oval processes placed obliquely and received into corresponding cavities in the upper articular processes of this vertebra. The form of the bones precludes any horizontal or turning motion of the head upon the atlas, and admits only of a slight yielding forwards and backwards. The condyles are placed so exactly parallel to the center of gravity, that when we sit upright, and go to sleep in that posture, the weight of the head has a tendency to preponderate equally in every direction, upon the slightest inclination in the line of gravity; as we see in those who are dozing in a carriage. Nay, their heads sometimes revolve in a circle, like the head of Harlequin on the stage. The head and atlas turn round upon the second vertebra; the upper articular processes of which, as well as the lower ones of the atlas, are formed into nearly horizontal planes, a form well calculated to admit of this motion. They are not, indeed, perfectly horizontal, but shelve a little to either side, so as to admit of a part of the lateral motion formerly mentioned. The second vertebra has growing up from its body a tooth-shaped process, and it is, therefore, usually called the vertebra dentata. This process is tied to the head by ligaments of surprizing strength, which are loose enough to allow the intended motion, but no more. This ready horizontal movement is requisite, to enable us suddenly to turn our eyes to different objects. If the head turned on the top of the pillar, there would be insecurity, unless some especial contrivance, not essential to the head or vertebral column, was instituted, as may be inferred from facts observable in Comparative Anatomy. The head is attached to the very summit of the column in the centre, by extremely strong ligaments, whilst in the circumference it is secured, not merely by other ligaments, but also by those powerful muscles which constantly support it, and occasionally move it in various directions.

The spinous processes of the vertebræ are connected to one another by what is called an elastic ligament, with the obvious properties of which, every one is familiarly acquainted, from having encountered it at their meals, in the necks of animals, where it forms the ligamentum nuchæ, which supports the head of the animal whilst grazing, without the expense of muscular exertion. It is yellow, tough, firm, and powerfully elastic.

The spinous processes are situated so far behind the centre of motion, that if they had been tied together by unyielding ligaments, these must have been formed of considerable length, to allow of the greatest degree of bending of the column, and then they would have been useless and wrinkled in its common position. The elastic ligament admits of the utmost motion of the column, and, by its powerful elasticity, tends to restore it, and retain it in its natural form. The elasticity of the substance, interposed between the bodies of the vertebræ, also co-operates in restoring the column to its natural figure. If we take the vertebral column of a young subject separately from the other parts of the skeleton, and forcibly bend it in different directions, we find it suddenly and forcibly recoil, and assume its proper shape. The vertebral column is not straight; it comes forwards in the neck and loins, so as to appear like the top and bottom of a perpendicular pillar, but in the back it projects posteriorly, and describes a segment of a large circle. In consequence of this form, the back part of the chest, the blade bones of the shoulder, and the weighty muscles of the back, project behind the centre of gravity, and become equiponderant to the weight in front; and, we know, that in an upright posture, the whole weight of the upper part of the body is so perfectly balanced on the base of the vertebral column, as to have an equal propensity to preponderate in every direction.

Though the motion taking place between the individual vertebræ is small, and such as can produce no alteration in the form of the vertebral canal injurious to the medulla spinalis, yet the effect of the conjoined motion of all the vertebræ is considerable; and appears still greater when observed in the motions of the head, which it supports. We can incline the head far forwards, backwards, or to either side, and nearly in an equal degree.

Had the vertebral column been formed straight, and the same extent of motion given to the head, the weight would have so preponderated, that its support would not only have been difficult, but it might have operated injuriously to the fabric of the column itself. As the column is constructed, when either end of it is projected in one direction, the other can be carried in the opposite, and the balance preserved. Thus, when the loins are brought forward, the neck and head can be carried backward, so as to preserve the line of gravity perpendicular to the basis of support; and *vice versâ* in all directions.

By constant practice, the muscles are so habituated to produce these opposite and balancing motions, as involuntarily to do so with the greatest exactness, as well as to co-operate with the elasticity of the column, in restoring it to its proper direction and form. The requisite actions are slight, transient, and varied, and therefore produce no fatigue. This circumstance, together with the disposition of the column to maintain its usual form, and the ease attendant on these motions, cannot be better exemplified than in the instance of riding on horseback. A practised and fearless rider will fold his saddle cloth into a cushion, place it on the back of a rough trotting horse, and sitting on it, keep his seat, undisturbed by suffering all the succussations of the steed to be transmitted to the body, above the pelvis, and preserving that part fixed, by constantly keeping the line of gravity of the whole perpendicular to the basis of support. Thus do we enjoy the most springy ease of motion, and perfect fixity of position, with scarcely any muscular exertion, and without any effort of mind, for volition cannot regulate the action of muscles in this manner, and those who, from apprehension, seek security in their own efforts, lose it, in proportion as they strive to obtain it.

The vertebral column in the back affords support to the twelve ribs, one end of which lies imbedded in cavities formed be tween their bodies, and their tubercles are connected to the transverse processes. The ribs successively and considerably increase in length, as far as the seventh, which causes the cavity they encompass to become larger; they then diminish in length, and the cavity of the chest becomes smaller. The seven upper ribs are connected by gristles to the breast bone. The five lower have their gristles united with each other, or have no connection except with the vertebral column. The breast bone is placed very obliquely, so that at the top it is very near the vertebral column, whilst at the bottom it is very distant. The ribs, in proceeding from the dorsal vertebræ, first take a direction backwards, and then rather suddenly turn forwards, so that the vertebral column projects into the cavity of the chest. This circumstance, and the oblique position of the sternum, both contribute to render the weight, before and behind the vertebral column, equiponderant upon its basis, in the manner I have formerly mentioned.

The upper or pectoral extremity of man, is divided into the shoulder, which is composed of two bones; the arm of one; the fore-arm of two; and the hand of many. The blade-bone of the shoulder is placed behind the chest, and not, as in brutes, by the side. It is in common so situated that the cup to which the arm is joined, and from which it hangs, projects exactly in the lateral direction, and consequently the weight of the arm has no tendency to move its socket forwards or backwards, but merely to depress it. Though the bones of the shoulder can be moved forwards and backwards, upwards and downwards, even in a considerable degree; yet the joint of the shoulder can never approach to the breast bone as it does in quadrupeds. The effects resulting from these circumstances are, that when the arms hang in their natural direction, the general line of gravity of the upper part of the body undergoes no change; but if the hands be brought either forwards or backwards, the weight proportionately preponderates, and the whole body moves upon the base of the vertebral column. The extent of motion of the shoulder joint in the directions that have been mentioned, greatly augments the sphere of motion of the arm and hand.

The joint of the shoulder is kept from approaching the front of the chest by the collar bone, which is nearly strait, though projecting a little forwards towards its middle, so as to give a slight convexity of outline to the top of the chest and bottom of the neck. The end of the collar bone, which rests upon the sternum, is bulky, and of a somewhat triangular form, but it rests in a thick bed of cartilage, which prevents its shape from being apparent. The scapular end of the collar bone is flat, and connected in an horizontal direction with a like-shaped projection of the blade bone, which forms the end of the shoulder.

When the trunk is bowed forwards, the

hands swing in the same direction, and then the weight of the arm drags forward the shoulder joints. In weakly children whose bones are deficient in firmness, the collar bones yielding under these circumstances, become convex in front, and the bulky sternal extremities are in some degree dislodged from their cartilaginous beds. The blade bone is also drawn forwards on the convex ribs, so that the back part projects beneath the skin. The weight of the shoulders and head now bears, in some degree, upon the walls of the chest, being transmitted by them to the vertebral column, by which means they also become deformed.

So commonly do these causes operate in the manner I have mentioned, that we rarely see exactly such a collar bone as I have endeavoured to describe; they must have been very healthy when young, who have such collar bones as are represented in the Grecian statues. To prevent the deformities incident to the causes I have mentioned, parents are accustomed to brace their children's shoulders backwards; nor do I think the practice wrong, where it is required, and when it is conducted with moderation; but surely we ought to caution the public against the absurdity of bracing the shoulders back, beyond what is natural, till the blade bones come in contact with the vertebral column, for this destroys the natural balance of the body, and is more likely to produce than to prevent deformity.

The joint by which the arm is connected with the shoulder, is a ball and socket joint, admitting of motion in every direction. Even those animals, whose pectoral extremities seldom move in any other direction but forwards and backwards for the purposes of progression, have a similarly constructed joint. The advantage derived from this mechanism seems to be, that it admits of the motion of the limb, or of the body singly. Thus, when at rest, the limbs may be moved without disturbing the position of the body, and when the limbs are injured, slight variations in the posture of the body are permitted, without communicating motion to the limb.

The elbow joint moves like a hinge, backwards and forwards. Now, if the first joint be a ball and socket, and the second a hinge, it is manifest that the hand may be put in almost every possible position within the area of that space, the circumference of which it is competent to describe by its utmost extent of motion. There are, however, two bones in the fore-arm; and one of them alone has its motions restricted to those of a hinge. This is called the ulna, and is the bone which sends backwards a projection, we name the elbow. The top of the elbow gives a surface for the attachment of the tendinous fibres of the extensor muscle, and affords a lever to increase its power. The lever in the human subject, is, however, inconsiderable, compared with what we observe in animals, the power of whose progressive motions greatly depends on the drawing backward of this part. We observe this in our dogs, and horses, and other animals; and it forms the first apparent joint in their pectoral extremities; for the arm and shoulder blade lie hid in the bulk and circumference of the body. The back part of the elbow in man, is formed into a smooth and somewhat triangular plain surface, upon which we occasionally lean. That nature designed this for an occasional resting place, is to be inferred from the coarse texture of the skin which covers it, which is similar to that placed over the lower part of the knee pan.

The form of the corresponding articular surfaces of the bone of the arm and ulna, freely admits an extensive motion forwards and backwards, and absolutely prevents any other. The bone of the arm has a groove formed in it, with lateral risings, and the ulna has a middle projection with lateral depressions. This groove making a kind of hinge for the ulna to move on, is formed obliquely, its upper part inclining towards the body. When, therefore, we bend the elbow, the fore-arm does not come in opposition to the arm, but carries the hand to the trunk of the body. When we bend the elbow, we generally wish to approximate or apply the hand to some part of our persons; and in consequence of the oblique direction of the pulley, we accomplish by one motion, what would have required two, had the groove been formed straight, as it is in animals. That part of the ulna which is next the radius, for so the other bone of the fore-arm is called, is hollowed out into a semicircular cavity, in which the radius revolves to a certain degree. The top of the radius is formed into a shallow cup, which fits on to a convexity of much greater extent of surface in the bone of the arm. Therefore, the cup can move forwards and backwards, in correspondence with the motions of the ulna, and can also, in any state of flexion or extension of the joint, turn round upon its own axis. The radius has also a semicircular convex surface, which is lodged in the excavation of the ulna, and at the same time revolves in that cavity to a certain degree. Such is the mechanism by which we are enabled in any state of flexion and extension of the elbow, to turn the hand prone or supine, for whilst the radius is revolving upon its axis above, it travels round the ulna below, and carries with it the hand.

The surface, which the fore-arm presents to make the joint of the wrist, is an oblong cavity of little depth. It is formed chiefly in the radius, and partly in a piece of cartilage, continued from the end of that bone over the extremity of the ulna. The side surface of the radius, which is applied to the ulna, is hollowed out into a semicircular cavity, receiving a corresponding convex surface of the ulna; so that the hand and the cartilage, continued from the radius, moves round upon the end of the ulna.

The wrist is composed of eight little bones placed in two rows. They form an arch slightly convex on the back of the hand. There are projections in front on either side, forming its basis or spring. These are secured together by the carpal ligament which is of prodigious strength. There is a motion between the two rows of carpal bones, so that when the wrist is bent, the arch of the carpus forms a kind of knuckle without any angular projection. We find the same structùre in the second apparent joint of the fore-legs of quadrupeds. What seems a knee is the wrist, and they kneel upon the knuckle of the carpus. The fabric of this part is particularly strong. Its arched form secures it from injury from above, the carpal ligament from below; but it is equally uninjured by forces applied to its side, else how could boxers strike with such force, or animals leap as they are known to do.

The four metacarpal bones, which are interposed between the carpus and fingers, are made large at either end, to form joints, and small in the middle, to afford room and arrangement to muscles, which move the fingers from side to side. Their bulky ends, which join on to the carpus, are connected by nearly plain surfaces, and admit of no manifest motion. The other ends, which support the fingers, are formed into rounded heads, and the first bones of the fingers have cup-shaped corresponding cavities, so that considering the skeleton merely, we might suppose the joint was one of the ball and socket kind, admitting of motion in all directions. We find, however, that the ligaments are so arranged as to limit the motions of the joints chiefly to those of flection and extension, allowing indeed of slight motion from side to side, and a slight horizontal turning of the finger on the end of the metacarpal bone, which motions are greatest in the fore and little fingers. The articular surface of this convex end of the metacarpal bones continues so far backwards and forwards, that we can extend the fingers a little beyond a right line with the metacarpus, and we can bend them to more than a right angle. The metacarpal bones are so connected by ligaments and muscles, as to prevent these ends separating from one another, and spreading, when we grasp convex bodies; and the end of the metacarpal bone, which supports the little finger, has a powerful apparatus of muscles expressly allotted to it, to keep it firm, in opposition to the power of the thumb, when we grasp bodies with force.

The bones of the fingers are made a little convex behind, but flat in front, for the convenience of grasping. The second and third joints of the fingers are formed into hinges, admitting only of flexion and extension. The last bones of the fingers are very small, the nail causing the apparent breadth of the end of the finger.

The thumb consists of three bones, the first of which is articulated to the carpus, and the joint appears like a hinge, though from the looseness of the ligaments, it admits of a small degree of motion in very various directions; which motions appear more considerable than they really are, when their effect is observed, as the extremity of so long a radius as the thumb makes. In consequence of this freedom of motion, we are enabled to apply the end of the thumb to each of the fingers and to different parts of the hand, and also to place the thumb in direct opposition to the power exerted by the whole of the fingers and hand, in grasping. The second joint of the thumb resembles the first joint of the fingers, not only in the form of the bones, but also in the arrangement of the ligaments, which limit the motions nearly to those of a hinge, and the last joint of the thumb, is like either of the two last joints of the fingers, a perfect hinge.

The fingers and thumb are of unequal length, and, on this account, they are peculiarly adapted for grasping spherical bodies, which are most difficult to seize and to hold. If, for instance, we take hold of a pocket globe, placing one of its poles in the hollow of our hand, we find all our fingers and the thumb opposing each other upon some parallel of latitude, and thus giving the greatest security to our grasp.

When the elbow-joint is fixed, the hand describes a complete semicircle, in pronation and supination; and the extent of its motion, in these directions, may be increased by variations in the position of the elbow and shoulder. As the hand moves through a yet more considerable portion of a circle in the utmost flexion and extension of the wrist, as it admits in all these motions of being carried to one side or the other, it is obvious that we can take hold of bodies in any point of the very considerable area, the circumference of which, the hand is competent to describe, when the other joints of the arm are moved to their greatest extent. The excellence of the mechanism of the pectoral extremities of man is proved by its results. The structures are so strong, and the powers so great, that we can seize, and hold, and pull, and push, and strike, with great power, and in such surprizingly varied directions; and yet the joints and powers are so nicely formed and adjusted, that we can also take hold of the smallest objects, and guide them with the greatest gentleness, nicety, and diversity of motion, by which means we are enabled to model and design the minutest objects.

The weight of the head, arms, and upper part of the body rests, as has been shewn, in equilibrio on the bone which supports the base of the vertebral column. This wedge-shaped bone is called the os sacrum, they say, because that part of the animal was frequently offered in sacrifices. It is very broad above and narrrow below, so that the weight which it supports would only tend to depress the broader part of the wedge into the narrower space, and render the fabric more secure. The sacrum is convex behind, and concave in front, for it forms a part of a somewhat circular bony cavity placed at the bottom of the belly and called the pelvis or basin. The sacrum terminates by a smooth surface of small extent, and oblong in the lateral direction, on which there moves backwards and forwards a little bone which is called the os coccygis, from its supposed resemblance to a cuckow's beak. This bone is occasionally thrust backwards, but is usually held forwards by muscles connected to it, and affords the last bony support for the weight of those bowels which may gravitate into the cavity of the pelvis in particular positions of the body.

This little bone is analogous to the tail of animals, which is moveable on the end of the sacrum, and composed of many pieces of various form in different animals. I mention this merely as one of the proofs, though it is far from the best, of the uniformity of the plan, and the diversity of the means and ends we observe in the construction of animals. The tail very commonly serves to animals the purposes of a switch, a balance, and a rudder. It is however a hold-fast in such as possess the *cauda prehensilis*, whilst to the kangaroo it is a prop and a leaping-pole, and to the beaver it serves as a trowel.

The sacrum derives support from the two side bones of the pelvis, by extensive surfaces, which converge as the wedge diminishes. These bones form a kind of circle, and are united with each other in front, and thus is the bony circumference of the pelvis completed. The back part of the circle being continued from the sacrum forms an arch on which the weight of the body is supported. No one can, I think, view this part of the skeleton without being struck with its architectural construction. The wedge forms the key-stone of an arch, on which, not only the weight of the upper part of the body, but also of those loads which we occasionally sustain, is supported. The side bones are expanded above the brim of the pelvis forming the hips, and give support to the viscera contained in the belly. The hips are much more expanded in females than in males. The ancients, who had a clear and strong perception of whatever is beautiful and useful in the human figure, and who, perhaps, delicately exaggerated beauty to render it more striking, have represented Venus as measuring one-third more across the hips than the shoulders, whilst in Apollo, they have reversed these measurements. The lower part of the side bones are formed into oblique protuberances, upon which we sit, and here we have a fatty cushion to rest upon. These prominences are placed parallel to the line of gravity, so that when we sit upright upon them, the weight of the body is here again found to be in a state of equipoize. The cavity of the pelvis in the human subject, is not placed as it is in brutes, in the same direction with that of the belly. Were it so, the contents of that cavity would be continually gravitating towards its inferior aperture. Even the pelvic viscera cannot be said to gravitate towards the inferior aperture of the pelvis, in the ordinary positions of the body; whatever presses in that direction must be protruded.

The weight of the whole upper part of the body is transmitted from the arch described by the bones of the pelvis, to a second arch, made by the form of the heads and necks of the thigh-bones. Their heads, which are very perfectly rounded, making a considerable portion of a sphere, are lodged in deep cups, the brims of which are particularly high in the upper and outer part, where the re-action of the ground against our descending weight, would ordinarily tend to dislodge them, had not such an occurrence been thus guarded against. These cups are placed a little in front of a perpendicular line let fall from the top of the sacrum. As the weight of the greater part of the pelvis, and of the muscular buttocks is placed behind the sockets, so when we stand upright, the whole of the incumbent weight is perfectly balanced on the rounded heads of the thigh-bone, and the most trivial variation in the direction of the weight occasions the body to incline towards that part, at which it takes place.

The hip-joint is the most complete ball and socket joint in the human skeleton, and the socket can move upon the ball with the most perfect facility, and with the nicest gradation and variation. Thus, when we stand upon one leg, we have the power of balancing the weight upon the rounded head of the thigh-bone. There are two modes of balancing, either by moving the incumbent weight upon the area of support, or by moving the basis of support under the incumbent weight. By the connection of our lower extremities with the pelvis, we possess the ability of balancing our weight in both these ways. No better demonstration of this need be given, than what is exhibited in those amphitheatres, where feats of horsemanship are displayed. We there see a man stand with one foot on the saddle, and maintain his balance, when his horse is at full speed. This he does when his body is placed horizontally, and with one arm and leg extended in opposite directions. To maintain so perfect a balance, it is necessary that the weight of the body should move in various directions, and with nicely adjusted gradations upon the head of the thigh-bone, and also, that by the motions of the knee and ancle, the support should be equally varied under the incumbent weight.

The weight of the body is transmitted from the arch of the pelvis, to a second arch made by the form of the heads and necks of the thigh-bones, the basis of which rests against the side of the bone near its top, and protrudes that part of the bone outwards, and the bottom in a contrary direction, so as to bring the knee-joint nearly under the general line of gravity of the whole body, and from this joint, the weight is transmitted in a perpendicular direction upon the arch of the foot.

I must not dwell upon the form of the bones or the structure of the joints in these pelvic or lower extremities, lest I should set my audience asleep. Suffice it then to say, that when the knee-joint is extended, so that the leg makes a perpendicular line with the thigh, and the ankle bent, so that the foot forms a right angle with the leg, each of these joints is rigid and immoveable. Such is their position when we stand; the whole limb forming a pillar for our support, and no motion can take place but at the top or bottom, at the hip or foot. But when the knee is bent, and the foot stretched out, as happens in progression, the same joints are loosened, and a lateral motion admitted, which is useful in the direction of our steps. The knee is secured in its extended state, so necessary for our support, by muscles which are incomparably the strongest in the whole body; and which hold the knee-pan elevated to the top of a pully formed in the front of the joint. But when these muscles are weak, then indeed are "the pregnant hinges of the knee disposed to crook," and yield to the incumbent weight. By the same muscles we are let down easily into our chairs, and they are the agents which raise us up again.

There are those who, having by habit preserved the motion of their joints to the greatest extent, and of their muscles to the greatest degree of action and yielding, can lower themselves gradually so as to sit upon their heels. These muscles therefore are employed to break our fall, if it takes place in the most dangerous direction backwards. The strong muscles in front of the body, more potent from the lever with which they operate, being attached far before the centre of gravity, also concur in bringing forwards the chest and head, and protecting them from injury. We see children, when in danger of falling backwards, by these means suddenly sit down upon the ground. Nature has also formed the lower limbs of children, whose powers are feeble and unpractised in balancing, so short as greatly to diminish the risk of injury from falling. Most young animals are formed with short limbs apparently for the same reason. Such formation however cannot be considered as the result of necessity, for when the mother suckles her young, whilst standing, their limbs appear of a preposterous length. When we fall forwards, we fall as a quadruped stands, our outstretched arms protecting the upper part of the body, and our bended knees the lower. When we stand on one leg, the weight of the whole body, as well as of those loads which it occasionally sustains, is transmitted by the bones of the leg upon the arch of the foot, which is very convex, and well adapted for its support, from whence it is transmitted to the heel behind, and to the ends of the metatarsal bones which form the first joints of the toes, so that it rests upon the ground. Chiefly however the weight is supported upon the ends of the metatarsal bones belonging to the great and little toe, which have a strong apparatus of muscles to keep them steady and preserve them in their relative situation to the heel. Thus is our weight supported on an arch and transmitted to the ground by a tripod: forms well known to be best adapted for giving support and security of position. Nature, however, gave us powers of grasping with our feet, and thus further securing our position, but these we in general lose for want of using them. They say, a Chinese will sit perched upon a ship's boom when it swings to leeward; and it is recorded, that Milo could stand with one foot on a quoit, and no man in Greece could push or pull him off. If this be true, he must have been not only a very strong man, but a very heavy one, and a most expert balancer.

