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OF

GENERAL ANATOMY:

TRANSLATED FROM THE LAST EDITION OF THE FRENCH OF

P. A. BÉCLARD,

PROFESSOR OF ANATOMY TO THE FACULTY OF MEDICINE IN PARIS.

WITH NOTES AND CORRECTIONS,

BY

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ADVERTISEMENT.

THE want of an Elementary work of the kind here presented to the Public must have been greatly felt by all Teachers of Anatomy in this country. It treats of matters most interesting to the Student of Surgery and Medicine, and furnishes him with a description of knowledge, and a body of facts which cannot be dispensed with in the present state of Medical Science. To meet the wants of my own class, I some years ago perceived the necessity, either of compiling a similar work to that of M. Béclard, or of delivering a course of Lectures on General or Physiological Anatomy; time and leisure have however been altogether wanting for so laborious a task as the first; the extension of my Winter course of Lectures on the Descriptive Anatomy of the Human Body, so as to embrace, in addition, a course of General Anatomy, I quickly perceived to be impracticable. The alternative which remained, was, to select for the use of my pupils, what I deemed to be the best of the numerous very excellent manuals of General Anatomy which, since the times of Haller, (whose work, entitled Elementa Physiologiæ, is a work on General Anatomy;) to the present day, have been added to the Continental Medical Literature. Without prejudice, and without a biass towards any particular doctrine or school, I could not hesitate in fixing on that of M. Béclard, which seemed to me to contain all that the Student could possibly desire, as an elementary work. The introduction, which treats of matters with which M. Béclard was not familiar, and of which, indeed, he was almost entirely ignorant, might, with great propriety, have been omitted; but I felt that so great liberty could not be taken with the first edition of the work.

R. K.

Edinburgh, Newington Place,
Dec. 15, 1829.

AUTHOR'S PREFACE.

The work which I now publish is a summary of the course of anatomy delivered by me during these last ten years; it is intended solely for students. My aim in publishing it, has been to present them, in a small volume, with a condensed view of the many researches made into human organization for a period of more than twenty ages.

I divide the anatomy of man into general anatomy, the special anatomy of organs, and the anatomy of regions. The present volume contains only the General Anatomy, and may be considered either as a separate work, or as the first part of a general treatise.

I have availed myself of the work of the celebrated Bichat, and of others published since his time on the same subject; and the various monographs treating of each system of organs have been carefully consulted. Moreover, the titles of the works which have served for the compilation of this have been carefully cited, not so much for the sake of a vain display of erudition, as to enable others to dispense with the reading of works which I was necessarily forced to read, and at the same time to point out to those who might be anxious to prosecute inquiry more deeply, a kind of select anatomical library.

There has been given at the head of every chapter an abridged history of the principal discoveries made concerning the system of organs under consideration. M. Lauth's History of Anatomy, of which as yet there is only one volume published, has aided me in giving several of these historical notices.

The first section of the introduction treats of the organization in general, the second of the human body. In the former, my object was to give the reader a general idea of Comparative Anatomy and Comparative Physiology. Not that it had been my intention, thereby, to exempt students from the study of the anatomy of the lower animals, but, rather to demonstrate the utility of such. In the composition of this part of the introduction, I have availed myself of the labours of M.M. Dumeril, Blainville, Geoffroy Saint-Hilaire, Lamark, and especially M. Cuvier, who might be quoted in every page. In the latter section, I have given general observations on the human body; spoken of its humours in general, a branch of the science of organization by far too much neglected since the labours of Haller and his school, who erroneously expected to find, in the nervous system, and in the phenomena of irritability and of sensibility, the whole secret of vitality.

Since anatomy is not to the physician a matter of barren curiosity, and mere speculation, but the foundation of all his knowledge in reference to medicine, I have thought that physiology and pathology ought not absolutely to be disjoined from it. I am fully persuaded, that pathological and common anatomy should be combined; therefore, the description of each tissue is completed by a sketch of the varieties and changes observed in it, and the whole work, by a chapter on the accidental productions common to several organs, or to all.

P. A. BÉCLARD.

Paris, 30 *August* 1823.

ACCOUNT

OF THE

LIFE AND WRITINGS

OF

BECLARD,

BY C. P. OLIVIER OF ANGERS.

To write the life of a celebrated man, is at the same time to honour his memory, and to render service to society; for in bringing to remembrance the triumphs of him whose every step was important and striking, those who would imitate him are taught by what paths they may arrive at renown, and the value in life of a justly acquired reputation is practically illustrated. It is with this two-fold object that we here attempt to expose the laborious life of an anatomist, whose loss will long be deplored by the Paris school of medicine, of which he was one of the brightest ornaments.

Pierre Augustin Béclard was born at Angers, on the 12th October 1785, of parents in whom probity was hereditary, and who had no other fortune than their good reputation. Although burdened with a numerous family, his father, by dint of industry and economy, contrived to give to each of his children the rudimentary education which they required, in order to qualify them for continuing the trade by which they lived. Thus, when the young Béclard had learned reading, writing, and arithmetic, he was taught to consider these accomplishments as the sum of his acquirements. But, whether he had a presentiment of his future success, or was inspired by an instinct, or an irresistible propensity, Béclard paid no regard to this intimation, but eagerly read all the books that fell in his way.