The arch of the tarsus, like that of the carpus, can also resist the effect of forces when applied against it sideways. We can walk on the ends of the metatarsal bones, and in that case, the short toes do but seem to increase the extent of surface on which we are supported. This security against injury in this direction, is further manifested in quadrupeds; for the tarsus is the structure of the second apparent joints, in their pelvic or hind limbs, joints which correspond to the carpus in front, and which are usually called the hocks. In those animals that leap to great heights or distances, the os calcis projects, so as to form a most enormous lever, and we judge of the animal's powers by observing this projection.

Such is the mechanism of our lower limbs, nor need I endeavour to shew its excellence, by the effects resulting from it. Every one knows from what heights we can leap, to what heights we can spring, and to what distances we can bound, without injury; as well as how swiftly we can run, how firmly we can stand, how nimbly we can dance, and how perfectly we can balance ourselves upon the smallest surfaces of support. Yet there are a few circumstances, which, I think, deserve consideration. Gravitation seems to be the chief cause which gives fixity of position to some parts, and consequent freedom of motion to others. When we stand upon one limb, we balance our weight upon the head of the thigh bone, and no effort is required to maintain our position, but what is necessary to secure the knee and ankle joints in that state in which they admit of no motion.

Thus standing, all the other limbs are free to move, and can be moved with great power, because they are connected to a perpendicular column which owes its stability to its great weight. In the sculptured figures of the ancients, if a man is represented standing on one leg, he seems as firmly fixed to the ground as a fast-rooted tree; and associating freedom and power of motion with this stability, we seem to expect the continuance of that action, which the figure is represented to have begun. When we stand upon both legs, we can transfer the weight from one to the other, with very little variation in the position of our bodies. The oblique direction of the thigh bones, the consequent approximation of the knees, and the transmission of the weight, in a perpendicular direction on the arch of the foot, seems to me designed to give us this facility.

In progression, the supporting limb

should be perpendicularly under the centre of gravity of the whole body, and the advancing one is brought forwards in a curvilinear direction. This course is the result of the rolling of the head of the thigh bone in its socket, and by it the advancing limb is brought forwards without striking the other, and carried to a position in which it is more directly under the centre of gravity of the body, when that is also brought forwards, than it would have been, had the limb moved in a straight line. The free and firm step of the soldier is the result of the circumstances I have mentioned. We are more struck and convinced of this, by observing that caricature of marching which is exhibited by opera dancers on the stage, for these gentry will raise the advancing limb above a horizontal line drawn from the front of the pelvis, and, performing sundry evolutions with the foot, will afterwards gently deposit it where it ought to be placed in ordinary progression: afterwards, throwing the weight of the body perpendicularly upon it, they exhibit the same extravagancies with the other limb. All which we deem elegant, because we associate the idea of elegance with security of support obtained without effort. As a contrast to such progression as I have described, I request you to observe, that of a very fat man, who walks with his legs far apart, and you will see that he is obliged to shift the weight of his body from one leg to the other, by a considerable degree of lateral motion of the body at every step he takes.

All the large muscles that act upon the thigh bone, turn it, and consequently the whole limb outwards, so that it appears evidently the intention of nature, that we should walk with our feet slightly turned to that direction; but I will not detain you, by shewing in what various ways this position of the limb contributes to the facility of our motion, and the security of our support.

Yet there is one circumstance I may mention, though it relates to a subject rather curious than useful. There appears amongst men, as amongst horses, two distinct forms, one calculated for strength, the other for speed or agility. The former is chiefly characterized in man by the shortness of the neck and loins, the greater proportionate breadth of the shoulders, the broad and highly arched foot, with a much projecting heel. The latter is distinguishable by the length of the neck and loins, the length of the thighs, by a narrower and longer foot, with a less projecting heel. Persons of the form that indicates strength are generally shorter than those of the other figure, so that we associate an idea of the height of a person with his make. This subject was remarked by Hogarth, who says, that if the figures of Quin and Garrick were represented of the same size, an observer would suppose Garrick to have been a tall man, and Quin a short one. Yet the contrary being the fact, he accounts for the deception, by saying, that Quin was a tall man of short proportions, and Garrick a short man with tall proportions. The Farnesian Hercules is an admirable representation of the strong form of man, but no one can observe the figure without at once perceiving, that it is far better calculated for cleansing the Augean stables, than for catching the stag of Œnoe.

Many of the bones which compose the skeleton are connected together without admitting of motion upon one another; and in this case, portions of elastic gristle are interposed between them to prevent jarring, and they are tied together by unyielding and exceedingly strong ligaments. When bones move upon one another, when a true joint is formed, the corresponding surfaces of each bone are covered by gristle, which is exquisitely smooth or polished. Between these smooth surfaces, a liquor, like white of egg, is effused to prevent their adhesion, and to facilitate their motion. The escape of this synovial liquid from the joint is prevented by capsules; and the bones are firmly tied together by ligaments of surprizing strength, which are so contrived as freely to admit those motions that the bones are adapted for, and to prevent any other. All the parts composing the joints possess so little natural sensibility, that notwithstanding the violent pressure and rapid motion they undergo, we are scarcely sensible of the parts, at which such motion is effected.

I feel that some apology is requisite for detaining your attention so long upon circumstances familiarly known, but not in general sufficiently contemplated, which I have been induced to do, because we are far better judges of the causes requiring mechanism, and the effects resulting from it, than we are of the vital processes. Therefore, from this least interesting part of anatomy, we derive the strongest conviction of there being design and contrivance in the construction of animals. Equal evidences of design and contrivance, and of adaptation of means to ends may be observed in the construction of the frame-work, as I may call it, of other animals, as in that of man, which subject seems to me very happily displayed in Professor Cuvier's lectures. Yet there are some who presume to find fault with the mechanism of the human skeleton. An excellent anatomist once said, there was not a well made joint in the whole body; but he was then talking as a carpenter, like one who had no means of judging of the works of nature, but by comparing them with our own limited designs and performances. It was however the comparing the mechanism of the hand and foot that led Galen, who they say was a sceptic in his youth, to the public declaration of his opinion that intelligence must have operated in ordaining the laws by which living beings are constructed. That Galen was a man of very superior intellect could be readily proved were it necessary. I have often known the passage I allude to, made a subject of reference, but not of quotation, and therefore I recite it on the present occasion, and particularly because it shews that Galen was not in the least degree tinctured with superstition. "In explaining these things," he says, "I esteem myself as composing a solemn hymn to the great architect of our bodily frame; in which I think there is more true piety, than in sacrificing hecatombs of oxen, or in burning the most costly perfumes; for I first endeavour, from his works, to know him myself, and afterwards, by the same means, to shew him to others, to inform them how great is his Wisdom, his Goodness, his Power."

There are, however, other structures in the body besides what I have just denominated the frame-work. Doctor Hunter could never demonstrate the back part of the human throat, the passages by which we swallow and respire, and the mechanism by which the extremely diversified intonations of the human voice are produced, without enthusiasm. Who, also, can examine the lachrymal parts of the human eye, without admiration? But why do we admire these things? Is it not because we understand them. We see the necessity for contrivances, and we find them constructed beyond our highest expectations, and perfectly adequate to effect the purposes for which we believe them designed. The same conclusion, must, therefore, in reason, be drawn from the examination of the structures we meet with in living beings, as that which has been deduced from the consideration of the works of nature in general, by the most intelligent and best informed men. That what we understand, seems excellent in a degree far exceeding our ordinary conceptions, yet appearing more and more so in proportion as it is minutely examined and attentively considered; and that we understand so much of the works of nature, as to warrant us in concluding, that we can only cease to admire, when we fail to understand.

LECTURE IV.

ON DIGESTION.

Those bodies which we call living, are chiefly characterised by their powers of converting surrounding substances into their own nature; of building up the structure of their own bodies, and repairing the injuries they may accidentally sustain. They not only differ considerably from each other in their size and external form, but also in their internal structure. Vegetables imbibe watery fluids from the earth, in which saline and other matters are dissolved or suspended, and these, in the very vessels of the vegetable, become the sap or nutritive fluid of the plant. This ascends with celerity and force; forms the leaves, flowers, and fruit, in which it is more particularly exposed to the influence of light, heat, and air; then returns and augments the woody stems and trunk, impregnates them with juices which concrete; and eventually descends to the roots, to nourish and increase them, and in various instances, to form means and materials, for the future production of vegetables of the same kind.

Such is the view of the nourishment of vegetables, exhibited of late by Mr. Knight, in his papers published in the Philosophical Transactions, and which has been drawn from the results of numerous well contrived and satisfactory experiments. The ascending sap has in it no marked peculiarity, being equally fitted to form the leaf, the flower, and the fruit; for he has engrafted the stalk, upon which each of these has been produced, upon the same kind of stem. Also, by dividing the descending vessels, he has stopped the formation of the parts below; and by performing this experiment in the root, he has prevented the growth of the potatoe, and even caused it to be injected from these descending vessels by which it is formed and supported.

In viewing the subject, according to this sketch, we cannot but feel surprize, that the vessels of plants should imbibe the raw juices of the earth, however impregnated, and so suddenly convert them into sap, which is a very peculiar fluid; for it seems a more wonderful kind of digestion than that which takes place even in the stomachs of animals. Here, however, the experiments of Mr. Knight seem to aid our conceptions, by shewing, that the returning vessels impregnate the plant with juices, which concrete, and are probably dissolved in the ascending watery sap, enriching it with nourishment, and it may be, chemically aiding in its formation. Mr. Knight finds that the specific gravity of the wood of trees, is diminished by the ascent of the sap. Thus, when the genial warmth of the spring excites those actions which imbibe the juices of the earth, and cause the ascent of the sap, the plant seems bursting with life and nutriment. The leaves bud in every part, and are formed with surprizing celerity. When, however, the tree has attained its full extent of annual growth, the returning sap is more especially employed in storing the interstices with materials to serve for nourishment in the succeeding spring; and to this Mr. Knight attributes the increased specific gravity of wood felled in the winter season.

It is in the leaf, however, that the distributed fluids of plants seem to undergo their chief elaboration; for here they are more freely exposed to the influence of light, heat, and air; much, also, is manifestly thrown off by perspiration; and much is probably added, so as to render these juices competent to form, under the agency of the vital energies, that extreme diversity of substances which we meet with in the leaf, the flower, the trunk, and the roots.

In animals, the matter by which they are nourished, is in general taken into a receptable or stomach, where it undergoes a process called digestion; and so analogous are the functions of life in vegetables and the lower kinds of animals, that Mr. Hunter considered this circumstance as the chief criterion of distinction between the two classes. I believe him to have been the first person who broached and established the now generally received opinions respecting digestion. His observations and reflections suggested to him, that the liquors secreted by or poured into the stomach, had the surprizing power of dissolving the dissimilar food by which different animals are nourished, and of converting it into a substance *sui generis*; this being the first and most important step to sanguification, or its ultimate conversion into that nutritive fluid which is distributed to every part of their bodies, for their formation and support.

Mr. Hunter knew that the gastric fluids were neither acid nor alkaline, nor endowed with any predominant quality, such as would induce us to suppose they had these wonder-working powers. He was fully apprized of the variety of substances from which different animals thus derive their nourishment. He mentions that the voracious caterpillar which eats such quantities of the leaves of plants, digests only their juices, and voids the leaf dry, which will afterwards unfold itself in warm water as tea-leaves do. He knew that the fibrous matter of vegetables, and the husks of grain, are in general not susceptible of digestion by the gastric fluids; and yet that some insects live upon them. Indeed they first pour upon the woody substance a liquor which dissolves it, and in this state they swallow and digest it.

Thus also does that foe to literature, the book-worm, make his way through the most massy folios, solving the most difficult passages, and digesting all as he proceeds. Indeed he pours his sauce, or cooking liquors with such profusion, as to tinge and affect the texture of the leaves to some distance round the circumference of the tunnel which he makes. Some creatures also thrive best upon animal substances in a disgusting and noxious state of putrefaction. Therefore it is evident, that life can, by means of the fluids it prepares, convert to its own purposes substances which are ordinarily most innutritive or pernicious.

Although the gastric fluids have no sensibly distinguishing character, yet Mr. Hunter knew that they not only coagulated milk, but white of egg, and other nutritive fluids; thus first rendering them solid, that they might be detained in the stomach till they underwent the peculiar solution, called digestion.* He knew that the gastric fluids checked and prevented the natural decomposition of animal and vegetable matter; that if putrid meat were swallowed by a hungry dog, it quickly lost all fœtor, and that no fermentation or putrefaction of food ever takes place in the stomach, if the gastric juices be healthy; therefore it followed that digestion could not be the result of any common fermentative process. Nay, he further knew that the gastric fluids sometimes dissolved even the stomach itself. Mr. Hunter could not wonder that such an event did not more

* He says he had examined this subject, and found the coagulation to take place in the various kinds of animals, downwards as far as fish.

frequently take place; for when persons die of disease, the gastric fluids have not for a long time been prepared, or they have been of an unhealthy quality, so that they are incompetent to dissolve the smallest quantity of the most digestible food, if taken into the stomach. Mr. Hunter could never wonder that the gastric fluids did not act upon the living stomach, for he full well knew that life was a chemist which regulated its own chemical operations, and controlled the effect of foreign chemical agency. He was, I believe, the first who plainly told the public, that chemical agents do not in general act upon living, as they do upon dead animal matter. He knew that worms live in the stomach, and yet that a meal of dead worms would form no innutritive repast to an hungry dog. He must have known also that the peculiar fluid which digests the food is not secreted at all times, but only when the stomach is excited by the stimulus of food, and even then but under favouring circumstances. If in this state persons are suddenly killed by accident, the gastric fluids will continue for some time to act, not only upon the food, but also upon the stomach itself, so as to form a large aperture by which the contents escape.

Having reflected upon all these circumstances, and made numerous experiments on the subject of digestion, we find him afterwards employed to open the body of a patient (who died when attended by Sir John Pringle, then President of the Royal Society,) in which a partial solution of the stomach had taken place. The appearance was to Sir John both new and unacountable; but when Mr. Hunter told him that it was not the effect of disease, but of solution by the gastric fluids; that he had frequently seen it, and that it made one of the reasons which induced him to believe digestion to be the effect of a solution of the food by the gastric fluid; the president urged him to draw up a paper on the subject; which was printed in the year 1772, in the 62d volume of the Philosophical Transactions. This paper attracted the attention of Spalanzani and others, and led them to make and publish experiments tending to demonstrate the fact, which is thus announced in the conclusion of Mr. Hunter's observations; "that digestion neither depends on mechanical powers, nor contractions of the stomach, nor on heat *; but on something secreted in the coats of the stomach, and thrown into its cavity, which there assimilates the food to the nature of the blood."

As, however, Mr. Hunter, in a second paper on digestion, has published his own commentary on the proceedings of those, who may be said to be his coadjutors in the proof of the fact, but who might appear to himself and the public as competitors in the discovery, I need not say any thing respecting this subject. Yet there is one point which I feel it a duty to advert to. Mr. Hunter, whom I should not have believed to be very scrupulous about inflicting sufferings upon animals, nevertheless censures Spalanzani for the unmeaning

* He might have substituted the word fermentation, for heat, for it would more plainly have conveyed his meaning.

repetition of similar experiments. Having resolved publicly to express my own opinions with respect to this subject, I choose the present opportunity to do it, because I believe Spalanzani to have been one of those who have tortured and destroyed animals in vain. I do not perceive that in the two principal subjects which he sought to elucidate, he has added any important fact to our stock of knowledge: besides, some of his experiments are of a nature that a good man would have blushed to think of, and a wise man would have been ashamed to publish; for they prove no fact requiring to be proved, and only show that the aforesaid Abbé was a filthy-minded fellow.

The design of experiments is to interrogate nature; and surely the enquirer ought to make himself acquainted with the language of nature, and take care to propose pertinent questions; he ought further to consider the probable kind of replies that may be made to his enquiries, and the inferences that he may be warranted in drawing from different responses; so as to be able to determine whether by the commission of cruelty he is likely to obtain adequate instruction. Indeed before we make experiments on sensitive beings, we ought further to consider whether the information we seek may not be attainable by other means. I am aware of the advantages which have been derived from such experiments when made by persons of talent, and who have properly prepared themselves, but I also know that these experiments tend to harden the feelings, which often leads to the unnecessary and inconsiderate performance of them. Surely we should endeavour to foster, and not to stifle, benevolence, the best sentiment of our nature, that which is productive of the greatest gratification and advantage both to its possessor and to others. Considering the professors in this place as the organs of the court of the college; addressing its members, I feel that I act as becomes a senior of this Institution, whilst admitting the propriety of the practice under the foregoing restrictions, I at the same time express an earnest hope that the character of an English surgeon may never be tarnished by the commission of inconsiderate or unnecessary cruelty. I need not, Gentlemen, caution you, who must feel anxious to maintain the respectability as well as the reputation of the medical character, against publishing experiments disgusting to common decency.

Now though Mr. Hunter clearly perceived that liquors could be and were prepared, possessed of surprising powers of assimilating the food to the nutritive fluids of the animal, he was likewise equally apprized of the variety of means which nature has instituted to prepare the food for digestion, and facilitate the action of the gastric fluids. With this intention, some animals are made to grind or comminute their food with their teeth, but this is not essential to the function of digestion, neither does it take place in the majority of animals. Therefore Mr. Hunter seems, in his Museum, to have placed the teeth amongst the weapons and instruments which are allotted to animals.

Many carnivorous animals, he observes, divide their food no further than is necessary to enable them to swallow it; and all animals whose food requires this degree of subdivision must have means to effect it. Mr. Hunter has shown that cuttle-fish have beaks like birds; and that worms have osseous teeth fixed in the fleshy circles that form their mouths. He has placed the preparations which show these and similar facts in a department of his Museum, allotted to show peculiarities belonging to individuals of any species or genus of animals, which do not belong to others of the same kind; and not among the preparations displaying the anatomical facts relating to digestion in general. Mr. Hunter studied anatomy as a physiologist, he investigated structure in order to understand function, and he has omitted to record or exhibit many anatomical facts, with which he doubtless was acquainted, because they did not seem to lead to a physiological conclusion.

Herbivorous animals in general grind their food with their teeth; nay those who spend a life of leisure and repose, are made to ruminate or remasticate their food, whilst other vegetable feeders, and I may cite the horse as a familiar instance, whose life is probably destined to more continual exertion, do not ruminate. The horse however has a constant propensity to feed, and the food passes readily from his small stomach; therefore, he would waste a great deal of food, had not Nature provided him with most capacious intestines, and contrived to produce a kind of second stomach and digestion in that part of the bowels called the intestinum cæcum.

Mr. Hunter was fully apprized that many of the insects, of the lower kinds of animals and some fish, have teeth of various sorts fixed in their stomachs to divide and comminute their food. He was convinced that birds do not swallow stones from mere stupidity as Spalanzani supposed, but to serve as temporary teeth, or as mill stones to grind their food under the operation of their powerful gizzards. In his paper on the stomach of the gillaroo trout, he says that, "the English trout swallows shell fish, and also pretty large smooth stones, which serve for shell-breakers." He also says, "the mullet has a stronger stomach than the gillaroo trout, but that they have neither the power, nor motion, nor horny lining of true gizzards."

Gizzards, like teeth, serve to subdivide the food, and thereby increase the surface on which the gastric fluids may act so as to facilitate its solution. Though birds in general have gizzards for this purpose, Mr. Hunter knew, that those which feed on flesh have them formed with their muscular and internal coat so thin, as scarcely to be recognizable for such organs. By feeding a rook with bread, he found that the muscular power of his stomach became much increased, and its lining much thickened and hardened; a fact corresponding to many other observations he had made, showing that the vital powers could alter the organization of parts, so as to adapt them to exigencies.

Another mode of preparing food for solution by the gastric fluids, is by a kind of maceration, generally in warm and moist places, a kind of cooking process, for which probably the complex stomachs of ruminating and other animals are designed. In ruminating animals which have four stomachs, the first or paunch, is a reservoir from which the food is thrown up to be remasticated; the fourth digests the food; but the exact function of the intermediate stomachs is unknown. Mr. Hunter has not omitted to display the contrivance by which in the calf, the milk is made to pass directly into the fourth stomach for digestion, without entering the others. The crops of birds and various other animals are also to be considered as macerating pouches, and which gradually supply materials for the operation of the gizzard. Their contents are likewise sometimes regurgitated, for thus does the bee store its cell with honey, and some birds feed their young.

Mr. Hunter was fully apprised that many of the insects, and of the lower kinds of animals have complex stomachs, crops, and gizzards; and he has shown these facts among the peculiarities to which I have already referred.

That digestion, or the solution of the food by the gastric fluids, takes place in some particular district, and not elsewhere, is, Mr. Hunter says, to be inferred, from observing that in fish and serpents, which swallow more prey at once than the stomach can contain, that portion of their food only, which is in the stomach, is dissolved, whilst that which is in the gullet undergoes no such change. Also, from observing that the yolk of the egg, which is conveyed into the intestines of the chicken, ascends into the stomach before it can be digested, Mr. Hunter was fully apprized, that parts of a single stomach might secrete the solvent liquors, and not the whole bag. He observes, that part of the stomach in several animals, is covered by cuticle, like the first, second, and third stomachs of those which ruminate. This occurs in the peccari, hog, rat, and horse. The fact of digestion occurring partially in the stomach, he says, is also evident in that of a dog, into which a large piece of meat has been swallowed at once. Towards the great end, the food will be found but little altered, towards the middle more, and towards the pylorus it will be similar to that which is found in the duodenum. Mr. Hunter was apprized, that the duodenum in some animals, might be considered as serving to digest the food; for it is formed of considerable capacity, resembling a stomach, and is chiefly recognized by anatomists as that intestine, in consequence of the biliary and pancreatic ducts terminating in it. He also perceived, that when the pylorus is not detentive, the gastric fluids might flow into the duodenum, and there complete the process of digestion.

The solvent liquors are secreted from the lining of the stomach, or sometimes poured into it from glands situated at its upper opening. The latter is commonly found in birds, because the lining of their stomachs is formed for trituration, and consequently not for secretion. Yet the same kind of structure is met with in other animals, and even among quadrupeds in the beaver. According to Mr. Hunter's notions of secretion, it must have appeared to him a subject of no importance whether the gastric liquor was secreted by particular glands or otherwise; for secretion is an universal function, and can take place as well from surfaces as glands. He was indeed anxious to note every variety of structure, and, as I believe, also in order to observe whether any thing could be found contradictory to his opinion that the several vital functions were the result of the actions of a principle distinct from the organization in which it adhered.

It must surely be curious and interesting to all, to be informed, that his opinions respecting secretion, opinions at the time which seemed almost inexpressible to himself, and incomprehensible to others, have been most perfectly verified by experiments subsequently made with a view to determine facts relative to digestion. Mr. Hunter thought that a subtile principle of life was diffused throughout the body, that it inhered in the solids, and was the cause of their different vital affections; that it pervaded certain fluids, which it could either modify, decompose, or recombine, and thus produce the extreme variety of new substances, that may and do result from one kind of nutritive and universally distributed fluid. He had no mode to express the idea; nor could any one discover a better than by saying, that specific and peculiar actions will produce specific and peculiar secretions. I have already told you, Gentlemen, how these terms were cavilled at. Mr. Hunter thought, that the vital principle was particularly accumulated in the brain, in those animals which possessed such an organ, and that it seemed in them a kind of source of vital energies, and that the nerves were internunciate chords, by which the affections of life were reciprocally communicated. The verification of Mr. Hunter's opinions must interest all, because they show how justly we may infer causes, by the industrious observation, and patient and accurate contemplation of effects; and therefore the result is creditable to human intellect, and gives us confidence in other opinions which are thus deduced. I shall briefly relate the experiments to which I have just alluded.

Doctor Haighton, after having fed a hungry dog whose stomach was empty, with flesh meat, divides the eighth pair of nerves which go from the brain, to be distributed to the stomach, and thus prevents or disturbs those vital actions, which are necessary to the preparation of the gastric fluid. Consequently, when after many hours, he kills the dog, he finds the food in the stomach perfectly undigested, and but little changed. He performs a similar experiment, but only divides one of the nerves of the eighth pair, and the dog becomes dyspeptic, having eructations and manifest uneasiness about the stomach; which symptoms continue for several weeks: and though the dog eats the food which is given to him, he becomes much emaciated, yet gradually recovers, as the divided nerve re-unites and resumes its functions. In like manner, Mr. Brodie having observed, that the administration of arsenic was uniformly followed by profuse secretion of mucus and watery liquors into the stomach, divides the nerves of the eighth pair in dogs, and then administers the poison, but no secretions are afterwards effused into the stomach.*

Professor Harwood of Cambridge gives to two dogs, equal in age, health, and appetite, equal quantities of flesh meat. They were pointers; and he suffers one of the dogs to do what nature indicated to be favourable to digestion, to lie down by the fire and go to sleep; but he entices the other into the fields, and causes him to hunt about for game. After some hours he kills both dogs, and finds the food in the stomach of the dog which had been kept in constant exercise, undigested and but little changed; whilst in the other it had, in the same time, not only been digested by the stomach, but converted into chyle by the intestines, and was rapidly passing through their absorbent vessels

* Philos. Trans. 1814.

in the high road to the sanguiferous system.

No one is disposed to doubt the results of these experiments, for every one is more or less convinced, by his own feelings, that affections of the mind, and bodily exertion, will, by disturbing or otherwise occupying the nervous energies, diminish or prevent appetite and digestion.

The pylorus, or opening by which the stomach communicates with the intestinal tube, is variously formed in different animals, allowing or preventing, in various degrees, the transit of alimentary matter. In the human stomach it is a small circular and muscular aperture, admitting of occasional dilatation, so as sometimes to give passage to a body of the diameter of half a crown, yet ordinarily so contracted as to detain even fluids in the cavity of the stomach; else how could we distend it with liquors as we sometimes do. It may be useful to mention a case which serves to illustrate the degree in which such detention may occasionally occur. A misera-ble woman took opium during the night in St. Bartholomew's Hospital in order to destroy herself, and before she was noticed next morning her purpose was nearly ac-complished. With scarcely any hopes, I injected into her stomach, by means of a varnished catheter introduced down the œsophagus from the right nostril, some le-monade, to which cordials and a solution of sulphat of zinc were added, in hopes of ex-citing the stomach and provoking it to vomit. Having injected in repeated doses what appeared to me to be a fully suffi-cient quantity, and waited till no hopes of success remained, I left the room. Some of the students, however, knowing the case to be desperate, injected more of the liquor, and when the body was afterwards examined, the stomach and gullet were found filled and distended up to the throat; nay a small quantity of the liquor had ac-tually overflowed the rima glottidis, and descended by the windpipe into the lungs. On the contrary, however, the pylorus in the horse gives ready passage to liquids, and even to the fibrous part of the food.

That animal will drink at once three or four times more water than his stomach can contain, which passes rapidly through his intestines till it arrives at his capacious cæcum, where it lodges.

He continues to eat in like manner, and the surplus of food must readily pass through the pylorus before it has been completely digested; on which account he would waste a great deal of food, had not nature contrived to produce a kind of second stomach and digestion in that part of the bowels called the intestinum cæcum. Mr. Coleman, professor at the veterinary college, suffered a thirsty horse, which was to be killed, to drink as much water as he chose, and after six minutes, the alimentary canal being examined, it was found that the water had passed from the stomach through the small intestines, a distance of sixty feet, and was collected in the cæcum.

Mr. Coleman supposes that nature has allotted to the horse but a small stomach, that the food might not, by being accumulated, impede the action of the diaphragm, and affect that free respiration which his speed of progression requires.

Having shown what Mr. Hunter knew and thought with respect to digestion, as carried on in cavities allotted for that purpose, it is proper to add, he was fully apprized that the same process could take place without the preparation and aid of solvent liquors.

Both analogy and observation warrant the supposition, that some animals have no digestive organs, and that their vessels, like those of vegetables, imbibe and distribute what becomes nutritious in the vessels themselves. No one has, I believe, seen digestive organs in the tenia; from various apertures we are able to inject different kind of vessels, so that this animal appears to be very vascular in every part, which is, I believe, as much as is known respecting its anatomy. In the fluke also, whose food is gall, and which lives and multiplies in the biliary ducts of sheep, we see the gall imbibed from an orifice into a vessel which sends off branches to all parts of the animal, apparently becoming its distributive or nutrient vessel. If this be true, bile, which is formed from the blood of the sheep, is reconverted into the blood of the fluke, and forms the fleshy substance of this animal. It was one of the distinguishing characters, and greatest perplexities of Mr. Hunter's Physiology, that he asserted vessels could modify their contents, so that a kind of digestion may be said to take place every where by the immediate action of the vital powers. The structure of the last mentioned animals, as far as it is known, is exhibited in the collection; and the preparations were given to Mr. Hunter by Mr. Carlisle, who made them whilst a student.

The hydatid seems to be nourished in like manner. Analogy would induce us to believe that it was nourished, like vegetables, by absorption from without. Of its organization however we are perfectly ignorant, for no evident structure can be discerned, even by the aid of the microscope. These animalcules are found in the natural cavities, or in those formed in consequence of disease, in the bodies of other animals. We meet with them in the abdomen, in bursæ mucosæ, and in cysts in the brain, liver, and other organs. The form of one species is a globular or oval bag, which has an undulatory motion, when put into tepid water. The bag contains a transparent fluid. Young hydatids form upon the bag, are detached when very small, float about in the liquor of the cavities in which they dwell, to grow and to multiply as their parents have done. Now, in a physiological point of view, we must consider hydatids to be nourished by absorption from without, or suppose the bag to be a digesting cavity, though no aperture is discernible. In the department of the Museum allotted to display the structure of the digestive organs, Mr. Hunter has first put up some hydatids, as if to mark the uncertainty of our knowledge with regard to the nourishment of this and some other animals.

With such exceptions, all other animals have a digesting cavity, and the lowest orders appear to have no other organs, the whole interior being stomach, and the whole animal forming only the walls by which it is surrounded and supported, as is exemplified in actiniæ and medusæ. Mr. Hunter, in his M.S. of they year 1776, writes as follows: "The apparatus necessary for digestion is as simple as any thing we can well conceive. It only requires a bag or cavity fit to contain the substance to be digested, joined with the power of furnishing the fluid capable of digesting the said substance. It is therefore to be considered as a gland and a cavity. Indeed, it is necessary, that another apparatus should be added; a system for absorbing the digested food and nourishing the bag, as well as preparing the fluid it secretes." Before this time, Mr. Hunter had injected the vessels of medusæ from the stomach with coloured glue, and their distribution is particularly beautiful. He was well acquainted with the fact that fluids may be imbibed from various apertures in the branches or members of these animals, and conveyed through tubes into a common cavity, which I merely mention to show that he was acquainted with that form of animal called rhizostome or root-mouthed.

As an evidence of an animal being little else than a stomach, Mr. Hunter has exhibited a specimen of the actinia associata. The mouth, which is surrounded by tentacula, leads into a cavity, like the finger of a glove, the animal being no more than the substance which forms the walls of this cavity. Mr. Hunter, in his M.S. proceeds to say, "that in some animals the stomach has but one aperture, serving equally to receive the food, and reject its residue. In others a distinct aperture is allotted for each of these functions. As the digestive organs become complicated, we find the stomach or digesting cavity has added to it an intestinal tube, in which the food undergoes still further changes; and this tube is also subdivided into two parts, and different functions are allotted to each. Glandular structures are also added, which prepare fluids subservient to the functions of the intestinal canal."

In the small intestines, the food is converted, in the higher order of animals, into chyle, which is a fluid very much resembling blood, and chiefly differing from it in its colour; so speedily and so nearly is the ultimate object of sanguification accomplished. The effect produced on the food in the intestines will be in proportion to the secreting surface of the canal, which pours on it peculiar liquors, and to the duration of its stay in the bowels. These objects are accomplished by the length and convoluted form of the canal; by its lining projecting and being formed into plaits, either transverse, longitudinal, spiral, or reticulated; by the formation of smaller fossæ or larger sacculi. Every variety in the animals hereafter mentioned is displayed, and so beautifully are the preparations injected, and so neatly put up, that these objects, which we generally view with disgust, attract the attention of strangers, who regard them as the most beautiful preparations in the whole collection. It is nearly at the commencement of the intestinal tube, that the bile and pancreatic liquors are poured into it. Mr. Hunter, in his paper on digestion, says "it appears from many experiments, that the digested or animalized part, when carried into the intestine, clings to the internal coat, as if entangled among the villi; whilst the excrementitious part and bile are found lying unconnected, in the gut, and as if separated from the other." This fact was more fully explained, and also exhibited in this theatre, by Mr. Astley Cooper, when he held the office of professor of Anatomy and Surgery to the College. He told us, that the gastric juices first dissolved that food which was most susceptible of digestion, thus affording an argument against much variety of viands; that the substance dissolved was discoverable in the solvent, and gave a character to the solution; thus the chyle prepared from animal or vegetable substances partook of the nature of such substances, and if dried and burned, emitted the same odour, and produced similar results to those which occur from the decomposition of the same substances before they have undergone such solution. Nay, he told us further, that the chyle formed from animal matter rapidly putrefied, whilst that prepared from vegetables was slow in undergoing a similar change. As an abundance of nitrogene seems to be the base of animal substances, so its disposition to combine with hydrogene, and to form ammonia, seems readily to break up the general bond of union of the parts forming the compound. Whilst engaged in examining the chyle, he also examined the lymph which the absorbent vessels contain, and his chemical friends, who were men of great knowledge and ability, report, that it is in all respects like the blood, except that it wants the globular particles and colour of that fluid, a proof that these vessels, as well as others, modify their contents, which is a physiological subject I shall subsequently have to discuss.

Mr. Cooper showed us how firm a substance the digested aliment had become, and how tenaciously it adhered to the villous surface or lining of the intestines, so that it might be mistaken for a part of that surface; and how turgid the vessels of the intestines appeared when the chyle was separated from their villous coat, the whole surface appearing as if highly inflamed or subtilely injected. This he attributed to the digested aliment having acquired, in consequence of undergoing the process of digestion, the property which is characteristic of the blood; that of spontaneous coagulation, so as to become solid and tough, in which state the coagulum of either may firmly adhere to the surface with which it happens to be in contact.

The gastric fluids are detained in the stomach, and therefore not wasted, and the last mentioned circumstance interested me, because it showed how the succus intestinalis is prevented from being wasted, and its action confined to that substance which it is designed to convert into chyle, whilst the excrementitious matter alone remains loose in the calibre of the intestines, and at liberty to be urged on by their peristaltic actions. Nay, Mr. Cooper further showed us that the same circumstances also obtained in the large intestines, that portion of the alimentary matter which could be modified and rendered meet for absorption, acquiring an adhesive property and clinging to the surface, which accomplished these purposes.

It is well known that a great and sudden change is wrought in the contents of the alimentary canal, immediately on its transit from the small into the large intestines, that a valve is formed to prevent any communication between them in a retrograde course; that the commencement of the large intestines, usually called the cæcum, is in herbivorous animals particularly capacious, and apparently calculated for detaining the alimentary matter; and in some, as in the horse, this portion of the alimentary canal is of surprising magnitude; that the extent of surface of the lining of the large intestines is much more ample in herbivorous than in carnivorous animals. So that from these and other observations, it is believed that the residue of the alimentary matter undergoes a great change in them, produced by the qualities of the liquors they secrete, and that this change prevents a spontaneous chemical decomposition of the contents, and conduces to the extraction of whatever may be useful from the residue of the food. But I shall not detain your attention on this subject, because I have already briefly expressed my opinions respecting it. I omit many things, for I only attempt to explain what I believe were Mr. Hunter's opinions on certain points in physiology. Sir E. Home has already told us how industriously he noted the varieties of the formation of this part of the alimentary canal in different animals.

Though I must not proceed to describe in detail the facts which Mr. Hunter exhibits, with respect to the structure of the digestive organs of different animals, yet I shall mention in what variety they are displayed, because it will show you, in some degree, the extent of his researches in Comparative Anatomy; and also, because you will find the other vital organs, provided they admit of it, exhibited in the same animals, in all the different departments of the Museum. A great number of other animals will, however, be found in other departments, which are not included in this, for though such animals may exhibit interesting varieties in other vital organs, they contain no remarkable peculiarity in those concerned in digestion. Mr. Hunter examined the structure of echini, crustacea, and some molusca with particular attention, and caused drawings of exquisite beauty to be made of them. I take this opportunity to show you some of these drawings, and to inform you that there are probably one thousand of them belonging to the collection. Mr. Hunter was particularly fond of drawings and paintings, and consequently rather fastidious as to the representations given of the objects in which he took so great an interest. There was no poor artist of talent in this town, that he did not befriend to the utmost of his power. Every man of genius was, indeed, his brother, and he felt a fraternal interest in his success.

Mr. Hunter has shown, in his Museum, the digestive cavities amongst

ZOOPHYTES.

In polypes, actinia, zoanthus, and medusæ.

ECHINODERMATA.

Various echini, asteriades, holothuriæ, and sipunculus nudus.

INSECTS.

Gryllus cristatus, gryllo-talpa, œshna, musca tenax (Lin.), cicada, bees, beetles, silk-worm, termites.

CRUSTACEA.

Crabs, lobsters, and cray-fish.

VERMES.

Aphrodita aculeata, amphinome, nereis, terebella, lumbricus terrestris, hirudo.

ANIMALS INHABITING OTHERS.

Hydatigena, tænia, ascaris, echinorhynchi.

MOLUSCA.

Sepia officinalis, loligo, octopus, lepas aurita, and others. Coronula diadema, chiton, haliotis, doris, clio, bulla aperta, chama, pecten, mya, teredo navalis, ascidia intestinalis, clavata, salpa.

FISH.

Skate, torpedo, sturgeon, various sharks, tetraodon, lamprey, annarrhichas, (gillaroo trout), mullet.

REPTILES.

Testudo, lacerta agilis, gecko, alligator, rana, siren, lacertina.

BIRDS.

Swan, common pigeon, crowned pigeon, ostrich, cassowary of New South Wales, East Indian bittern, Solan goose, pelican, turkey, raven, rook, crow, and gull.

MAMMALIA.

Man, dog, lion, beaver, porcupine, hare, rat, anteater, manis, opossum, wombat, ornithorynchus, sloth, bear, peccari, hog, guinea-pig, calf, goat, elk, deer, camel, horse, various cetacea.

LECTURE V.

ON THE ABSORBING VESSELS.

Next to the organs which digest the food, there are displayed in the Museum those vessels which imbibe it from the bowels, and convey it, in the higher classes of animals, into the sanguiferous system.

Mr. Hunter, having convinced himself by observations and experiments which are published, that these vessels are the only ones which perform the function of absorption, attributed the removal of every thing in the interior of the body to these minute, highly susceptible, but undiscernible agents. Believing that secretion or deposition was a process very generally going on throughout the body, he used to call the absorbents, the modelling vessels, from perceiving that if secretion exceeded absorption in any part, increase of bulk and deformity would ensue. He was led on by degrees to believe, that these vessels, acting in excess, took away the very substance of which parts or organs were composed, so as to create large chasms in them. Seeing what things were done, and under what circumstances they took place, he was led to advert to the causes which excite or diminish the actions of these wonder-working vessels; but the advantages we have derived, in the practice of our profession, from the researches of Mr. Hunter with respect to this subject, have already been the theme of several lectures which I have had the honour of delivering in this theatre.

When his opinions on the functions of the absorbents were first promulgated, they appeared to others, not merely wild, but absolutely incredible; and when he was asked, how he could suppose it possible for these vessels to do such things as he attributed to them; he answered, nay, I know not, unless they possess powers similar to those which a caterpillar exerts, when feeding on a leaf. I relate this anecdote, merely to show that Mr. Hunter was one of those who could believe there must be means adequate to produce effects, though they were undiscoverable by our senses. It is interesting to know how generally opinions, which he first broached and established respecting the absorbents, are now received and adopted; for it is a striking proof of the facility and firmness with which we believe what is probable, when we have no motive for contesting or denying it. All seem convinced of things scarcely explicable without requiring that kind of proof which some are accustomed to demand on other occasions.

The first preparation which Mr. Hunter has put up in this department of his collection is a common hyacinth root; which I cannot believe exhibits any thing more than may be observed with a glance of the eye, in the windows of our houses, during the spring season. We see the succulent roots descending from the tuber, and the leaves beginning to bud. I cannot believe that Mr. Hunter, or others, have ever seen the minute absorbing vessels which must, nevertheless, exist in these roots, consequently, I conclude that he exhibited this preparation merely as an argument; as if he had said, you must grant me that there are vessels to imbibe the juices of the earth which afterwards become the sap or nutritive fluid of the plant; and I am convinced there are similar vessels to perform a similar function in all parts of animal bodies. After having been teased and perplexed by sceptics, he could only reply from analogy, and therefore, I suppose he put up this root, which though it shews little to the eye of sense, he thought might demonstrate much to the eye of reason.

Mr. Hunter, however, has exhibited in this department of his Museum, many specimens of what may be considered as the trunks of these undemonstrably minute vessels. He also injected them in whales, to show their analogy to those found in other mammalia, and that they were very minute vessels, even in such monstrous animals.

I was acquainted with Mr. Hunter at a period of his life when he must have greatly interested any one, who duly appreciated the results of his talents and labours, or who had any sympathy for the highly susceptible mind of genius, rendered still more so by excess of exertion, and the perturbed feelings incident to bodily disease. He seemed to me conscious of his own desert, of the insufficiency and uncertainty of his acquirements, and of his own inability readily to communicate what he knew and thought. He felt irritated by the opposition he had met with in establishing his opinions; and still more by finding, when he had surmounted this difficulty, that those opinions were, by the malice of mankind, ascribed to others. All which, I think, may be fairly inferred from a single sentence he one day addressed to me: "I know, I know," said he, "I am but a pigmy in knowledge; yet I feel as a giant, when compared with these men." It interested me to find amongst the manuscripts to which I so frequently refer, a long extract from a French author, who was said to have taught the same opinions relative to absorption before him. Mr. Hunter has made his own commentary upon several of the passages, and as it seemed to him that by nothing short of a new construction of words and sentences could any resemblance of opinions be made to appear, he was induced to add, "This reminds me of a dispute that took place between a zealous convert to the Newtonian philosophy, and a Hutchinsonian, in which the latter having, by garbling and transposing certain passages from the Scriptures, seemingly made good a very absurd proposition; the latter retorted, Yea but it is also written, Judas went out and hanged himself; moreover it is added, Go thou and do likewise." Those who were acquainted with Mr. Hunter, know full well that he had a great deal of drollery in his composition.

No one can read Mr. Hunter's works without being convinced that he was a man of perfect candour and scrupulous veracity. Such a character must be its best biographer, and I am much gratified that he has, to a certain extent, published his own account of his deeds and designs. The first editor of the European Magazine, printed in 1782, was well acquainted with Doctor Hunter and his brother, and being desirous of givng, in that work, an account of the distinguished schools of science both at home and abroad, he began with the lectures of these brothers. That the account and anecdotes of Mr. Hunter are genuine, the editor has given me the most positive assurance, adding, "I received the materials from his own hand." Here John Hunter speaks for himself, but is made to tell his story with simplicity and effect, by the friendly aid of the then editor * of the magazine. That Mr. Hunter acquired the best physiological knowledge of the time from his brother's lectures cannot be doubt-

* Mr. Perry, now editor of the Morning Chronicle, who superintended the publication of the European Magazine at its commencement, though but for a very short time. I have annexed his account of Mr. Hunter, to this publication, because it is brief; and it must, I think, be interesting to all to be informed what were the intentions and objects of Mr. Hunter, in his lectures and labours.

ed, but he was not satisfied without examining facts for himself and forming his own opinions. Therefore we find Mr. Hunter asserting that all this kind of knowledge had been the result of his own personal observations and reflections; he does not say that his opinions are new, but only that they are new to him. It was the malicious transfer of his facts and opinions to others, which, as I believe, first induced him to read, or rather to get books read to him; and we find him in every instance candidly acknowledging the claims and merits of his predecessors, whenever he discovered them.

ON THE ORGANS FOR THE DISTRIBUTION OF NOURISHMENT.

It has been already remarked, that in some minute and even vivacious animals, no organization is discernible, and therefore nothing can be known in them, respecting the subject now under consideration.

There seems, however, to be a very exact coincidence of opinion between Hunter and Cuvier, as to the structure of the fresh-water polypes (as they are called), the hydræ of Linnéus. Professor Cuvier believes, that polypes are formed of a pulpy substance, having pores that imbibe nourishment, which becomes arranged so as to constitute their bodies, and to produce their shoots or offspring. Mr. Hunter says, "I have an idea that some animals absorb their nourishment similar to a sponge, and dispose of it immediately to their own increase."

To me, however, who confide more in the eye of reason, than in that of sense, and would rather form opinions from analogy, than from the imperfect evidence of sight, it seems too hasty an inference to conclude, that in the minute animals, there are no vessels nor other organization because we cannot see them; or that polypes are actually devoid of vessels, and merely of the structure described, because we can discern no other. Were it, however, really so, such facts would then only show with how little, and with what various organization life could accomplish its principal functions of assimilation, formation, and multiplication. Who has seen the multitudinous, distributive, and absorbing vessels, and all the other organization which doubtless exist in the vitreous humour of the eye, than which no glass ever appeared more transparent or more seemingly inorganic? How strange is it, that anatomists, above all others of the members of the community of science, should hesitate to admit the existence of what they cannot discern, since they, more than all the rest, have such constant assurance of the imperfection and fallibility of sight?

Amongst the zoophytes, Professor Cuvier says, that in medusæ and similar animals, vessels arise from their digestive cavities, which do not return, but exhaust their contents in deposition, effusion, and transpiration. It is ascertained that Mr. Hunter injected the vessels of medusæ from the digestive cavity, in some of the specimens preserved in the Museum in the year 1779, and these vessels appear beautifully distributed throughout the substance of the animal, frequently communicating like the threads of network. In animals thus nourished, in which there is no circulation, there can be no distinct respiratory organs; neither do they want them, for their blood or nutritive fluid is every where exposed to circumambient air.

In the animals included in the class of vermes, according to the arrangement in Professor Cuvier's lectures, many of which have red blood, and therefore its motion is more apparent, we meet with the first generally acknowledged instance of circulation. They have a dorsal vessel running the whole length of the animal, which is large in the middle, and becomes gradually smaller towards either end. Sometimes there are dilatations in it, causing it to appear as if varicose; and there are lateral dilatations which may be considered as hearts; or the whole tube may be regarded as the heart of the animal. This vessel is displayed in the Museum in the common earth-worm. The animals of this class have in general large vessels on each side lying in contact with the air-vesicles or lungs, which are considered as the venous trunks returning the blood to the dorsal vessel. They are exhibited in the Museum injected in the leech. Mr. Hunter says, "they are the venæ cavæ, or great returning veins of the body, and also the pulmonary veins; for in them the blood is aerated." His mode of expressing this two-fold office, is by saying, "such veins are both corporeal and pulmonary."

It must be exceedingly difficult to inject the vessels of vermes, so as to display their communications; nor do I find that Mr. Hunter has made any preparations to demonstrate the various branches of the dorsal vessel or its returning veins. What is asserted in general with respect to this subject, has, I believe, been chiefly discovered by observations made with the miscroscope on those animals when living. Mr. Hunter, in expressing his observations on the manner in which the body is supplied from the dorsal vessel in these animals, says, they have not one aorta or distributive trunk, but many aortæ. Professor Cuvier, in his account of the organs for the distribution of nourishment in the class of vermes, principally appeals to the evidence of what may be seen in the arenicola, or lumbricus marinus of Linnéus. Sir Everard Home, being particularly desirous of examining the circulation in this animal, on account of its having external branchiæ, sent for Mr. Clift to the coast of Sussex for this purpose; and their conjoint observations on the vessels and circulation in this and other vermes, are printed in the Philosophical Transactions for 1816.

That Mr. Hunter was as well acquainted with the circulation in animals of the worm kind, as any of his successors, is, I think, evident from his writings. He says, "they have the most simple kind of circulation, which is, when the blood, propelled by the heart, becomes aerated in its circulating passage." He also says, the motion of the blood is a kind of undulation; which phrase, though not sufficiently explanatory, must, I think, principally have been suggested by what is observable in animals of this class. I am, however, aware that the motion of the blood in the vessels of the chicken and its appendages before they are conjoined, and a circulatory motion consequently established, might have suggested the same expression. In worms, we see the dorsal vessel pretty suddenly filling, till it is distended with blood; it then contracts, urging on its contents, till it is empty, when, after a time, it is again replenished. Thus wave follows wave, but the cause of this interrupted, or seemingly undulatory motion, has not perhaps been fully explained. Analogy would induce us to consider the systole and diastole of the dorsal vessel, as similar to what is observed in the heart of the higher classes of animals, and that the tardiness of the circulation is the cause of this apparently undulatory motion.

The spiracula or tracheæ in the sides of worms terminate in vesicles, which are considered as their lungs. They are numerous and distinct, situated all along the sides of the animal in contact with the lateral blood-vessels. These air-vesicles, or lungs of worms, are exhibited by beautiful preparations in the Hunterian Collection; and in some instances, vesicles are also shown in the back of the animal.

It is scarcely credible with what patience Mr. Hunter examined the structure of the lower kinds of animals. He contrived spectacles with glasses of different degrees of magnifying power, so that by a slight alteration of the position of his head, he could look through the one or the other. Mr. Clift tells me, he would stand for hours motionless as a statue, except that with a pair of forceps in either hand he was picking asunder the connecting fibres of the vessels or parts, till he had unravelled the whole structure. Thus did he make the preparations of the amphinome flava, and aphrodita aculeata, which you will find in the Museum. In the former, he thought he had distinctly traced numerous minute vessels, which he considered as absorbents, extending from the bowels, laterally nearly the whole length of the animal, and terminating in small vesicles, which lie in contact with the respiratory organs. In the former he found numerous minute tubes continued from the intestines, which are of considerable length, and which, after ramifying towards their extremities, terminate in little oval cells or cæca, which are lodged in the sides of the animal, in contact with the pulmonary vesicles.

There are different preparations of these parts in the Museum, and when the intestines happen to contain a whitish substance, it is also seen in the tubes and cells; when the bowels contain a blackish matter, it is likewise found in these appendages. What Mr. Hunter thought respecting this subject is not known. Such tubes may be considered either as terminating in the intestines, or proceeding from them.

In order to attempt the investigation of this subject, I requested Mr. Clift to inject the alimentary canal of the aphrodita with fine injection, and it passed into these numerous tubes, and cæca, all of which are fully distended; but we cannot observe that the injection has gone further. I show you this preparation, and you see these cæca in their natural situation, from which they are removed in the other specimens. I beg leave also to mention, that being desirous to ascertain how far the distributive vessels of the lower kinds of animals admitted of being injected from their digestive cavities, as is the case in medusæ, and also to observe, whether any transudation took place through their sides, I requested Mr. Clift to inflate and inject with subtile liquors, the digestive organs in echini, insects, and vermes; and as far as his enquiries have yet extended, he finds the canal similar to that of the higher classes, neither air, nor injection impelled, escapes from it, either through its sides, or by proceeding into vessels.

According to the present arrangement of the subjects of Comparative Anatomy, insects form the next class to zoophytes, and worms succeed to insects. I have told you what Mr. Hunter knew and thought about the structure and functions of worms; first, because it is probable that analogy, as well as his own observations, which may indeed have been biassed by analogy, led him to believe, that the circulating and respiratory organs of insects were similar to those of vermes. Like Swammerdam and others, he considered the dorsal vessel as the heart of the insect, and it is exposed in his Museum in the bee, the preparation being marked, the heart of the bee. We find bees, beetles, and silk-worms injected in the Hunterian Collection, but how, no one can tell. I should not have supposed that Mr. Hunter would have injected from the spiracula or orifices of the tracheæ, with which he was well acquainted. Yet the injection, wherever impelled, might have been effused, or have got into and pervaded the air-vessels, which is supposed to be the case, by those who put faith in the modern opinions respecting the anatomy of insects. Mr. Hunter also believed, that the pulmonary organs of insects were similar to those of the vermes, and he says, they not only serve to ventilate the blood, but to give levity to the body of the animal in those insects which fly. He says, the vesicles are larger in beetles, whose bodies are heavy, than in the lighter kinds of flying insects. He further mentions, that the vesicles or lungs of the flying insects are different from those of others; as they extend throughout the whole length of the body.

You probably know, Gentlemen, that the present belief with respect to the nutrition of insects is, that the digestive aliment absorbed from the bowels passes on by the same tubes to all parts of the body, and that tracheæ, or air-vessels, are equally distributed, so as to produce a general and complete aeration of the nutritive fluid. It is further believed that the glands of insects are merely composed of contorted tubes. Yet the crustaceous animals, (formerly accounted insects,) spiders, some phalangia, and scorpions, are admitted to be of a different structure, and to possess both circulating organs and lungs like those of vermes. Lyonnet, Cuvier, and others, assert that the dorsal vessel found in insects gives off no branches, and that no motion of fluids can be perceived in them, even by the aid of the microscope. Professor Cuvier says, "tout le corps est nourri par une fluide stagnant." Yet even vessels can produce a free and forcible motion of their contents, as is evident in vegetables, and in the absorbents of the higher classes of animals. If there were no current in the fluids of insects, how could liquors run so freely as they are known to do from the contorted tubes that form their glands? Professor Cuvier is disposed to consider the irritability of animals as greatly dependent on the aeration of the blood; and ascribes the vivacity and power of insects to its great exposure to air. Yet this opinion cannot, I think, be maintained as a general inference in physiology: for what animals are more agile, powerful, and indefatigable than fish, and yet we have reason to believe their blood is very imperfectly aerated?

I have done, as I am convinced Mr. Hunter would have done, candidly acknowledged his opinions, and readily admit them to be erroneous, if they are shown to be so. I cannot, however, but imagine how he would have rubbed his head, and thought, and wrought, till he had satisfied his mind respecting this subject; when, if he became convinced that the modern opinions were right, we may readily suppose what a train of reflections would have succeeded, How curious must it appear that these very vivacious and powerful little creatures, which also possess such a complex apparatus of muscles, should be nourished in a manner not unlike that of vegetables; that the food, when digested, should be absorbed from their bowels, and that the absorbing system should become the distributive one, without the aid of any pumping engines or hearts to urge on the current.

To Mr. Hunter, however, who believed life to be a principle independent on structure, which could exercise its functions with diversity of means, none of the circumstances I have alluded to could excite wonder. He would labour, as he always had done, to ascertain facts, and the additional facts would, on this, as on other occasions, only serve to confirm his already well established theory.

In the present class of animals denominated crustacea, Mr. Hunter examined the lobster with particular attention, and has left most beautiful drawings, as well as preparations, demonstrating its anatomy in general. He was probably induced to make this attentive examination from considering it as a large specimen of the insect kind, in which the structure common to the whole tribe might be more readily discovered and displayed. With respect to its circulating and pulmonary organs he says, " The heart which is unilocular, propels the blood throughout the body, which fluid receives purification in its passage; and that the blood returns, both from the body and from the lungs to the heart, which it throws out, in a mixed state, equally to the body and lungs." Every one is acquainted with the pulmonary apparatus of lobsters and crabs, that pith-like production that is drawn out of their bodies with their legs when they are torn off.

Ascending to the newly established class of molusca, I find Mr. Hunter acquainted with all the facts which have warranted later Comparative Anatomists in making this distinction; so that he might himself have formed the arrangement, had his mind been directed to the subject of classification. Speaking of the situation of the heart in the multiform animals now included in this class, he says, it is very various, and seems chiefly to depend on that of the lungs: also that it is differently situated, even in animals of the same kind, as in the snail and slug. With respect to its structure, he says, in the snail, and in many of the inhabitants of shells, it is composed of an auricle and ventricle, whilst in others it has two auricles and one ventricle. He thinks that in the single heart with two auricles, it is formed, as it is in reptiles, to receive the blood both purified and unpurified, and to throw it out in a mixed state. He distinguishes in this class of animals between the corporeal and pulmonary hearts, observing, that the snail has a heart for the former circulation and not for the latter. He particularly examined, and was thoroughly acquainted with the circulating and respiratory organs of the cuttle-fish, which are displayed with his usual perspicuity and accuracy, by preparations in the Museum, and also by beautiful drawings, two of which have been lately published in the Philosophical Transactions for 1816, by Sir Everard Home.

As no one can doubt Mr. Hunter's knowledge of the circulation in fish and reptiles, I shall say nothing on this subject, except remarking, on account of the physiological inference the fact admits of, that the fish has only a pulmonary heart. It is composed of an auricle and ventricle, the former receives the blood returned from all parts of the body, and the latter propels it through the gills, where, having undergone the change produced by respiration, it returns by vessels which, ending in a single trunk, form the great distributive vessel or aorta of the animal, to which no heart is connected; so that the blood receives no additional impulse besides that derived from the action of its containing vessels. Therefore, these extremely agile, powerful, indefatigable, and vivacious creatures are supported by a languid circulation and trivial respiratory process: a fact which warrants the conclusion, that the powers of life can be exerted according to their allotted manner, without that quick supply of materials, or great degree of change produced in the circulating fluids by respiration, both of which many physiologists have been accustomed to consider essential to the production and maintenance of such high degrees of vital action.

In order to explain the varieties of hearts met with in different animals, Mr. Hunter seems to have sought for some generic term, simply expressing the number of cavities found in them, without any reference to the connections or offices of those cavities; and his friends must have supplied him with the terms which he employs, Monocoilia, Dicoilia, Tricoilia, and Tetracoilia. He considers the heart as a pump, which forcibly impels the fluid it contains into the vessels. Where there are two cavities, he says, one is an auricle, and the other a ventricle. The auricle is a cistern or reservoir, from which the contents are suddenly forced into the more efficient cavity or pump. Sometimes there is a heart or pump to the pulmonary circulation, and none to the corporeal; and sometimes there is one for the latter and not for the former, and sometimes one for each. Even in the quadruped and bird, in which the heart appears most complex, he says, it is equally simple, there is a heart for either circulation, but these are united into one organ.

In advocating Mr. Hunter's reputation as a general physiologist, I ought not to omit to commemorate his labours in examining the circulation of the blood in the higher classes of animals. Doubtless the phænomena of the constant supply of blood to every part, and the building up and repairing the structure of the body, must have appeared to him so curious and wonderful, as to induce him to admit nothing upon the authority of others, and to examine every fact for himself.

Though I now engage in a subject which more especially I have a right to discuss, as it relates to human anatomy, yet I must not weary you by detailing facts familiarly known, or proving propositions which are generally admitted. Were I also to advert to the doctrines of others, I should have to collate asserted facts and opinions, irreconcilable with one another, and to engage in controversial discussion; yet why should I bandy about the ball of controversy, wasting both my own labour and your time, if I know I must let it fall at the conclusion, just where I took it up at the beginning? It seems best for a lecturer simply to say what he thinks, and why he thinks it, because it is the only way in which he can feel, and consequently create an interest in that which he delivers. I shall therefore merely tell you what I have been taught by Mr. Hunter to think with respect to the principal parts of the subject of the distribution of nourishment in the higher classes of animals.

First, then, I find Mr. Hunter examining the structure of the arteries or tubes by which the blood appears to be carried to every part of the body. He is neither clear nor confident in his description of them; and yet I know not that any one has described them better. Internally they are membranous tubes, which is a common character of all sorts of vessels, the polished surface of the membrane admitting their fluid contents to pass along with the greatest facility. He knew that exterior to this, and not far from it, there was some substance, thin, but particularly strong and unyielding, which caused the vessel to have a regular circular form when distended. He found that when the trunk of the distributive vessels, the aorta, was injected with a force equal to ninety pounds, this part suddenly cracked, and the external elastic matter of the vessel readily yielding, it became distended by the effused injection, into a bulky, but irregular, form.

Mr. Hunter thought that the great quantity of elastic matter which surrounds large arteries was well calculated to prevent that injury to the vessels, which the powerful propulsion of blood by the heart might otherwise occasion. Nay, he observed that the quantity of elastic matter was greatest where it appeared most wanted, that it was greater on the convex part of the arch of the aorta than on the concave. He further observed, that certain arteries which are occasionally much elongated, have a far greater share of elasticity in their longitudinal direction than others. The quantity of elastic matter surrounding arteries also gradually diminishes as these tubes recede from the heart, and the impulse of that organ diminishes; which well known fact corroborates the opinions I have just mentioned. The elasticity of the large arteries may also lighten the labour of the heart by the kind of suction it may sometimes occasion.

Mr. Hunter knew, that in cases of hæmorrhage, the arteries would gradually contract upon their diminished contents, to a much smaller calibre than common; and he measured their areas in the contracted state in which they were found in a horse that had been bled to death. He then distended them, so as to destroy the effect of this vital contraction; and having suffered them to regain that calibre which their elastic property naturally determines, he again measured their areas, and found that the aorta had contracted, in the first instance, to more than one-tenth of its natural diameter, the iliac to one-sixth, and the crural to one-third. He also observed, that arteries corresponding to the radial of the human subject, and others of the same size, were closed. I also think it evident, in the common operations of surgery, that arteries of no inconsiderable magnitude, which have bled vehemently, and in a large stream immediately after their division, very speedily cease to bleed, and remain with their orifices so closed, that they are scarcely discernible. I have seen the radial and ulnar arteries of the human subject, appear like impervious chords. This happened, indeed, in young patients. Yet, Mr. Hunter never attempted to demonstrate muscular fibres in arteries; he says there is a reddish substance surrounding the tube near the internal coats, which he believed to be the structure possessing irritability. Specimens of arteries thus contracted, and contrasted with others of the same size, but of their natural dimensions, are exhibited in the Museum. Mr. Hunter must have been acquainted, from his brother's lectures, with the inconclusive experiments of Haller, relative to the irritability of different parts of the body. He adopted another and a better mode of determining, whether parts possessed a power of vital contraction. Observing that this power in muscles produced contraction after the ordinary functions of life had ceased, he tried whether, and for what length of time, parts could contract in this manner. Thus did he satisfy himself, that the arteries of the funis umbilicalis had vital energies remaining in them sixty hours after its detachment.

Mr. Hunter's notions of life were peculiar. He thought that it was an active principle, which, by operating in various modes and degrees, produced the different phænomena by which its existence is characterized. He knew that parts, in which no muscular structure was evident, were nevertheless irritable, and that the modes of contraction and relaxation of muscular parts were various. He seems by no means satisfied, that all the phænomena of muscular relaxation can be accounted for, on the supposition of the abatement or cessation of an active power. Without, therefore, pretending to determine the modes of action of the sanguiferous tubes, seeing that they have a power of vital contraction upon the diminishing quantity of their contents, knowing that vessels alone are capable of producing a quick and forcible current of their contained fluids, as is evident in the ascent of sap of vegetables, and still more so in the acceleration of the current of the fluids contained in the absorbing vessels of animals, as they approach to the trunk of the system, we seem warranted in concluding, as Mr. Hunter has done, that the different degrees of power allotted to different parts of the arterious system, is given to them for the purpose of aiding in carrying on the circulation.

When the blood is projected by that powerful engine, the heart, into the large arteries, little energy on their part is requisite to urge on the rapid current; but in proportion as the heart's influence diminishes, power is allotted to the vessels to aid in its propulsion. There are some modern physiologists, and those of high repute, who consider the heart, by its actions alone, as fully adequate to maintain the circulation, and consequently discredit the irritability of arteries, except of those which are called capillaries. But where, I would ask, am I to suppose that these capillaries begin? I cannot observe the sudden and deep blush of shame, or extreme paleness of terror, without being convinced that arteries of no inconsiderable size possess vital activity; we cannot believe that the heart's influence can be partially exerted, determining the blood into one set of vessels in preference to another. How then can we account for the vehement hæmorrhages which take place from inflamed arteries, unless we admit vessels of magnitude to possess vital activity? Do we not know that an hæmorrhagic action is a natural phænomenon in some parts of the body, that arteries occasionally pour the blood so impetuously into the corpus cavernosum and spongiosum, as suddenly and forcibly to distend them?

I can scarcely believe that if an anatomist were injecting the principal artery of the dura mater, and had burst its trunk, he could, with his utmost efforts, expel so large a quantity of injection, and compress the brain to the degree that we sometimes find it to be by blood, when that vessel is torn and irritated by injury. Yet the same vessel does not bleed when exposed. Can we account for such facts from the actions of the heart alone? How also, I would ask, am I to account for the vehement throbbing of all the large arteries of the arm, even as far as the axilla, which may be sometimes observed, when an abscess forms at the end of one of the fingers? How am I to account for the distinct pulsation we often perceive in the carotid, or abdominal aorta, unless some vital activity be admitted to exist even in the larger vessels? We may indeed, in some instances, account for the phænomena which we observe, by supposing constriction to have occurred in the capillaries of the large pulsating trunk; but this supposition appears to me very inadequate to explain the whole of the phænomena of such occurrences.

Our physiological theories should be adequate to account for all the vital phænomena, both in health and disorder, or they never can be maintained as good theories.

Mr. Hunter enquired if the area of arteries increased as they receded from the heart, and for this purpose examined the trunk of the common carotid, which runs to some distance without giving off any branch of importance. He found it largest at the end furthest from the heart. He was convinced that the conjoined areæ of all the minute arteries must greatly exceed that of the aorta, where it emerges from the heart, and therefore that every portion of blood projected by the heart was moving into an increasing space.

Mr. Hunter, who believed that, in living beings nothing was constructed or done in vain, could never have observed the very curious contortions of some arteries, which he has taken much pains to display in his Museum, nor those of the great vessels as they enter the skull, without supposing that some purpose was effected by them. Neither could he contemplate the coalition of currents of blood moving in contrary directions, which is produced by the arteries communicating and conjoining with one another, without admitting that it must tend to retard the velocity of the motion of such opposing currents. Mr. Hunter therefore joined in the physiological belief, that all the circumstances we observe in the distribution and ramification of arteries, are calculated to produce a rapid current of the blood through the larger vessels, in order that it may arrive unchanged at the part for the supply of which it is designed; and that other circumstances there occurring, are intended to retard its motion, so that it may be modified and rendered subservient to the purposes of secretion and nutrition.

Now you know, Gentlemen, that some physiologists suppose the velocity of the current of blood to be equal in all sets of vessels. With respect to this subject, I will merely refer you to an experiment of Hales, in his Hæmastatics. Having estimated the probable force of the heart, he put a tube into the aorta of a dead dog, and kept it filled with water to a height which would give an equal propulsion to the supposed power of the heart. Under these circumstances, having opened the abdomen, he cut along the tube of the intestines, at that part most remote from the mesentery, and observed the water running tardily from the orifices of the divided arteries.

He then divided the mesentery at the edge next the intestine, where the vessels being larger, the water ran rapidly from them; and when he opened a vessel of considerable size, it gushed from it with the same velocity and force that blood issues from the same sized vessel when divided in a living animal. I refer you to this experiment, because it seems far better calculated to display the effects likely to result from the circumstances we observe in the distribution and ramification of arteries, than any we may make with tubes of our own construction.

Mr. Hunter was convinced that arteries terminate in veins; for if we inject the former with any subtile fluid, it quickly and freely returns by the latter. I know not, however, whether the magnitude of some of the communicating tubes was ascertained till of late years. I have in my possession a hand which was injected with wax about thirty years ago, and the wax passed freely from the arteries into the veins, so as to afford a beautiful exhibition of the network of small veins, which proceed to terminate in the larger trunks, in a manner which I had never before seen demonstrated, except by injections of quicksilver. In dissecting this hand, the vessels which transmitted the injection from the arteries into the veins were apparent. Some artifice is, however, necessary to our success, in making these preparations. We should suffer a part to become slightly putrid, before we inject its vessels, which produces a yielding state of them, favourable to the transit of the injection. Yet there are arteries which terminate in veins, so small, as not, in their natural and healthy state, to transmit even coloured blood, so that there is, in fact, something similar to a speculation of Boerhaave's, something like a descending series of vessels. It also evidently appears, that the great mass of the blood is freely transmitted from the arteries into the veins, so that it rapidly and regularly circulates; and we therefore conclude, that but a small portion passes into the finer vessels, there to undergo those modifications which fit it for the production of the secretions, and the various materials for the nutriment of the body.

The veins freely communicate with one another, and joining together, they form tubes of apparently larger dimensions, but of less actual calibre than the branches by which they were formed; so that in these vessels the blood is obliged to pass through converging channels, which eventually end in the two venæ cavæ, the conjoined areæ of which are inconsiderable when compared with the space the blood has occupied in all the minute veins of the body. Consequently, if the heart pumps out an ounce and a half of blood at each action into the arteries, and the same quantity is returned, in the same time, to that organ by the veins, it must be urged in the like interval from the small arteries into the veins, and run with accelerated velocity as it approximates to the heart. Of this circumstance we may, I think, be convinced by ocular demonstration, even in the ordinary practice of our profession. There is much more space in the veins than in the arteries, which prevents any trivial obstruction in the former channels from impeding the transmission of the blood into them through the latter. The superficial veins which meander on the surface of the body are beset with numerous valves, or flood-gates, which prevent the blood from moving in a retrograde course, and oblige it to go onwards towards the heart. The blood sometimes returns to the heart, chiefly by the deep-seated veins which accompany corresponding contiguous arteries, and at others more abundantly through those on the surface. Mr. Hunter believed that veins possessed vital activity, but it must be of the kind allotted to the muscles of tardigrade animals, and such as various parts of our bodies are also endowed with. Indeed the large veins near the heart are said to evince an irritability of the more common kind. The nature of the irritability of veins may enable them to adapt their calibre to their contents. Mr. Hunter argues that, as the vena portæ in the liver performs the function of an artery, it probably is irritable. We know that it fails to secrete, or secretes with profusion; that sometimes it prepares healthy, and at others faulty, bile, which variation of function can scarcely be supposed to take place in a perfectly passive vessel.

The blood returning from all parts of the body is, in the higher classes of animals, propelled from the right side of the heart through the lungs. To observe the circumstances resulting from the conjoined actions of the heart and respiration, Mr. Hunter contrived a pair of bellows by which he could maintain the latter process in an artificial manner, and thus he was enabled to observe how greatly the heart's action depends on its continuance. He says, "the nearest dependence of the heart is upon the lungs, for a stoppage of respiration produces a stoppage of circulation; and a renewal of the former is attended with a renewal of the latter. Thus, in my experiments with artificial breathing, the heart soon ceased to act, whenever I left off acting with my bellows; and upon the renewal of artificial breathing, it in a very short time renewed its action, first by slow degrees, but becoming quicker and quicker till it came to its full action." Mr. Hunter displays the subject of the structure and uses of the lungs, according to our present notions. He says, "that as the function of the lungs becomes augmented in animals, so are their cells minute, and the pulmonary vessels subdivided, by which means the surface of the air and the blood exposed to reciprocal influence is proportionately increased. Carbone is evidently thrown off, and a change produced, of the precise nature of which we are ignorant, but which is rendered evident to our senses by a change of colour; for the purple current acquires a scarlet hue, or, as it is commonly expressed, the venous blood becomes arterious. Chemists have considered the change as contributory to the production of animal heat; which opinion may indeed be true, though the manner in which it produces such an effect, has not as yet been explained." Mr. Hunter, who believed that life had the power of regulating temperature, independently of respiration, says nothing of that process as directly contributing to such an effect. He says "breathing seems to render life to the blood; and the blood conveys it to every part of the body." Yet he believes the blood derives vitality also from the food. The experiments of Mr.

Brodie, which I have mentioned in the first lecture of this year, seem satisfactorily to show, that the transitions of colour, which are produced in the blood by respiration and circulation, are not of themselves alone adequate to occasion a change of temperature. I am at a loss to know what chemists now think respecting heat, whether they consider it to be a distinct species of matter, or mere motion and vibration. Among the curious revolutions which this age has produced, those of chemical opinions have a fair claim to distinction. To show which, I may mention, that a lady* on her first marriage, was wedded to that scientific champion who finally overthrew the dominion of phlogiston, and established in its stead the empire of caloric; and after his decease, on her second nuptials, was united to the man, who vainly supposed he had subverted the rule of caloric, and restored the antient but long banished dynasty of motion and vibration. In this state of perplexity, I cannot advance with

* Madame Lavoisier, who afterwards married Count Rumford.

prudence or probable security one step farther than Mr. Hunter has led me. I must believe respiration to be essential to life, and that life has the power, by its actions, of maintaining and regulating temperature.

Mr. Hunter suggested that the blood ought, for numerous reasons, to be considered as a living fluid, and adds, " that the blood has life, is an opinion I have started for above thirty years, (which must have been in the year 1760,) and have taught it, for nearly twenty of that time, in my lectures." I quote this passage merely to show how early he had acquired those notions of life, which I consider as the primary stimulus of his meritorious and highly useful exertions. He wonders that this opinion had not been more deeply impressed on the minds of medical enquirers, because the blood undergoes evident changes from variations in the state of the health, and the actions of the vessels. Life is generally attributed to solids only, yet these are formed from the blood, which could not give them what it did not possess. He says, that in the years

1755–6, when making drawings of the changes which took place in the incubated egg, he was particularly struck with the well known fact, that the yolk and white, which we cannot suppose to be organized, did not putrify; and this led him to believe that fluid and semi-fluid substances might have a principle of life diffused through them.

Every one must be convinced that the power of the heart is very considerable, even from observing the thickness and compactness of its fleshy structure. Dr. Hales estimated its force as equal to a little more than 70lbs. That it could not act with the enormous force which some have attributed to it, Mr. Hunter inferred from finding that a force of 90lbs. burst the inelastic part of the aorta. Mr. Hunter believed that the forcible projection of an additional quantity of blood from the heart into the arteries, produced a sudden motion in the whole column contained in these tubes, and occasioned their almost simultaneous pulsation in every part. He could not doubt that if they were contracted, they would be distended by the impulse of additional fluid; yet with reference to this point, he observes, that upon laying bare an artery, no distention of the tube is apparent; and that the distention seems to take place in proportion as it is covered or compressed.

Such, then, is the view Mr. Hunter has exhibited of the circulation in the higher classes of animals; and on contemplating it, we perceive how every part of the body may duly receive its allotted portion of nourishment and life, as well as how each part may receive less or more than its ordinary quantity, in consequence of the vital actions of its own vessels.

I do not perceive, however, that his representation of the circulation differs materially from that of the best physiologists who preceded him. But he has the merit of examining every point for himself, and under all the varieties of circumstances; as well as of ascertaining what before appeared obscure and uncertain. This theory of the circulation has been assaulted, and yet, as far as I can perceive, without being either injured or invalidated. Therefore I am disposed to maintain it, for the same reasons that I am his theory of life, because both are probable, cautiously and philosophically deduced, and adequate to explain all the phænomena of health, disorder, and disease; which I think cannot be said of any other theory relative to either of these subjects.

LECTURE VI.

ON SECRETION AND NUTRITION.

At the conclusion of the former lecture, I exhibited a kind of sketch of Mr. Hunter's facts and opinions relative to the circulation of the blood, and the change wrought in that fluid, by respiration. I have now to enquire wherefore does the blood circulate? Is it not for the nourishment of the body, and the preparation of various fluids and substances subservient to the animal economy? We believe, for reasons which I need not detail on the present occasion, these objects to be effected by means of minute vessels, which go off from the extreme arteries, and which sometimes terminate by open orifices, effusing or depositing their contents; whilst sometimes they lead on to other channels, which collect and convey the fluids they receive, to certain reservoirs or surfaces. These vessels which prepare and separate something from the circulating fluids are called the secerning vessels. It is curious to observe Mr. Hunter's expressions with regard to these agents. " I would not," says he, " call them arteries; they are workers, they are the labourers." He would not consider them as concerned in the circulation of the blood, they are the chemists and the architects of the body. That such vessels could separate from the blood something that was formally present in that fluid, might be easily credited. But how they could prepare that extreme diversity of fluids and substances which they are known to do, formed a problem that was never solved till the time of Hunter. He thought that the vital principle of the vessel, acting on that of its fluid contents, produced these chemical changes. He thought that there was a correspondence or concert of affection and action between them, a harmony as he calls it. Thus did he attempt to explain how a morbid state of fluids could induce an unhealthy action of vessels, and how the latter could reciprocally occasion the former. Was he not, indeed, a strong and clear-sighted man, who could see so far through the obscurity in which these subjects were involved, in his time? But the sun of science has since shone on them, and we now see distinctly the probability and rationality of his theory. Sir H. Davy's experiments prove that they are electrical actions, by which all combinations and decompositions of matter are occasioned, and that what is called electricity pervades every thing whether solid or fluid. In speaking of digestion, it has been already shown, that actions productive of secretion are regulated by the general powers of life, by the energies of the nervous system. Every one now seems convinced, by direct experiments, that vessels so modify their contents, that the liquids and substances which the absorbents take up, become lymph, a fluid resembling blood, in their transit through those vessels; and that the chyle imbibed from the bowels is undergoing continual modifications as it proceeds through these channels to the sanguiferous system. Yet, as I have mentioned in my former lectures, the most direct proof of the truth of Mr. Hunter's opinions respecting secretion was given by himself, and at a time when these subjects were involved in darkness, by showing the effects resulting from the application of morbific animal poisons.

From observation and analogy, Mr. Hunter was induced to believe, that the coagulation of the blood was an effect resulting from the vital principle, and similar to that contraction which takes place in muscles, after the cessation of the ordinary functions of life. He mentions that in animals killed by lightning, or large charges of electricity, in those which have been hunted to death, or destroyed by violent blows on the stomach, he had observed that the blood did not coagulate, neither did the muscles become rigid.

That the powers of life inhere in any distinct substance which makes no part of the visible structure of the body, may indeed, in every instance, be doubted, but if this be conceded, the consideration of the vital phænomena oblige us to admit that there is a principle of life pervading the blood, so that Mr. Hunter's opinions on that subject cannot well be disputed, and appear to be fully established by Sir H. Davy's discoveries. Yet his opinion of the coagulation of the blood being occasioned by its vitality has neither been proved by himself, nor disproved by others. It is a detached opinion making no part of the general discussion relative to the vitality of the blood; and therefore it is strange that so much has been said and written about it. Those who do not understand, or who dislike Mr. Hunter's opinions, have in general furiously assailed this detached and seemingly unsupported one, yet without in the least injuring or altering it; whilst others, who are advocates for Mr. Hunter's theories, have hurried to its defence, as if all would be lost should this single opinion be destroyed. Thus both parties seem to have been led away from the main subject. How seldom do we consider propositions with the deliberate exercise of those powers of observation and reason with which we are endowed? We are partial to our opinions, and consequently prejudiced against those of others. In argument we strive for victory rather than seek for truth. That self-conceit which leads us chiefly to attend to our own opinions and feelings, and to disregard those of others, renders us indocile, unfits us for patient and impartial consideration, and is a great obstacle to the progress of science, as well as to human happiness in general.

Mr. Hunter believed that the secerning arteries, having prepared the various kinds of nutritive materials for building and repairing the different structures of the body, deposited the atoms from their open orifices with such regularity, as in a great degree to achieve this surprizing purpose. He however believed that the life of the parts assisted in producing their arrangement. The occurrences met with in disease afford the strongest confirmation of these opinions; every fibre being subject to sudden and unnatural increase, mutation, or removal.

In consequence of the opinion that each

particle was deposited by an appropriate vessel, he was induced to add that every part of the body may in this sense be said to be equally vascular; what is meant by increased vascularity depending upon the greater size or number of the vessels, which transmit the blood, allowing them to be more distended with red blood, or our coloured injections. Further, he observes that an increase of apparent vascularity may be the result of vessels passing through parts to terminate elsewhere.

Now, though Mr. Hunter attributed so much to the agency of vessels, he believed that life, in various instances, formed these active tubes. His opinions might indeed be biassed by what he had observed in the cicatricula of the egg, but he thought that vessels might be formed in effused gelatinous matter, as he says they are in the areola of the egg, called cicatricula. In speaking of the latter subject, he says, "The arteries are the very first active parts of the system. We find them in action before they are connected to the heart, and in this state they are the only parts that have strength, so that we can dissect them without injection, the other parts readily giving way." He seems confident that vessels form separately, and afterwards become united with one another; and he believed that vessels might also be thus formed and conjoined in the gelatinous substances effused previously to the growth or reparation of parts.

In the union by adhesion, he supposed that though new vessels might be produced, the original divided vessels pullulated and inosculated, and became pervious and entire as they were before their division, so that blood or injection would permeate them as before. He thought, that when parts were united by a common vascular substance, the vessels and vital agency of the parts divided could gradually convert the common uniting medium into its own nature. Thus does he suppose that the nervous fibres are produced and elongated through the common uniting medium by which a divided nerve is conjoined. We see surprisingly rapid growths take place either naturally or in consequence of disease; yet at the very summit of the growth, we must admit that there are nerves, because there is feeling; that there are absorbing vessels, because there is absorption. Medicines imbibed from the surface, are conveyed into the sanguiferous system through the originally existing absorbent channels, and the blood is returned in like manner from the summit of the new-formed part, through the pre-existing veins. The original structures must therefore have grown to the very summit of the newly-produced substance, or similar parts must have been formed in it and conjoined with them.

With regard to arteries in general, he says, "That they have within themselves considerable powers of increase, both in magnitude and length, as well as of producing new shoots; all which is evident at the time of the formation of the new horns in the stag, and also in utero-gestation. Such actions, likewise, extend by sympathy to a considerable distance from the part immediately engaged in any increase of growth both in the arteries and in the returning veins."

Mr. Hunter has put up in his Museum several preparations to show the celerity with which the processes productive of union are carried on. Yet, as the effusion of injection may redden parts and give them the appearance of vascularity, so that we are liable to be deceived, I shall not refer to these preparations in evidence of this fact.

Mr. Hunter was convinced that life might remain in a dormant state, in detached parts, for sixty hours, as has been mentioned in the first lectures. He therefore could not wonder at the facts with respect to transplantation or engrafting of portions of animal bodies with which he was acquainted; yet he says that the transplanted part must have life, to accept of the union, because he believed, that a correspondent and co-operating action was necessary for its accomplishment.

Mr. Hunter observing how firmly the gum sometimes attached itself to a transplanted tooth, and thinking the comb of a cock resembled the gum in its texture, transplanted the tooth of a dog and set it in the comb, where it became firmly fixed. He next transplanted a gland taken from the abdomen of the cock, to a similar situation in the belly of a hen, where it also became attached, and as he believed, nourished, for he probably thought he had injected it from the general arterious system. The uniting medium by which it is firmly connected is certainly very vascular, yet I do not see that any injection has passed into the vessels of the transplanted gland. The preparation is in the Museum, so that you can examine it for yourselves. Mr. Hunter probably believed that it was nourished, from its neither wasting nor decaying. As, however, the evidence was not very distinct, he next transposed the spur of a young hen to the leg of the cock, and that of the latter, to the leg of the former bird, which spurs grew, and thus set the subject at rest in his mind. It may seem, however, curious, that the hen's spur grew to a greater size on the cock's leg than it would have done upon the parent animal, which Mr. Hunter considered as a proof of the greater vigour of constitution of the male bird.

Next to the organs concerned in the circulation and aeration of the blood, Mr. Hunter displays the various kinds of kidnies allotted to different animals as a specimen of glands in general, and as the agents by which the impurities are carried off from the circulating blood. Carbone and water, with trivial quantities of saline and animal substances, are discharged from that fluid from the surfaces of the body, both from the skin and lungs. The kidnies also carry off redundant water from the blood, which is a proper vehicle for salts casually received or accidentally formed; but which is likewise made to suspend various kinds of solid animal matter. As many of the old materials of the body, and some of the unassimilated matter of our food, are insoluble in water, nature has given the kidnies powers of converting various kinds of animal matter into a peculiar and very soluble substance, lately recognized and denominated urea. So soluble is it that we may evaporate the water of the urine to a considerable degree without precipitating the urea; and when we add large quantities of water to urine, the urea will pervade the whole, and be dissolved in it, so as to be distinguishable in every portion by appropriate tests. Lime removed from our bones, or taken into the circulating vessels with our food, becomes also dissolved in the water of the urine by means of phosphoric acid, which the human kidney prepares in so large a proportion, that the superfluous acid will redden the vegetable blue, and dissolve more lime than is usually found in urine. That the phosphoric acid could not exist formally in the blood, but is prepared in the secretory vessels of the kidney, must be evident to every one on consideration. Yet in herbivorous animals, who take into the circulation a great deal of flint with their food, the urine is rendered alkaline in order to dissolve that kind of earth.

I have been induced thus briefly to advert to the functions of the kidney, because the quantity and quality of its products can be ascertained, and thus throw light upon the subject of secretion in general. When water abounds in the blood, whether from more being imbibed from the digestive organs, or less being carried off from the surfaces of our bodies, the quantity separated by the kidney is proportionately increased, and *vice versâ*. Thus do the secretions become vicarious to one another, and conjointly tend to maintain the proper quantity and quality of the circulating fluids.

The qualities of the urine also demonstrate how much secretion is affected by different states of the nervous system in general. When the kidney is rendered irritable from various causes, and persons are in that state usually termed hysterical, it scarcely separates any thing but water from the blood, which is, indeed, produced in an inordinate quantity; and it is probable, that a different state of the nervous system, may render the kidney incompetent to transform the animal matter into urea, and thus prove a cause of foul and deficient urine. How curiously and universally are the nervous functions sometimes disturbed by trivial causes? Even harsh and discordant sounds, affecting the brain, may disturb the functions of the kidney; so that there may be some who, "when the bagpipe sings in the nose, cannot contain their urine."

Those of the medical profession must readily accord with the additional remark of Shakspeare, that such affections, which may well, indeed, be called "masters of passion, sway us to their mood in what we like or loathe." For we well know, that our patients and ourselves, from disturbance of the nervous functions of the digestive organs, producing such affections of the brain, may become irritable, petulant, and violent about trifles, or oppressed, morose, and desponding. Permit me, however, to add, that those of the medical profession must be equally apprized, that when the functions of the mind are not disturbed by such affections, it displays great energy of thought, and evidence of established character, even in death. Have we not lately heard, that the last words of Nelson, were, "Tell Collingwood to bring the fleet to an anchor?" Shakspeare has also represented Mercutio continuing to jest, though conscious he was mortally wounded; the expiring Hotspur, thinking of nothing, but honour; and the dying Falstaff still cracking his jests upon Bardolph's nose. I request you to excuse this digression, which I have been induced to make from perceiving, that if such facts were duly attended to, they would prompt us to make a more liberal allowance for each other's conduct under certain circumstances, than we are accustomed to do; and also incite us to the more active and constant performance of the great business of human life, the education of the mind; for, according to its knowledge and dispositions, do we possess the ability of contributing both to our own welfare and comfort, and to those of others.

The saccharine diabetes is a disorder which elucidates in a very striking manner the nature and effect of the vital actions in the process of secretion. If the stomach does not digest vegetable food, so considerable a portion of it is sometimes imbibed from the bowels, as to render the serum of the blood turbid, though not sweet. In the kidney, the vital actions combine the vegetable substance into something resembling sugar, which, being very soluble in the water of the urine, in this form obtains an outlet from the body. Thus those who have trivial and temporary incompetency to digest vegetable food, have also a corresponding degree of saccharine diabetes, which is often unnoticed; but when the disorder of the stomach causing this failure of digestion is established and permanent, the diabetes is constant, if vegetable substances be eaten. *

* In saying this, I by no means deny that diabetes may not also result from disturbed vital actions in the kidney. Dr. Sanders, of Edinburgh, informs me that he has of late particularly attended to the state of the medulla spinalis and vertebral nerves both in chorea

ON THE ORGANS OF PERCEPTION AND VOLITION.

After the exhibition of the organs by which animals are nourished, their curious structures built up, and their various liquors and substances prepared, Mr. Hunter shows the nervous system, or the means by which parts of the body seem to have sympathetic communication with one another, and with the brain, which is commonly believed to be the organ of sensation and volition. I have nothing to add with respect to this subject in general, to what is contained in the introductory lectures. When I wrote them, I had not indeed attended to Mr. Hunter's views of the nervous system in the lower kinds of animals; neither had I read Professor Cuvier's Lectures. It is therefore proper, on

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and diabetes, and that he finds their vessels very turgid, with other signs indicative of their having been in a state of considerable disorder; which state, in diabetes, however, may either be a cause or effect of renal irritation.

the present occasion, to mention that both these zealous and industrious enquirers into the structure of animals, seem to acknowledge that there are some beings, in which they have not been able to discover any regular nervous system; yet upon dissecting them, they meet with fibres which they believe to be nerves. Mr. Hunter has shown these kind of threads in the sipunculus nudus.

In animals of the worm kind, which are formed of a series of rings, the nervous system is also composed of an equal series of connected ganglia, each ganglion supplying that ring of the animal to which it corresponds, so that each ring may be considered as possessing a perfect nervous system. The connection between the ganglia may also be supposed to produce effects which I have endeavoured to express in my first lectures by the words "concurrence of impressions and actions." When animals, whose nervous system is thus constructed, have such sensations as we possess, and recognize in the higher classes of animals, when they are sensible of light, sound, odour, and touch, the upper ganglion which surrounds the œsophagus must be considered as the brain, and from this, nerves may be traced to the eyes, antennæ, and feelers. Mr. Astley Cooper tells me, if the longitudinal nerve be divided in the earth-worm, it can no longer regulate its motions. When a worm is divided, each part moves and crawls by its own powers, but if the longitudinal nerve be divided, when the worm is entire, the motions of either end so counteract each other, that the animal cannot crawl, which shows that the volition of the worm proceeds from its brain, and cannot operate on the parts beyond the divided nerve.

In insects and crustacea, the nervous system is similar to that of worms.

In molusca, there is no longitudinal source of nerves analogous to the medulla spinalis. There is an upper ganglion, similar to that considered as the brain in the animals just mentioned, and a lower one to supply the viscera and the rest of the body. Mr. Hunter says in his MS., "There are two large nerves descending on either side of the œsophagus, and then uniting into one, forming a ganglion at their union, which he thinks serves the office of the sympathetic or visceral nerve, and the medulla spinalis."

In fish and reptiles, the nervous system approximates to that which is found in the higher classes of animals. In the former, it is extremely small. The brain and medulla spinalis of the squalus maximus is exhibited in the Museum. It therefore appears that fish, such agile, powerful, indefatigable creatures, which are also so surprizingly retentive of life, have not only a very languid circulation, scanty respiratory process, but also a disproportionately small nervous system. We need not indeed marvel at such facts, because the animals in which the energies of life seem greatest, are those in which neither circulating organs nor nerves are discoverable.

Mr. Hunter has in his MS. particularly described the various forms of the brain in the lower classes of animals, and has exhibited specimens, showing its varieties, in his Museum. As this organ becomes large and complex, so, it is well known, do animals proportionately possess various perceptions, propensities, faculties, and sentiments; which induced Mr. Hunter to believe that it was the organ of sensation and other properties originating in that source.

These circumstances being shown, the different organs of sense are next exhibited; and the structure of the eye of the fish and bird appears to have been particularly examined and contrasted by Mr. Hunter. But I must not enter into this subject, for it would be useless to begin without proceeding; and if I proceeded, I should weary both myself and my audience before I returned to the point from which I had set out. Neither do I perceive that any conclusion can be drawn from the most patient investigation of the subject, except that which has been deduced in the introductory lectures; that vibratory actions occurring in the nerves, in consequence of impressions made on them, are transmitted to the brain, and variously affect that which is perceptive. It is evident to reason that our perceptions have no rational correspondence to the causes producing them; and nature may have allotted to animals various kinds and degrees of perception adapted to their wants, and the situation they occupy in the scale of existence. No one can guess what kind of vision belongs to the fly. There are probably 25,000 hexagonal lenses or menisci on its surface, or the same number of distinct visual organs, as some comparative anatomists would have us to believe. Some animals may have great susceptibility to light, odour, and sound, and yet may not possess great general susceptibility. We find indeed, in may instances, organization adapted to function, and yet it is highly improbable that we shall ever be able to explain function by means of our knowledge of organization.

Having promised to endeavour to confirm, by additional physiological arguments, the theory of nervous and muscular actions proposed in my first lectures, I proceed to redeem this pledge. That life continues in detached parts of vegetables and animals, seems evident, from the continuance of irritability; and to this subject only, I excited your attention in the introductory lectures. On the present occasion, I wish you to consider, that all the vital functions are, occasionally, equally manifest in the detached part; for when such parts possess powers of supplying and distributing nourishment, growth and formation will continue, so that the detached part becomes as perfect and complete as the body from which it was removed. This happens in vegetables and zoophytes.

In animals of more complicated structure, also, reproduction of parts takes place, to a degree that often excites wonder, because we are apt to judge of other things by ourselves, or by those which we are most accustomed to observe. The claws of lobsters, when torn off, are renewed. It is said, that the divided parts of an earth-worm, if cut in two, will each become perfect; and that the head of the snail, and eye of the newt, will grow again, when removed. Yet, I would ask, what is there in these facts more surprizing, than in the reproduction of the stag's horns, and of the plumage of birds; or in the formation of superflous limbs in the fœtus, or of monstrous excrescences in the adult? All parts are originally formed by vessels; and why may not these agents form them anew, or produce them superfluously?

In the lower kinds of animals, different parts of the body may each be considered as possessing a perfect nervous system. Those animals which are capable of great degrees of the reproductive processes, have great tenacity of life, and powers of continuing its functions without the ordinary supply of food. It is said, that frogs and toads have lived in hollows of wood and stones, so that it is probable they were supported only on the reputed "cameleon's dish," the air, and the moisture it contains. Snails will live when covered up in a glazed pan for more than a year. Now, though I do not, under such circumstances, see any thing astonishing in the instances of reproduction which are reported to have taken place, yet I should hesitate to admit that the brain was ever perfectly reproduced, till such a fact was established by observations on the future life of the animal, and by subsequent accurate anatomical examination. As far as I have observed, divided earth-worms, and most decapitated snails, perish; and I know that we may decollate the latter very completely, and yet but partially remove the brain; the reproduction of which would not then appear so wonderful, for even in the higher classes of animals, the life of parts seems to operate so as to convert surrounding substances into their own nature and structure.

In the higher classes of animals, in which distinct organs are allotted for carrying on the vital functions, if parts be detached, they necessarily perish, for the springs of the vital actions are removed. There can be no supply of blood or nervous energy, for the detached parts are cut off from their sources. There is no manifestation of the existence of life in the detached part, except by the delay of putrefaction, and the continuance, for a time, of the phænomena of irritability.

To this striking evidence of the existence of life in detached parts, I directed your attention in the introductory lectures; nor do I perceive any reason to add to what was then said, in order to persuade an unprejudiced person that it is a superadded power, only inherent in the visible structures to which it is connected. But on the present occasion, I would ask, whether irritability alone is capable of causing all the phænomena which take place in the reproductive processes I have now referred to? Can it alone produce assimilation and decomposition, and all the varieties of growth and organization? Those who think the phænomena of life depend on organization, must necessarily suppose as many kinds of life as of structures, and still assign no cause for the production of such structures. Those who think that irritability depends upon nerves, must do so by a violation of their own principles, for they must *suppose* the hydatid to have nerves, though none can be demonstrated, even by the aid of the microscope. Yet if they choose to contend that the phænomena of irritability in detached parts which possess nerves are maintained by their presence, it is impossible to refute them, for we cannot remove the nerves without destroying the irritable substance. The arguments which invalidate their supposition are, that irritability exists where we have no evidence of nerves, and that it bears no proportion to the magnitude of the nervous system.

From the perplexities and obscurity of other opinions, let me turn your attention for a moment to contemplate the simplicity and clearness of Mr. Hunter's Theory of Life. In all its functions he recognized an active principle, capable of producing motions in matter that would not move without it, and of controlling motions to which, from other causes, such matter has a propensity, and of exerting its powers in different modes and degrees in the structures or substances in which it inhered. He thought that a similar vital principle was diffused throughout the body in different degrees, and to use the expressions with which his friends have furnished him, that the materia vitæ diffusa communicated with the vital energies of the brain, by means of actions transmitted through the nerves or internunciate chords, as he called them; he also considered these actions to be productive of the sympathetic effects referred to in the introductory lectures, and which are wholly unintelligible upon any other supposition.

In forming our opinions on the subject of sensation, I admit that a choice of difficulties is presented to us; and I prefer that which seems the least. If I judge, as I own is natural, of other things by myself, I shall be led into a dilemma that a man of great intellectual powers and acquirements has been, and whom I have already praised for the important additions he has made to our knowledge of the functions of the nervous system. As we perform certain actions in consequence of reasoning, he was induced to believe that brutes act in a similar manner from a similar cause. Regardless of the opinions of great numbers of highly intellectual men, that instinct is a blind impulse, unconscious of the end which it effects, he maintains his own, and is consequently obliged, as he proceeds, to suppose that brutes have tradition. But I am sure, had he continued to examine their actions to the extent he might have done, he would have been compelled, either to relinquish his dogma, or to assert things still more incredible. It would require more intellect and ability than falls to the lot of any human individual, by experiment, induction, contrivance, and practice, to accomplish what animals perform without education or communication with one another. The full consideration of this subject, induced a philosopher to conclude, that the actions of animals were the result of laws established by an intelligent cause, and to express the opinion by the brief but empathic exclamation: "*Deus est anima brutorum.*" Yet further, as animals perform certain actions in consequence of feeling, the gentleman alluded to is led on to suppose, that similar actions in vegetables are also the result of feeling; nay, he even attributes to them the more subtile sensations of smell and taste, and believes them to be undoubtedly actuated by the passion of love. As he has published all this in a scientific work, containing many highly valuable observations, I conclude that he was firmly convinced of what he has asserted; which shows how opinions are acquired and established. We have only to think in a certain manner repeatedly, and we shall become convinced of what at first might have appeared doubtful, or even improbable. It is therefore prudent, before we indulge in certain trains of thought, and suffer them to become habitual and predominant, to consider their ultimate tendency and probable influence on our conduct, both with respect to ourselves and others. It is surely right, before we enter a path which we mean to pursue, to enquire whither it may lead us.

The long continuance of life, when the brain is removed in tortoises, the dissections of that organ by Doctors Gall and Spurzheim, the late experiments of Le Gallois and Dr. Wilson Phillip, showing that the vital functions can be carried on in warm as well as in cold blooded animals, after the brain has been removed, provided, indeed, artificial respiration be kept up in the former class, all tend to show, what comparative anatomy also teaches, that the brain is not essential to the vital functions. There are animals which have no brains, and in proportion as they possess them, so do they appear to have sensation, volition, and other faculties. Every portion of newly acquired knowledge only corroborates the already well established opinion, that sensation, volition, and the intellectual faculties are connected with the brain alone.

The experiments of M. Le Gallois show that there is an analogy in the functions of the medulla spinalis in the higher and lower classes of animals. In the latter, it is a series of connected gangalia, each supplying the portion of the body to which it corresponds; and even in quadrupeds we sometimes observe the medulla spinalis to swell out in portions, so as to appear like a series of connected ganglia, as is evident in the preparation which Mr. Hunter has exhibited of that part in the lion. The experiments of M. Le Gallois, show that the nervous influence of portions of the body, corresponds with that part of the medulla spinalis to which their nerves are connected; that it forms a kind of centre from which nervous actions radiate, and to which they tend. Yet according to the view I have exhibited of the nervous functions in the introductory lectures, it appears necessary that such actions should be transmitted to and from the brain in order to communicate sensation and volition.

M. Le Gallois seems, however, to suppose, that sensation continues in the medulla spinalis after the brain is removed. Now were I to entertain the same opinion, I might be led on to suppose that a duck decapitated by the side of a pond, which has been known to run a few steps into the water, and swim a few strokes from the shore, was voluntarily taking refuge from injury in an element where it had formerly found security, was gratified by the feeling derived from it, and elated at accomplishing its object. The mind revolts from the supposition that nature would have formed the lower kinds of animals doomed to destruction, so defenceless, or, that they should repair the injuries they sustain in the manner they are known to do, did they possess the sensibility of the higher classes. Sensation seems allotted to animals in different degrees and faculties adapted to their peculiar situation. Were it however possible that I should believe all that seems required of me, and go on to attempt to account for the phænomena of life upon such principles, I know eventually I should be compelled to believe that atoms were sentient, and intelligence universal.

The opinion that sensation, volition, and other faculties attendant on perception, are connected with the brain alone is natural to most men, confirmed by reasons so strong and clear, that they have convinced those of the greatest intellect in different æras and countries, and it is corroborated by all the discoveries in science. I have already observed, that we know nothing but the properties of the different substances we recognize in nature; of the subject which supports these properties we seem, in every instance, to be equally ignorant. Mr. Hunter's proposition, that the phænomena of life are produced by something which is superadded to structure, cannot, I think, be disputed. But if this be granted, the facts which have been mentioned, call upon us also to admit, that life is not essentially perceptive; and I further contend, that reason absolutely prohibits our supposing, that perception, with its concomitant attributes of consciousness and volition, and its various attendant faculties, propensities, and sentiments, can be the result of any arrangement or motion of insensible atoms. I know, indeed, I may be asked how I can suppose a distinct sentient principle to be formed, added, or connected? To which I answer, it is impossible to entertain any supposition on these subjects, because we can have no knowledge but what is derived from our perceptions. Yet I can firmly believe, that there may be, and are things, of the nature of which we can never entertain the least idea, from their having no correspondence to the objects of our senses. To me it seems, that true philosophy shows us the imperfection of our senses, and limitation of our powers; so that by a kind of light which it elicits from our own ignorance, it instructs us in the lessons of humility.

By adopting the opinions which I feel it my duty to inculcate, we not only avoid many difficulties and absurdities, but also perceive the scheme of nature to be beautiful and benevolent; and we are excited to actions useful to others, and honourable to ourselves. Nature has given life an active power to vegetables, which occasionally evinces its activity even in them by irritable motions. The irritable actions of life are however more particularly allotted to the animal kingdom. She has superadded to life sensation, but confined the sentient principle to the brain alone, and yet enabled it to perceive all that happens in the body, and even in remote objects, as well as to regulate those actions which may contribute to the welfare of the perceptive individual. She has allotted sensation and faculties in various degrees to animals, adapting both their feelings and dispositions to the situation they occupy in the graduated scale of existence. She has made man in the highest degree sensitive and intelligent. She has given him reason and sentiments of so exalted and commanding a nature, that under their excitement he will sustain and encounter what his nature as an animal most dreads and abhors. At the call of honour, or under the conviction of right, he will endure torture with seeming apathy or derision, and welcome death with smiles. In the exercise of his intellectual powers he is abstracted from his body, and unconscious of its existence.

But I forbear to say more; for I have not received the appointment of professor of moral philosophy to the college. Yet it is a part of my duty to place before you, Gentlemen, a specimen of what I believe to be the ancient Greek philosophy of life, and a sample of some modern French physiology on the same subject, for your consideration and choice.

Now though I have forborne to consider the structure of the organs of sense in general, I wish to say a few words on that of the human skin, which is capable, in all its parts, of distinguishing what are called the tangible properties of substances, because the skin forms the surface of the body, and there is probably an analogy in the coverings of all kinds of animals. Had the skin been exposed to the air, it would have either become dry and horny from evaporation, as we see in the dead subject when the cuticle is removed, or encrusted, from the same cause, by the residue of the fluids it pours forth. It is therefore necessary that it should be defended by an outer garment impermeable to moisture. The cuticle, which seems a compact, though thin substance, through which the water effused beneath it, when we are blistered, does not even transude, appears well calculated for this purpose. It is most exactly fitted to the surface of the true skin, descending into every groove, and rising over every eminence. Yet however neatly fitted this water-proof garment may be, it would be liable to be wrinkled or displaced by friction, were it not firmly connected to the skin by a net-work of very minute, soft, and seemingly mucaginous fibres, which are therefore denominated the rete mucosum. This part is variously coloured in different persons; it is tawny in some, freckled in others, and black in the African. These investments of the skin do not appear to be sensible, and doubts have been entertained whether they are in any degree vascular.

We must however, I think, admit that vessels arrive at the surface of the cuticle, through which gaseous and watery fluids containing some mucilaginous and saline substances are eliminated from the circulating system. We see the sweat escaping from regular pores, and not irregularly transuding, as if it passed through interstices in the cuticle. Substances rubbed on the skin gain entrance into the absorbing vessels, and it is very improbable that they pass through the compact cuticle, in order to arrive at their orifices. We see the ducts of the oil-bags terminating on the surface of the cuticle. It seems here right to observe, that myriads of oil-bags are disseminated throughout the skin, from which ducts proceed to the surface of the cuticle to anoint it every where; and that it is most liberally oiled in parts subject to the greatest friction or evaporation. If we throw water upon our arms, we find it repelled in globules, as from a greased surface. Every hair also receives a small covering from the cuticle, as it penetrates that substance; which covering so tenaciously adheres to it, that in taking off the cuticle, when the skin is slightly putrid, we tear the bulbs of the hair from the beds in which they grew, and they remain firmly connected to the cuticle in consequence of this investment.

There are processes of the skin entering the interior of animals; and though these differ materially from it in appearance, yet an analogy of structure may be traced in them, so that they may fairly be considered as internal skins. Their surfaces, to which also the air may have access, are every where besmeared with mucus, and therefore they are commonly called the mucous membranes of animals. Mucus is an animal substance, admirably adapted for the defence of the surfaces which it covers. It is mild and unstimulating, possessing a viscidity which causes it to cling to the surface it is designed to defend, and being particularly immiscible with other fluids, it is not likely to be removed by the liquids contained in cavities formed of such membranes, or even by the current of fluid when passing through tubes of the same construction. In evidence of this, I may mention, that the surfaces of fish are smeared over with mucus, which is liberally poured out from the orifices of numerous ducts, rendering the surface of these animals particularly slippery, preventing also any adhesion between them and the element in which they move, and serving the same purpose in facilitating their transit through the water, that greasing the bottom of a boat is known to do. Yet though they swim through the water with such celerity, the skin is never denuded of mucus.

There are intermediate surfaces in animal bodies, between those which I have described as external and internal skins, and these are also defended by appropriate lackers, which, however, I shall not detain you by describing. Yet I wish you to observe, how admirably the cerumen of the ear is adapted, from its obvious qualities, to defend and keep moist that process of the skin which lines the tube of the ear. Its tenacity causes it to cling to the surface it is designed to protect; it is not liable to dry into a crust, as mucus does, nor to become rancid and acrid, like oil. Its bitterness, they say, also renders it disgusting to insects, which might in our sleep seek to nestle in that passage. The necessity for the lining of the tube of the ear being kept constantly moist is evident, for when the cerumen is deficient in quantity, or faulty in quality, then the oscillations of sound, or the pulsation of the vessels, produce vibrations in the tube, causing noises, which patients compare to the rustling of leaves, or the gushing of waters, and the beating of hammers.

Though the exact structure of the coverings of animals appears to be less accurately known than that of most other parts, yet from the general consideration of the subject, I think we are warranted in concluding, that Nature has either, from the texture of the substances with which she has invested them, or the qualities of those with which they are besmeared, cut off all communication between the interior of living beings, and the elements in which they live, except what takes place through tubes or passages which she herself has formed. Even in vegetables we observe some surfaces besmeared with adhesive wax, others varnished with resin, whilst the grasses are glazed with transparent flint.

After the exhibition of the structures already adverted to, Mr. Hunter calls our attention to the fat of animals, which he considers as not actually making a part of the body, the animal being much the same with or without it. We find his attention, however, excited by the great increase of fat in hybernating animals, prior to their becoming torpid; and there are contained in his MS. many observations and experiments which he requested his pupil, Dr. Jenner, to make for him, relative to this subject, in hedgehogs.

The exterior coverings of animals are next shown, which are to be considered as their clothing or their armour, and respecting them, it seems worthy of remark, that they are all made of the same kind of material, which is impenetrable to moisture. Hairs, feathers, scales, and horny cuticle, resemble each other in this particular, and also in their chemical analysis.

Mr. Hunter has shown the analogy of the formation of feathers and hairs. Each is formed by a vascular substance, which ascends to some distance up their shafts. Hairs are bulbous rooted, and the stronger ones are more deeply implanted in the skin. The capsule of the bulb, which is tough and shining, being opened, is found to contain a very vascular pulp which can be injected, and ascends up the shaft of the hair so as successively to form it at the bottom; and thus to increase its length. I cannot suppose this circumstance was commonly known at the time Mr. Hunter made these preparations, for a knowledge of this fact much diminishes our surprise at the accounts we have received of the plica polonica, in which disease the hairs are said to be ill-formed, matted, and to bleed from their roots.

The hairs are sometimes straight, and sometimes curved or waving, and when of the latter kind they intermix and form a fleece. In birds and beasts the stronger hairs and feathers make an external coat, and beneath this we find a downy or furry vestment of the same parts, but of a more delicate structure.

These garments of animals are, from their texture, bad conductors of heat, and well calculated to prevent external heat or cold from affecting the animal temperature.

The garments of animals also exclude moisture from being oiled, either by unctuous fluids transuding from the skin, or from their being applied by the voluntary act of the animal; Nature having given to birds in common, and particularly to those that are aquatic, as well as to many animals, oil-bags for that purpose.

The coverings of many animals seem merely designed for their defence, as the shells of tortoises, armadillos, and the scales of the manis. The coarse scales and spines of fishes, the bucklers of the sturgeon, and hard projections of the skin of the crocodile, all serve the same purposes. The porcupine and hedgehog have quills like those of birds, but they want the fibrous part or plumage, and are remarkably strong and pointed. They may indeed be considered as a defence to the animal, when they lie horizontally; but as it is well known these animals, when attacked, suddenly squat down, bringing their fore and hind legs near together, and putting their head between their fore-legs, then contracting their skin in a direction towards their belly, by an appropriate muscle, the quills are raised, and a chevaux de frise of pointed spears presented in every direction to the assailant. When the horny or crustaceous investments of animals are of one piece and unyielding, there is a necessity, whilst the animal is growing, for casting these coverings and forming new ones, adapted to the increased bulk of the animal; and we find that snakes and lobsters thus cast their skins or shells.

Mr. Hunter next displays the weapons and instruments which Nature has allotted to animals; and here we find exhibited the spurs of the cock, the retractile nails of the cat kind, which must be considered as weapons; whilst the fixed nails of other kinds of animals may be regarded as instruments, with which they scratch or burrow. The hoof of the horse is shown; for it is used as a weapon. The horns of animals, being displayed elsewhere, are not included in this department of the Museum.

The teeth seem to have been considered by Mr. Hunter chiefly as weapons and instruments. Though teeth do not usually grow, yet those in the front of the mouth of the animals, now called rodentia, are continually growing, so that they project and prevent the animal from masticating, if not worn down by gnawing, according to the intention of nature. The venom bags, and tubular teeth, or fangs of serpents, by which the wound is inflicted and the poison injected, are shown, and also the stings of scorpions, bees and wasps.

Those animals which cannot hunt their prey, and would become victims of its resistance, can, by such means, instantly deprive it of power, and speedily of life. Such animals also as depend upon casualty for support, are generally formed to sustain long abstinence without that decline of power which occurs in others, and for the occasional digestion of enormous quantities of food. It is, however, but a small part of the highly interesting subject, of the means by which various animals obtain their sustenance, that falls within the province of the Comparative Anatomist to discuss; it is that part only which relates to structure, the rest belonging to the Natural Historian. The proboscis of animals is to be considered as an instrument, and that of the elephant is here shown.

In this department of his Museum, Mr. Hunter also displays the electrical organs of the torpedo and gymnotus, his account of which is published in the Philosophical Transactions. I have already suggested in the first lectures, what reflections they probably induced. He has put up equal portions of the brain and medulla spinalis of the raia torpedo, and a more common ray fish of equal size, so that they appear like the front and back view of the same preparation, in order to show the disproportion, and the immense size of the nerves which go to the electrical organs. How strange and unexpected is this mode of defence and assault, which probably palsies the prey or assailant. Even the polype seems to have a power of inflicting sudden death; but by what means, is not, I believe, ascertained. The worm which it seizes, is swallowed without resistance, or its struggles would lacerate the tender body of its devourer. I have thus, as briefly as possible, told you what are the facts, and their arrangement, which Mr. Hunter has exhibited, relative to these parts of the animal economy in general.

An adherence to the chief object of these lectures, which is to exhibit Mr. Hunter's opinions relative to the principal vital functions, has obliged me to hurry through these last departments of the Museum, and prevented me from noticing many interesting facts belonging to less important parts of the subject. I may, however, mention that Mr. Clift informs me, when Dr. Schreibers, of Vienna, whose account of the anatomy of the siren lacertina is published in the Philosophical Transactions of the year 1801, (which is the only animal known to possess both lungs and gills, and consequently fitted to live both in air and water,) inspected the preparations of the pulmonary and other organs of that animal contained in the Museum, he was surprized to find that Mr. Hunter knew nearly, if not all the facts relating to its anatomy, which he himself had been able to communicate to the public. Two species of the siren were examined by Mr. Hunter, one of which was brought from South Carolina, in 1758, and afterwards bought by him. Also, after Dr. Latham had published his account of the conformation of the larynges of various birds *, he was sur-

* Linnean Transactions, Vol. iv.

prized to find that Mr. Hunter had exhibited most of the facts contained in his paper on that subject, and several varieties, with which he was unacquainted, but which he deemed worthy of being communicated to the public. Now almost all the preparations in the Hunterian Collection were made before the year 1780, and have been publicly exhibited since the year 1783. We must, therefore, consider Mr. Hunter as the discoverer of all the facts, ascertained by his preparations, that were not publicly known before that time; whilst the open evidence and communication of his labours entitle him further to be regarded as the prime mover in those investigations, and as the source of that light, by which the subject of the comparative structure and functions of living beings in general, has of late been so highly illumined.

LECTURE VII.

It is one of the characteristics of living beings, that they multiply their species; which they sometimes effect in consequence of subdivisions of their bodies, or by the production of shoots, that afterwards become detached. Both these modes are evident in vegetables and polypes. In general, however, the multiplication of the species is effected by the production of seeds and eggs, containing nutriment for the germ of the future vegetable or animal, which, thus supported, grows till it acquires powers of deriving nourishment from other sources. Those animals, which multiply their species in this manner, are said to be oviparous. Sometimes the ova seem to be hatched within the body of the parent, and, under such circumstances, the animals are said to be ovoviviparous. This mode of multiplication is frequent in the lower kinds of animals, but it is met with also in the class mammalia, amongst the oppossum tribe. From observing the peculiarities of structure in the sexual organs of the animals last mentioned, Mr. Hunter was convinced that they did not produce their young like other quadrupeds; yet he was unable to get the American oppossum to breed in this country. The facts have been ascertained, since our more free communication with New Holland. That large animal, the Kangaroo, produces a young one, not exceeding twenty grains in weight, which is received into the abdominal pouch of its parent, and being there protected from cold and injury, clings to the nipple of its mother, and takes sustenance according to its wants. It is curious to observe the difference of form between the parent and its young offspring. The mother has monstrous hind legs, by which she springs to a surprizing distance, whilst her fore paws are very diminutive, serving merely to feed and to scratch with. On the contrary, the young Kangaroo has monstrous fore-paws, with which it clings to the nipple of its mother, and scarcely any hind legs; so that its form, at its birth, is suited to its present exigencies, and not to its future modes of life. By degrees, the young Kangaroo fills and distends the abdominal pouch, and peeps abroad through its aperture, which gives the first intimation to others, that its parent has become a mother.

The common mode of the multiplication of the species, in the higher order of animals, consists in the exceedingly minute ovum, containing no nutriment for the growth of the embryon, but merely its germ. Yet this possesses powers of extracting nourishment from the vessels of its mother; and when the young has attained a certain degree of perfection, it is expelled from her body, and is, or will become, a miniature resemblance of its progenitors. Animals that bring forth their young in this manner are called viviparous.

There are organs allotted for the formation of the ovum called female, but it never increases beyond a certain point, unless excited by the application of a peculiarly stimulating substance prepared by other organs, called male. Sometimes both kinds of organs are found in the same vegetable or animal, and sometimes the organs of each sex are allotted to different individuals. How far the prerogative of the female organs may extend with respect to their power of forming the rudiments or primordia of the embryon before the peculiar stimulus is applied which is said to fecundate the ovum, is probably unknown. The female organs of plants will, I believe, prepare a seed, though no fecundation has taken place. The progress of the formation of the young vegetable in the seeds of different plants is known to vary considerably. In the common bean, the plumula or first shoot is very evident, and even well formed. Experiments on vegetables might tend to elucidate the extent of the powers allotted to the female organs. Frogs and fish prepare and exclude their membranaceous ova prior to fecundation; and some degree of organization is discoverable in that part which would produce the embryon, if fecundated. Female birds prepare and deposit their crustaceous ova when secluded from the presence of the male. From the magnitude of some of them, and the facility with which they are obtained, they have been made subjects of interesting examination by various physiologists.

Mr. Hunter began his examination in those of the hen and goose in the year 1755, and the industry and accuracy with which he noted all the changes occurring during incubation are evident. He has put up in his Museum two sets of eggs, showing these changes from the first few hours of incubation to the maturity of the chick, and consequent conclusion of that process. As many of the appearances, however, are evanescent, or destructible by immersion in spirits, he procured beautiful drawings to be made of them by the best artists. It seems proper to mention, for it exhibits the peculiar character of his mind, that at the time of his death he was engaged in some additional investigations of the same subject.

These were the inquiries by which he was chiefly convinced that life was a great architect. He believed that vital actions begin simultaneously in various parts of the semi-opake and whitish areola which is called the cicatricula. He says that there is a zone of bloody points at a distance from the part where the rudiments of the chick begin to form. He suspects that blood is first formed, and vessels afterwards. He is certain that vessels forming in different parts of the areola, afterwards coalesce, and that the fœtus is not developed, but built up.* I kept some pullets last winter secluded from the male bird, and Mr. Clift examined the cicatricula of the eggs which they laid in the spring by the microscope, without being able to observe any differ-

* I have already mentioned that he believed that the vital processes were carried on in the same manner in the uniting medium of parts that have been divided or removed.

ence in the organization of the cicatricula of these and other eggs. He says, that there is the same appearance of opake spots in the circumference of the areola at a little distance from its disk, and the same kind of central opacity, which, after the heat of incubation has been applied for some time, become, according to Mr. Hunter's description of them, a zone of bloody points where vessels form, which afterwards communicate with other vessels proceeding from the centre.

There have been some persons, who, from thinking formation impossible, have been led on to suppose that the rudiments of all mankind existed in their first parents. There are many who believe that there is some primary fibre from which all the rest are produced. I would ask them how and where they suppose this fibre to be formed? If they answer in the ovary, they even then admit Mr. Hunter's opinion, that life has the power of forming a fibre. The ovum is formed in the ovarium by a secretion from its vessels. It is impossible to suppose even a fibre to be secreted; we are therefore obliged to suppose such a fibre to be formed, either by the vessels of the ovarium, or by the vital powers inherent in the ovum.

The ovum is formed in a capsule of the ovarium, and is free to move when an aperture is produced, either, by its bursting or ulceration. How far, I would ask, can we suppose the formative actions to have proceeded in so minute a substance as the ovum of viviparous animals? It is so minute as to be with difficulty discernible even by the microscope, nay, even after it has been for some time resident in the uterus, as has been testified both by Harvey and Hunter. Yet this atom, escaping from its cell, and failing to get into its proper receptacle, the womb, being like a seed endowed with vital powers, shoots forth roots, attaches itself to surrounding parts, extracts nourishment from them, and in due season forms a perfect but extrauterine fœtus. Such cases, you know, are not of unfrequent occurrence. It seems, therefore, highly probable that the ovum, being endowed with plastic powers, forms its own parts, and proceeds in such formation to different degrees in different animals and vegetables; yet such actions are not continued beyond a certain point, unless the appropriate stimulus be applied to excite them.

It appears then to be the prerogative of the female organs to produce an ovum, which, when excited by the application of some substance prepared by the male, becomes capable of beginning or continuing those actions which eventually produce a new living being possessing properties and powers similar to those of its parents.

Without this magic application, plants may drop their seeds, and oviparous animals deposit their eggs, which though they do not seem destitute of life, yet never continue its actions, but slowly decay. On the contrary, after they have received this specific excitation, they become surprizingly retentive of life; and though its actions are often suspended by adverse circumstances for a great length of time, nevertheless they afterwards may begin to build up the very curious structures of plants and animals, endowing also each structure with its appropriate degree and function of vitality. Some speculators indeed have imagined that the primordium vitæ originated in the male; an opinion that involves in it much absurdity, which I shall not attempt to expose. It seems refutable by the former argument. The stimulating substance is a secretion; and we cannot suppose that any thing which is organic can be at once secreted;—it must be built up. I beg leave to remind you, Gentlemen, that it is not my intention to dispute about Mr. Hunter's opinions, but merely to display them.

If the male merely prepares a stimulus, it is requisite that it should possess powers of peculiar excitation, and that the ovum should be endowed with a corresponding and appropriate excitability; and it seems further necessary that such appropriate peculiarities should be restricted to the individuals which belong to certain species or genera of vegetables and animals. If such properties were not thus limited, but general, hybrid productions might become common; and as the offspring resembles its parents, great diversities of vegetables and animals would be produced, so as eventually to destroy all the original and striking distinctions of form and character which Nature has instituted. Nature has also made mules in general unprolific, as if she had said, "Thus far may you go, but no farther." I know that some exceptions to this rule are occasionally to be met with, but to these the grammatical adage seems particularly appropriate, "*Exceptio probat Regulam.*"

The offspring may more particularly resemble the male or the female parent, or equally resemble both, as is evident in the common mule. Now, thinking as Mr. Hunter did about the formation of the embryon and its future growth, this resemblance must have appeared to him extremely curious; and he used, in his lectures, to record every instance that came within his own knowledge, with his usual accuracy and fidelity. He recited instances of children who had never seen their parents, resembling them, not only most exactly in form, but also in manners, and in peculiar and whimsical habits. He mentioned also cases where children acquired the same diseases at the same period of life to which the parent had also been subject at the same age. He dwelt upon the resemblance of twins, and (as in his lectures on sympathies) actually wearied his audience by the number of facts he recorded, and the minuteness and accuracy with which he detailed them.

Such instances, however, are not only curious, as demonstrative of the powers and progress of the vital actions, but they also deserve general consideration; for children resemble their parents not only in person but in mind. Nature has made us to love youth, health, and beauty of form; to delight in amiable dispositions, and admire various kinds of intellectual excellence. She has given us propensities which tend to perfectionate the human race; but we, for mere lucre, become wedded to age, disease, and deformity, malignity, folly, and even insanity. "*Quid non mortalia pectora cogis, auri sacra fames!*" But if, like Prometheus, we presume to give life in opposition to the laws of Nature, we shall receive the same punishment, for our children will become the vultures that will prey upon our vitals.

In investigating this part of the works of Nature, the multiplication of the species, we perceive, as in other instances, the same uniformity of design, and diversity of means; the same gradation, and seeming concatenation in their series. Yet this concatenation, though delightful and interesting to our observation, is perplexing to our understanding; for each link of the chain is perfectly independent of the other, nor does any necessity for such series and order, or seeming connection appear. Still, however, it produces on the mind effects similar to those which are derived from viewing a highly finished picture, wherein the shades and variety of light and colour are so softened down and blended together, that it is difficult to say where the one ends or the other begins.

In examining the sexual organs of vegetables, we find the males and females in general included in the same flower, and sometimes so arranged, that the pollen of the males is likely to fall upon the stigmata of the females, both of which circumstances seem calculated to ensure fecundation. Yet, in other instances, we find the male organs in one flower, and the females in another of the same plant. Again, in other instances, the male and female flowers are on different plants, so that the process of fecundation is left to be effected by the sport of winds, or the occupation of the bee, which having collected the pollen, or bee bread, from the male flower, transports it beneath his hairy thighs to the female, which he visits, to suck the honey from its nectary; and thus undesigningly applies part of the pollen to the stigmata. When the male and female parts are included in the same flower, we find each of them varying in number from one to twenty and more. We find in some instances the males proportionately much more numerous than the females, and in others the number of females far exceeding that of the males; and we are unable to assign any adequate reasons for the facts we observe. Yet in examining all the works of Nature we find the same difficulty; we know not why those works are formed as they are. It is a problem that can only be solved after Captain Shandy's method, by saying, "It is the will of Heaven, brother," which, as he replies, is cutting the Gordian knot, without attempting to untie it.

In the seeds of most plants, much more nutritive matter is found than is necessary to supply the young plumula, till it acquires means and powers of deriving sustenance from other sources, and this surplus affords nourishment to animals which feed on such seeds or grain. In the various kinds of fruits, a great quanity of esculent matter is produced, which must be considered as designed for the food of animals. In the accomplishment of this object, we again observe an extreme diversity of means; sometimes the seeds are contained in the centre of the fruit; and sometimes set in the circumference, or surface. Sometimes the little embryon of the young plant, with the esculent substance, is included in a firm case. In those plants, which thrive every where, the seeds are light, and scattered abroad by the air; and some are curiously feathered to prolong their flight, whilst others, adapted to peculiar situations, are heavy. Even animals are made to disseminate vegetables which serve them for food; for, having eaten the seeds, some pass undigested through their bowels, and vegetate where deposited, in ground thus also manured. The seeds of some vegetables probably contain scarcely any thing but the germ of the young plant, and do not therefore vegetate, but under favouring circumstances. Those of the mushroom kind are perhaps as good an instance as can be produced. The multitudinous seeds appear to the naked eye a most subtile and light dust, which when diffused through the air, forms an evanescent cloud.

Nature has made also some animals monoicous, and placed the male and female parts in the same individual; though in general she has allotted them to different individuals, particularly in the higher classes, and given to each its distinguishing sexual character. The male is in general the largest and the strongest; but there are exceptions to this rule, showing that this ordinance is not the result of necessity. As the vital powers of animals speedily decay and shortly cease, the production of successors becomes a most important object.* Nature has therefore given animals of different sexes the strongest propensities, so to communicate

* How exceedingly various is the duration of life in different vegetables and animals! Yet for this variety we can discern no adequate cause.

with one another as to produce the fecundation of the ovum, and she has limited this propensity to individuals of the same species, and ordained a repugnance to gratify such desires with others. She has caused such desires to occur only annually in some animals, and at different periods in others; at times, however, favourable to the production or support of the future young. The sexual organs seem to wither during the sterile interval, and most surprizingly to enlarge during the breeding season, which affords us a means of judging of what are the sexual organs in the lower kinds of animals. This temporary excitement of the vital actions, and correspondent alteration in the appearance of the organs, seem to have interested the mind of Mr. Hunter; and he has put up as a contrast, the organs which prepare the fecundating fluid of the sparrow, as they appear during these different seasons.

There is a circumstance relative to the female of the human race that deserves the consideration of the philosophical physiologist. A monthly discharge takes place from the uterine cavity; it is of a nutritive quality, resembling blood, and from its quantity, languor and weakness is induced whenever it occurs. Why Nature should have doomed the human female to the periodical loss of so much nutriment and proportionate power, is a problem that can only, in my opinion, be solved by supposing that it relieves uterine irritation, and mitigates the extreme of sexual desire; thus enabling her to conform to the laws of morality, and the social compacts that are established between us.

That Mr. Hunter viewed the whole of this subject in the light I have endeavoured to represent it, seems manifest from the arrangement he has adopted; for he has exhibitted all the varieties of the sexual organs, first in vegetables and afterwards in animals. He has also shown the females as they are found before and after impregnation. His mind, however, seems to have been greatly excited by the diversity of means which Nature has contrived to secure the life of the defenceless young, and to supply it with nourishment suited to its tender age, when it is incapable of supporting itself.

In his paper on bees, he appears much interested in observing, that their eggs are deposited in separate cells, before which there is a kind of platform ; that the labouring bees bring regular supplies of bee bread, at stated times for the young maggots; that when these begin to spin and assume their pupa state, the labourers close the mouth of their cells, and cease to bring them food; that they return exactly at the time when the maggot has undergone its metamorphosis and become a perfect bee; that they now unclose his cell and bring him honey, the sweet food which is to be his future support, and which he is afterwards to collect and lay by with such incessant toil during the summer season, to serve as a common store for himself and the community, when the inclement winter has cut off those sources from which it has been obtained; and that, on the very day following his transformation, he is sent off with the swarm to participate in its provident industry.

In his paper on the secretion from the crops of brooding pigeons, he observes, that it is not alone in the class mammalia, that Nature has ordained the parent to supply nourishment to the young from its own body, for that pigeons feed their young with a secretion from their crops, which they bring up and project into the throats of their offspring. This secretion does not take place except at the required time, and it occurs chiefly in the male bird, to which the office of feeding the young is principally allotted. We account for the secretion of milk in the breasts of females, from their sympathetic connection with the other sexual organs, but the fact just mentioned cannot be accounted for in this manner, nor, indeed, upon any law of necessity. Mr. Hunter, whose habit it was to think upon every subject, seems inclined to attribute it to a feeling of fondness; for he observes, that the male bird acts in the same manner when he caresses his mate. Nor is this supposition improbable; for we know that certain feelings evidently affect the different secretory organs of our own bodies.

Mr. Hunter exhibits the nests of birds and field-mice amongst the preparations, which display the anatomical facts relative to the nourishment and defence of the young. This seems on a par with the hyacinth root which I formerly mentioned. Neither show any thing which is not known to the most ignorant, but both evince what were his habitual thoughts, and at the same time display a simplicity of character by no means common.

Dull indeed must that mind be, which could examine the extreme variety and ingenuity of the means employed for the protection and support of the offspring, and their adequateness to the purpose for which they seem intended, without feeling the strongest excitement. The subject in general, however, belongs to the natural historian. The department of the anatomist ends, after having recounted those circumstances which relate to the structure and animal economy of living beings, that are calculated for the purposes just recited. According to this division of the subject, I may mention, that whilst some animals build nests or habitations to cherish their young, others have them formed in their own bodies. Of this I have already mentioned one instance, when speaking of the marsupial quadrupeds which are ovoviviparous. The Pipa or Surinam toad excludes its eggs like other animals of the same kind, yet the young toads become afterwards lodged in separate cells on its back. The pouches of marsupial animals are permanent, and they suckle their young, but there are no cells in the back of the Pipa during its unimpregnated state, nor do these cells appear to secrete any thing; neither have they any communication with the interior of the animal; all which circumstances Mr. Hunter took much pains to examine and display. Why this great toad should differ in this manner from others of the same kind, how the cells are formed, or the young get into them, is not I believe known; yet surely no one who has attentively examined and considered the works of Nature, can doubt of there being good and sufficient reasons for this peculiar deviation from the commonly established structure and economy of such animals.

It is from the consideration of the means by which the continuance of the different species of animals is ensured, that we derive the firmest conviction of the works of Nature being neither the effect of necessity, nor of chance; and therefore it follows that they must be the effect of causes and laws inscrutable by man. The young of some animals are born with very perfect senses and powers, so that they scarcely need maternal care. Yet as young animals cannot have experience, and must be exposed to danger from their deficiency of size and strength, the mother generally nurses them, and directs their conduct, till they are able to procure their own sustenance, and secure or defend themselves.

When the mother must seek her food, and be absent from her nursery, the young are born with scarcely any vision ; whilst others have such perfect senses and powers as to be able to accompany their mother in search of food. The most helpless and imperfect offspring is that of the human race ; but the long nursing which is required, creates and strengthens reciprocal attachment between it and its parents, which continues throughout life ; so that according to the laws of Nature, children are disposed to return such kind attentions when age shall have reduced their parents to feebleness and second childhood. How opposite to all this is the mode by which the cuckoo species is continued ? The parent has no solicitude about its young; yet Nature has taught it to ensure the continuance of the species by depositing its egg in other birds' nests. How curious is it that the just hatched cuckoo should have peculiar appendages to its wings, with which it can confine the legitimate offspring against the sides of the nest, and that it should possess instincts which cause it to protrude them one by one out of its cavity ?* How curious also is the mode by which the continuance of the species of the œstrum equi is effected? Surely it is wonderful that this fly, as if endowed with intelligence, or instructed by experience, should never deposit its eggs, but in those parts of the horse to which that animal can apply its mouth, so that they may be swallowed. By this means the larvæ are provided with a warm lodging and plenty of food during the winter season, and are not expelled till spring, in order to undergo their metamorphosis into perfect flies. I must not proceed further in this endless subject, the full investigation of which has convinced the most intelligent of mankind, that the order of Nature is the result neither of necessity nor chance.

Every part seems perfect in its design, and calculated for the good of the indi-

* Cuckoos however have been known to hatch their own eggs.

viduals which compose it; yet these individuals are often supported at the expence or by the destruction of others. The less powerful animals herd together, and set watches to warn them of approaching danger; as they are exposed to invasion, and the destruction of their companions by the solitary and fierce tyrants of the forest that issue from their secret dens. Nature has however made the animals that are liable to destruction exceedingly prolific, so that their race cannot well be exterminated; whilst she has made destructive animals in general unproductive; and when it happens otherwise, we find means which counteract their excessive multiplication. Why Nature has formed carnivorous animals, or produced such a variety of living beings, is a problem difficult to explain. Yet, this being a part of her plan, we cannot but admire the means by which it is accomplished; for every thing contributes to promote the welfare of the individuals in their proper sphere, and to ensure the continuance of their kind according to its destined proportion, so that centuries elapse without the extinction of a single species. All animals seem also to be put under the dominion of man; and as his species multiplies, it fosters and feeds the useful and innocent, and destroys those of a contrary character.

From observing the art with which predaceous animals entrap their prey, and the fury with which they destroy it, some are inclined to represent the scheme of Nature as one of fraud and rapine. Yet, surely, it is better that animals should suddenly perish for the good of others, than that they should be doomed to linger, and ultimately to starve, from that want which excess of multiplication must necessarily produce. Be it also remembered, that many of these creatures have little sensation, that all are far less sensitive than man, and that they neither anticipate the future, nor reflect on the past; so that their sufferings are transient, and necessary to general good. There are some who are inclined to represent the sufferings of animals as calamitous; but surely they have not considered that pain is Nature's monitor, and contributory to the welfare of the sufferer, by teaching it to avoid what is injurious. Neither do they seem to have reflected that it is the necessary reverse of pleasure; and that without enduring the occasional penalty of the one, we should not enjoy the more continued comfort and delight of the other.

It seems strange, that some minds appear to delight in blaming what they do not understand, and feel a repugnance to believe, that any thing may originate in causes which they cannot comprehend; and, therefore, probably they are induced to suppose a kind of necessity. All nature is full, says one reputed philosopher. Whatever can be, is; says another. But it would be far more easy to show cause why we should believe that there is a plenum of matter, than of contrivance.

On the contrary, however, the most intelligent men who have studied the works of nature to the greatest extent, and with the greatest attention, have been convinced, that they are the results neither of necessity nor of chance; and, consequently, that intelligence must have operated in ordaining the scheme and order of the universe. The common sense of the bulk of mankind, who judge from general observation, leads them to entertain the same opinion. Both agree, that in examining the works of Nature, whatever they understand seems most admirable; and when they cease to admire, conclude that they do not understand; for "'tis but a part they see, and not the whole." They also clearly perceive that partial evil tends to general good.

You, Gentlemen, must examine this highly interesting subject for yourselves; for when I consider what might be said and shown with relation to it, I feel ashamed of the inadequateness of the representation I have given; which, nevertheless, I hope may be useful, by exciting you to enquiry. You must either form your own opinions, or confide in those of others. To form correct opinions it is necessary that all the facts belonging to any subject, should be attentively examined and considered, without prejudice or partiality; and this is no light labour. It is a task more suited to an ancient Grecian philosopher, than to one of the present school; for the latter is busied in collecting new facts, in adding to the stock of knowledge, and is consequently apt to take partial views of subjects, and not sufficiently to contemplate the general system of nature.

I have now led you round the gallery of the Museum, and have briefly informed you what probably were the designs of Mr. Hunter, in the preparation and arrangement of the subjects there exhibited. Having restricted myself to the consideration of those facts only, which form the basis of his opinions relative to the principal vital processes; I have been prevented from noticing many important circumstances, belonging to other subjects, in anatomy and physiology. The gallery of the Museum, is, however, but a small portion of it, and throughout the whole, we observe Mr. Hunter's solicitude to procure evidences of every important fact relative to the subjects in which he was so greatly interested; and also the same genius and reflection displayed, in endeavouring to interpret the works of Nature, and to arrange and concatenate the facts, according to their series and order, so that each should be distinctly seen, both by itself and in relation to others.

Now, though what I have said is so incommensurate to the merits of the man I have endeavoured to eulogize, or with the claims of the subject I have attempted to discuss, yet I flatter myself that I have attained the objects I had in view in writing these Lectures. I wished to show in what manner Mr. Hunter had examined the various vital processes, and also the general extent of his researches in Comparative Anatomy, and consequently from what an extensive and well arranged series of facts, his notions of life had been deduced. Yet it is almost necessary to pursue the same course of reflections, that he himself has done, to be fully aware of the intensity of thought with which he has considered many parts of the subject. In thus asserting the claims of Mr. Hunter, I hope that I shall not be considered as blind to the merits of others, or reluctant to acknowledge the valuable information which we have received from other anatomists since his time. I wished also to corroborate, by additional arguments, the opinions I merely alluded to in my former lectures, and which I consider to be those of the most intellectual of the Greek philosophers, that perceptivity, and the various properties of mind, are not attributes of mere life, but probably of a distinct substance.

Mr. Hunter's Theory of Life has however been said to be absurd and untenable, and even has been held up to ridicule by those attached to the physiological opinions that have chiefly issued from some of the writers of the French school. What those, who are advocates for such opinions think, it is difficult to determine, because they do not explicitly declare their sentiments. There is a mysticism in their expressions and manner, calculated to delude the ignorant, and perplex those who have not fully considered the subjects under discussion. Therefore, it seemed right to place distinctly before you, in the first lectures of this year, the only opinions which the mind of man is capable of entertaining, relative to the causes of motion in matter. In exploring the cause of the contrary states of motion and rest, the mind's eye alternately dimmed and dazzled, becomes weary and confused, and ceasing from the fruitless search, fixes itself upon a partial view of the subject, which it thinks it has obtained. We feel a strong conviction, that a more subtile and mobile substance, or a more attenuated species of matter pervades, acts upon, and is the cause of motion in that which is more gross and inert.

Who can observe the seemingly vital effects which the warmth of the sun produces, even in common matter, or the terrific and destructive consequences of intense heat, without thinking that heat must be essentially active, or that it excites actions in something that is so.

Who also can observe the quick and powerful motions of animals, without believing that something active is incorporated with them? The consideration of the vital phænomena call upon us to admit, that there is some power of controlling, exciting, and modifying those chemical changes, to which the atoms composing them have, under certain circumstances, a propensity, as well as of arranging the materials in diversified structures. Philosophy must always be founded in Nature, and its rules be adapted to the subjects to which they belong. It is natural to man to observe, to enquire, to reason, to believe in various degrees up to perfect conviction; and we may perform any of these acts, according to the precepts of philosophy. Scepticism has no right to boast of an exclusive claim to be accounted philosophical. Confidence may also be as philosophical as doubt. It is absurd to expect mathematical demonstration in subjects which do not admit of it, and the absurdities of determined doubters have been exposed by writers both of a serious and satirical cast.

Now, though the changes occurring in common matter are extremely diversified, and highly contributory to all the wants of living creatures, they are still so uniform as to afford a plea for maintaining, that they may be the effect of inherent propensities in the atoms of which this matter is composed. But to suppose that all the varieties of vital action and other facts belonging to the structure and economy of living beings, which we have been lately considering, are the results of inherent propensities in the atoms of matter, unassigned and unsupported by intelligence, seems to me too absurd to require any attempt at serious or formal refutation. I have therefore, never, except in one instance, paused to make those reflections which the subject so constantly and naturally excite, and now, in conclusion, I will only observe, that upon the supposition just mentioned, we must be led to expect the phænomena to be more uniform or more diversified; nor could we imagine it possible, that there should be that regularity in their series, and that adaptation of means to ends, which we so constantly observe.

It has been said that "an undevout astronomer is mad;" yet he only contemplates the immensity and order of the works of Nature, and the causes of the varieties of light and seasons, so serviceable to the living beings which inhabit this planet, and, as he infers, to those of others. But what shall we say of the anatomist who observes the structure and functions of those beings, who examines their extreme variety, and regular gradation and connection, without any feeling or perception that Intelligence has operated in ordaining the laws of nature? We judge of others by ourselves, and assuredly such a character must, by the bulk of mankind, be considered as possessing either a deficient or perverse intellect.

The opinion that Intelligence must have ordained the order of Nature, is not only impressed by her decrees upon the bulk of mankind, but is confirmed by the observations and reflections of the most observant and intellectual individuals of the human race. Those who think that intelligence may exist distinct from organization, are disposed to admit that the intelligence with which they are endowed, may have a separate existence. Those who think that perception is not essential to life, but is an attribute of something different, are also disposed to admit the separate existence of perception and intelligence; and thus do these two opinions produce and support each other. Both opinions are natural to most men, and confirmed by the observations and consideration of the most intellectual of the human race.

Gentlemen, I was presumptuous enough in the first lecture to imagine myself that honourable character, — a British advocate. I also imagined that you were impannelled as a jury, a tribunal in which we glory, and by whose decision we must abide. Now, however inadequate I may be to perform the part I have arrogated to myself, you are fully competent to discharge the duties of the tribunal I have supposed you to form. You have the ability to decide, and the power to punish. You can inflict the severest of all punishments, that of which the greatest despots stand in awe, those who may be said to be "safe from the bar, the pulpit, and the throne," yet tremble at the strong and open expression of general disapprobation. The medical republic should legislate for itself, for the public in general know little of our peculiar studies, and may consequently estimate our opinions with respect to certain subjects at a much higher value than really belongs to them. We should not therefore suffer crude speculations to go forth, bearing the seeming stamp of medical authority, when they are contrary to the sentiments of the bulk of the profession, derogatory to its character, and injurious to society.

In arguing the subject relative to the opinions which we are warranted to form respecting the nature of life, I disclaim having any allusion, in what I have said, to those of particular persons; and I have, as much as possible, endeavoured to conceal all perception of individuals, by massing them together in a crowd. I contend with no man about his opinions; for charity instructs me to believe that each forms the most correct opinions he is capable of doing. I contend only against the promulgation of those that have a pernicious tendency. In the assumed character of a British advocate, I must be an advocate for liberty; but then, it is for British liberty, for rational liberty, for liberty without licentiousness, for the liberty that our laws allow, which confirm to every individual his natural rights, giving him licence to think and act as he pleases, or deems proper, so long as his actions do not tend to the detriment of other individuals, or to that of society in general. Let me not either derogate from my assumed character by neglecting to remind you, Gentlemen, that the consideration of the *quo animo* is the vital principal of the British law. There may be inconsiderate persons who commit error without adverting to its diffusively baneful consequences; who, thoughtless of the course and contingencies of human life, may undesigningly broach opinions tending to weaken and destroy others which form the spring of every generous and noble action, and our only support under oppression and affliction. There may be those who do not perceive how our notions respecting life can influence our conduct. But this indeed surprizes me, because Voltaire was so well acquainted with the evil tendency of his own doctrines, that he checked the conversation of his companions, whilst the servants remained in the room, lest, observed he, we should have our throats cut.

That ignorance may not, however, be hereafter pleaded in mitigation of your verdict, I deem it my duty, with the utmost brevity, to represent the effects of different opinions upon human actions. For this purpose, I first select the case of a powerful monarch, called by historians Sardanapalus; who chose, for reasons perhaps best known to himself, to write his own epitaph, as follows. "Eat, drink, and be merry; for the rest is nothing;" an epitaph, says Aristotle, fit for a hog. It cannot be doubted, that Sardanapalus was one of those who considered the grave to be a "place of eternal rest." To show the effects of the contrary sentiments, I would ask, is it credible that Socrates, after drinking the poison, would have calmly discoursed on philosophical subjects with his friends; or that Brutus would have stabbed the Roman he most loved, rather than suffer his country to be enslaved, had they not formed a proper estimate of human life, and considered themselves but as performing a part, in the presence of immortal and

and intelligent observers? Or why does the untutored Indian deride the cruel torments of his enemies, but that he also believes he is going to the land where his father is gone, and would feel shame to be recognized a degenerate son?

Being desirous to avoid all personality, and to contend only against opinions, it seemed necessary to denounce those that I meant to oppose, at the very outset, and in the first lecture; for if we try to hit a mark, and others are to judge of our success or failure, it is necessary to place the object distinctly in the view of the observers. Yet even in ascribing opinions and conduct to a party, under the denomination of modern sceptics, I may give offence; for some may suppose themselves comprehended in it, though they do not actually belong to it; whilst others may even think it unwarrantable to suppose that there can be any such party at I have described. Hesitation in decision is natural to many characters, and caution, to a certain extent, is an indispensable ingredient in all those who have any pretensions to be accounted philosophers. But the party I allude to are not real sceptics, and their professions and conduct form a curious example of a *vis inertiæ*; for after resolving not to think on certain subjects, they argumentatively endeavour to prevent others from thinking; whilst on the one side they reject a very few propositions, merely because they are deficient in a kind of proof that the subject does not allow of, and that cannot be rationally required; on the other, they admit a host of absurdities, apparently without examination. Therefore, upon the very grounds of their own doubt, they marshall and exercise pernicious and discordant opinions, drawn from every possible and remote source, with which they assail the opinions of others, that at least may be said to be innocent and useful, but which also confer a dignity on human nature, and excite us to generous and honourable actions. I feel it to be my duty, Gentlemen, to prevent, if possible, the banners of physiology from being purloined and carried into such a service; and yours not to suffer those of our profession in general, to appear in so disgraceful and mischievous a contest.

There are " Smellfunguses" and " Mundunguses" * in science. I pity the man who can survey all the wonders of the vegetable and animal kingdoms, who can journey through so delightful a district, and afterwards exclaim, " all is barren." Still more do I pity those, though the sentiment is mixed with strong disapprobation of their conduct, who, after having seen much to admire, shall, when they meet with a circumstance they do not understand, presumptuously dare to arraign the wisdom and benevolence of Nature. In the progress of science, many things which at one time appeared absurd and productive of evil, have afterwards, upon an accession of knowledge, been found to be most wise and beneficent. I deem no apology requisite, Gentlemen, for endeavouring to impress on your minds certain axioms relating to philosophy in general, when they are directly deducible from the subjects of our peculiar studies. I have constantly and carefully avoided every argument foreign to the subject, so

* Characters thus denominated, and pourtrayed by Sterne in his Sentimental Journey.

that, if occasionally I may have appeared to sermonize, I have quoted both the chapter and verse of my text from the Book of Nature. I address you, Gentlemen, as students of that great book, and earnestly exhort you to study it with such sentiments as I have endeavoured to inculcate. The conviction that every thing tends to some immediate or eventual good, is the greatest incentive to its study. It was this conviction that excited Hunter to such continual enquiry, or involved him occasionally in the depths and perplexities of intense thought; for he was never satisfied without being able to assign an adequate reason for whatever he observed in the structure and economy of animals. This conviction makes the study of Nature highly interesting, and may indeed be said to render labour delightful, or to medicate the pains attendant on its toil. To those who entertain such sentiments as I have endeavoured to inculcate, every thing seems animated, beneficent, and useful; they have the happy talent of discovering even

> "Tongues in the trees, books in the running brooks,
> Sermons in stones, and good in every thing."

APPENDIX.

Extract from the European Magazine for 1782, *containing a Syllabus of a Course of Lectures on the Principles of Surgery, delivered by Mr. John Hunter, F.R.S., St. James's, London; with Anecdotes of his Life.*

This very celebrated Course consists of near an hundred Lectures. — It begins in the month of October, and continues till April, and is given every other evening, from seven to eight o'clock, the honorarium being four guineas.

Mr. Hunter's Lectures do not contain a Course of Practical Surgery, with the Operations necessary for different cases—but his purpose is to give a comprehensive view of the system, and investigate the principles upon which the practice of surgery is founded, viz.— To show the actions of the body and its parts when in the diseased state, with the actions and effects of nature to recovery—and the necessary and proper assistance to be given by the Surgeon. The principles of diseases are the first parts of surgery to be learned. They are to the Surgeon what the first principles of the mathematics are to the practical geometrician, without the knowledge of which a man can neither be a philosopher nor a Surgeon. In our research after diseases, says Mr. Hunter, we ought not only to understand the case, which becomes the immediate object of Surgery, such as inflammation, suppuration, mortification, &c. but also the cause of the effect; for without this knowledge our practice must be very confined, very precarious, and often applied too late. This knowledge opens to the Surgeon varieties of treatment. It teaches him in one instance to remove the cause—in another to increase the effect—in another to change it to some other disease—and gives him, what is the most essential point, the knowledge of the proper moment for the surgical operation, where an operation is necessary. In the animal body the power of restoration to a state of health arises out of the Animal from its own mechanism and action. If the Animal was in all cases equal to the task, there would be no occasion for the Surgeon; but it is necessary in many cases to assist nature by the introduction of artificial powers—to increase the living powers of the Animal when they are inadequate—to retard them when violent—or to change them when wrong. Both the chemical and mechanical powers are made use of in Surgery.—Chemistry is introduced to destroy what cannot be altered—and mechanics frequently restore what had been accidentally or artificially destroyed. It is not only necessary for a Surgeon that he should know the different parts of an animal, but he should know their uses in the machine, and in what manner they act to produce their effect. He ought not only to know the whole of any one simple action, or the knowledge of all the actions singly—but he should ascertain their correspondence—mark their relations, and acquire a competent idea of the compound actions and general fabric of the machine. Operations should never be introduced but in cases of absolute necessity. A Surgeon should never approach a victim for an operation but with humiliation—it is a reflection upon the healing art. He is then like the Savage in arms, who performs by violence what a civilized nation would accomplish by stratagem.

Mr. Hunter having observed, that the greatest part of the books published in Surgery, contain little else than relations of cases, and modes of treatment, and that the practitioners have been too easily satisfied with a collection of facts, without embracing the catalogue of diseases as a system, proposes in his course to examine the theory and principles of diseases in a regular series. His doctrines are drawn from personal observations made in the course of an indefatigable life, with the constancy of a most adventurous mind. His ideas, his mode of reasoning, as well as his arrangement of diseases are new; and he therefore has received little aid from books or from other professors. The novelty of his ideas occasion also the application of new terms; and those which he has given, he may consider as clear and explanatory, since they are adopted by others, and brought into use.

The Course begins with the Physiology, or natural History of the Animal; but so far only as is necessary to the understanding the principles of diseases; in which new ideas and new arrangements of the subject are introduced.

The Physiology of Diseases follows—the action of medicines—and brings him to the consideration of diseases in general.

The Diseases of accident being the most obvious and simple, in preventing the natural operations of the Animal, begin the Surgical part of the Lectures, in which he explains the most simple modes of restoration.

Then follow the diseases whose mode of action is similar to those arising from accident.

As the treatment of diseases arising from accident is various, those which are the most simple come first in view. This leads him therefore to explain,

The first mode of union of separated parts, called "Union by the first intention," and

Inflammation.

On both these subjects he is very full, especially the latter, as it is one of the first principles in most diseases, and produces a variety of effects.

Inflammation leads him to the second mode of the Union of Parts; as happens in wounds where the first mode has failed, or has been neglected. This also leads him to

The Union of Parts originally in contact only as the natural cavities, but united for very wise purposes, and which are called Adhesions.

The cure of many diseased parts, as fistulas, indurated tumors, &c.

The diseases of bones.

The knowledge and cure of gun-shot wounds.

Inflammation also makes a principal part in all specific diseases, as the Small-pox, Lues Venerea, Cancer, &c.—and therefore he takes great pains to investigate its principles.

Then follows Suppuration, and those actions are illustrated by the consideration of

Compound Fractures, Hydrocele, Suppuration of the veins after bleeding; gun-shot wounds, &c.

And, in the second place, by the various diseases arising from spontaneous suppuration, as abscesses, diseases of the bones, diseases of joints, &c.—This leads him to the consideration of

Granulations, their course, progress, kinds and use; and also of

Cicatrization.

After Inflammation and its general consequences, he proceeds to treat of specific diseases, such as

The Lock Jaw.

Scrophula.

Poisons in general.

Peculiar Poisons, as the Lues Venerea, Cancer, &c. &c.

This Course of Lectures is illustrated by a collection of diseases, and of Comparative Anatomy, which, in point of curiosity, accuracy, and comprehension, is equal to any collection in the world. It has been made by Mr. Hunter himself, and what chiefly contributes to its extraordinary value and advantage is, that he knows the particular history of the greater part of the diseases, which he has preserved — the patients were under his observation in the Hospitals — he has minuted the progress, and accounted for the various appearances and effects of each disease, with a fidelity that now renders his collection a most instructive school for the Student.

Anecdotes of Mr. John Hunter.

We have introduced the Syllabus of the Course of Mr. Hunter's Lectures on Surgery in this place by choice, as he is the brother of the celebrated anatomist, Dr. Hunter, whose Lectures made the subject of our first number. When so eminent an example occurs of congenial talents and contemporary distinction in two brothers, it would be an outrage to separate them. We might have been permitted to deviate from regular order for the sake of so extraordinary and so splendid a circumstance; but when no method nor link is broken, it would have been unpardonable to have overlooked the opportunity of gratifying the honourable pride of man in the exhibition. Dr. Hunter having settled in London, sent for his brother John, who accordingly came to England, being at that time in his eighteenth year. He immediately applied himself to the study of anatomy and surgery; and, for several years, he was employed in the dissecting-room, where he suddenly began to display his uncommon abilities. The doctor was anxious that he should go into partnership with him, and in the year 1758, declared him to be fully adequate to the important office of a Teacher; but Mr. Hunter, with a modesty which is always the attendant of genius, felt insuperable embarrassments and objections to speaking in public, and he declined the advantageous and honorable offer, on account of his aversion to public speaking, and his extreme diffidence of his own abilities and skill. But he continued in the same anatomical pursuits till the year 1760; when, anxious for a more enlarged field of observation, he went out as Surgeon General to the Army, first to Belleisle, and afterwards to Portugal. In this extensive scene, he indefatigably studied the nature and treatment of gun-shot wounds; and he acquired great credit from his humanity and talents. He has constantly, in his practice, been an enemy to operations — he has resorted to them unwillingly, in the last resource, although no practitioner has been more distinguished for a steady and skilful hand in an operation than himself, where necessity drew him to the expedient. — On the peace in 1763, he returned and settled in London as a surgeon, and came, in a very short time, to the possession of an extensive practice. Now it was that he began to form his system. In books he found, as we have mentioned, no other lights in the investigation of surgery, than what arose from the enumeration of independent facts and cases, without reasoning and without principles. He totally rejected books, and took up the volume of the animal body. — He was as indefatigable in his pursuits, as he was adventurous in his conduct. Though an enemy to operations on others, he was regardless of himself, and exposed his person to all the active and artificial powers, by which he might ascertain the properties, and trace the effects of medicine on the human frame. He was not deterred by the shocks which such trials must necessarily give to his constitution; nor by the fatigue, labour, and loss to which they exposed him. He began at the same time to form his collection of diseases; and for this purpose he attended the various hospitals, in order to see the curious cases, and to observe, with his own eyes, the progress of the various diseases, which he might procure into his custody. He from this time also employed himself in forming his collection of comparative anatomy. The whole together has cost him more than 10,000*l.* besides the labour it has required in the preparations. Of this sum more than two thousand pounds have been expended in the purchase of dead animals only. In the year 1768, he was chosen Surgeon to St. George's Hospital; and in the years 1772, 1773, and 1774, having collected his ideas and observations, he assembled the pupils of that Hospital, together with a few chosen friends, and read to them, without expence, a course of lectures on the principles of surgery. In the year 1776, he was appointed Surgeon Extraordinary to His Majesty. Prior to his going abroad, he had been present at the dissection of more than two thousand human bodies, and in the year 1754 or 55, discovered the structure of the placenta, and the communication between the mother and placenta. He had also employed himself a good deal, even at this time, in comparative anatomy, and had discovered the absorbing system in fowls, and in the crocodile, which is one of the amphibii, proving by experiments that the red veins did not absorb. This was published by Dr. Hunter, in his Commentaries, in 1762. Since his return, as we have already mentioned, he has been particularly earnest in his attention to comparative anatomy. He has a house and gardens in the country, on purpose for his experiments on living animals and vegetables. For the last five years he has employed in his house an ingenious draughtsman, who is engaged, at a regular salary, for ten years; and also another person, engaged for the same time, to manage and keep his preparations in order. He means to class the animal world according to their structure, in which he has made considerable advances. His objection to standing forth as a public teacher still continued — and it was only overcome by the intercessions of his friends, and by his own consciousness that he might be useful to students, in explaining the principles and analogies which he had observed in diseases, and reducing thereby the art to a more regular and less precarious system. Dr. Hunter's library is, perhaps, the finest in Europe in choice, scarce, and valuable copies, and it cost 16,000*l.* Mr. Hunter's is comprehended in a few cases, and were it not, he says himself, for the presents made him by contemporary authors, would hardly have consisted of a hundred volumes. His opinions, therefore, are all his own, drawn from personal observation;—he does not say that every doctrine is new—some of his opinions may have been given before—but they are new to him. He acts in his character of a public lecturer, with the disinterestedness that has marked his conduct through life; for though the honorarium is only four guineas, the course continues six months; whereas there are courses of lectures, comprehending both anatomy and surgery, which are gone through in the short space of six weeks. We by no means think ourselves qualified to pronounce on the merits of living teachers. It is our business to state the simple facts, and to be cautious that, in our collection of the materials, we are neither imposed on ourselves, nor impose on our readers.

THE END.

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