The Central Schools, which had been established in the departments as so many foci of knowledge, destined to enlighten a regenerated nation, were then in full activity. Béclard enrolled himself among the pupils of those which had been formed at Angers, and quickly brought himself into notice by the progress which he made, and the rapid success which he obtained. It was there that he for the first time acquired a conception of the resources of study, was inspired with the love of science, and learned to devote himself to its cultivation. Yet, notwithstanding the illusions on which his ardent mind already fed, his parents were grieved to see that such dispositions had sprung up in him, and to keep him in the station in which he was born, had him successively appointed book-keeper to a merchant, writer in a lottery office, and clerk to the director of diligences. Béclard acquitted himself ill in these occupations, for which he had as much repugnance as unfitness. He was accordingly judged unfit by his patrons for the occupation of commerce or clerkship. The disgusts which he experienced in a situation so ill adapted to his natural propensities henceforth infused in the character of Béclard, a tinge of melancholy, which subsequently turned in some measure to his advantage, by disposing his mind at an early period to the meditation which the profound cultivation of the sciences requires.

There is a period of life when a man, as yet undecided respecting the state which he is to embrace, studies as it were the part which he is to play in the world, and prepares himself before hand for properly discharging his future duties. This period of Béclard's life was marked by an indolence which afflicted his family : he was, as it was said, fit for nothing, and neglected to procure for himself a prosperous futurity. The reason was, his secret intentions had not yet been interpreted, nor had the stimulus been applied to his emulation which it required; but from the moment that his father, yielding to the influence of good advice, and overcome by the solicitations of his son, who only wished to become a medical practitioner, permitted him to attend the lectures delivered in the secondary school of medicine established at the hospital of the city, and when the young student thus saw opening before him a career on which he ardently longed to enter, the torpor which had too long paralyzed his faculties ceased.

It was in 1804 that he commenced the study of medicine; and, by a circumstance which presented itself to give Béclard a consciousness of his powers, the situation of *eleve interne* at the hospital was for the first time laid open to competition. A pupil, who has since been lost in the crowd, had then a reputation which I may call brilliant, for each age has its celebrity, and was considered as a formidable competitor. He was even already appointed to the vacant place by all the suffrages. However, Béclard so surprised his judges by the extent of his knowledge and the precision of his language, that he was proclaimed victor. This was the first ray of his glory.

During his residence at the hospital of Angers, he devoted almost the whole of his time to the study of anatomy, which formed the object of his predilection. He exercised himself with the observation of the diseases which succeeded each other and varied indefinitely in an asylum open to all human miseries. He accustomed himself to perform the minor operations with address. He learned under experienced masters, among whom Mirault, whose name is recorded in the annals of the art, distinguished himself, to interpret with sagacity and without prejudice the facts with which our science abounds, and from which one is often liable to draw inferences calculated to flatter his favourite opinions. In this school, more useful than celebrated, he at length acquired the rudiments of accurate knowledge, and of that eclectic and severe spirit which at a late period rendered him so worthy of admiration.

Béclard might prove by his example and success, much better than could be done by long reasoning, the utility of secondary schools of medicine, in which the small number of the pupils commonly allows them to see the facts better, and consequently to acquire at an early period an experience which, in the great schools, the crowded multitude of students always acquires only with difficulty. Accordingly he was seen to leave the humble theatre of his first labours, already rich in knowledge, which, if not of great extent, was yet of the most certain kind.

During the first years of his medical studies, he devoted himself to the study of the Latin language and philosophy, which were taught him by the chaplain of the hospital, who took pleasure in sowing in so fertile a soil instructions which could not fail to spring up there with rapidity. Our young student at the same time cultivated botany. He obtained several prizes in natural history, and by his zeal, his ardour, and his success, gave promise of a brilliant career. Béclard's residence at the Hospital of Angers has left remembrances which his successors will transmit from age to age, and which will always be to them the incentives to a noble emulation.

At this period, Bichat was in the middle of his too brief career, and filled the scientific world with his glory and his name. In the conversations which the young Béclard had with his family, he frequently allowed expressions to escape him which showed how happy he should be could he one day rival the founder of general anatomy. Bichat was in a manner his idol. He longed to render homage to his genius, and to attach himself to his triumphal car. Unfortunately for him, death removed

Bichat before our young student could hear his lectures, for it was not until 1808 that he removed to Paris; but he had already collected with avidity notes taken at the last course of that celebrated anatomist.

In 1808, Béclard was received as a pupil of the first rank in the Ecole Pratique and hospitals of Paris. In 1809, he obtained at the school of medicine prizes in anatomy, physiology, medical natural history, chemistry, and physics. Nor was it long before he was admited as an *eleve interne* to the hospitals. In 1810, he again carried off prizes in anatomy, physiology, medicine and surgery, and M. Roux entrusted him with the honourable charge of preparing and repeating his lectures, at the Hospital de la Charite.

Hitherto Béclard was known only to his rivals and friends, and all his merit only shone in his vast memory and the facility of his expression. His genius had not yet assumed a determinate character, nor had any original investigation unveiled to him his resources; but presently an opportunity of signalizing himself presented itself. The situation of principal conductor of the school of practical anatomy of Paris was rendered vacant by the appointment of M. Dupuytren to the chair of operative surgery. Béclard, who was named *prosecteur* in 1811, became a candidate for the office and was successful. He had already gained the esteem of numerous pupils who had attended his private courses. His reputation as an anatomist had scarcely begun; but the moment the new chief dissector found himself surrounded by so many means of instruction, he hastened to profit by them. He had besides, in his inauguratory thesis, pointed out in the most luminous manner what course a person entrusted with this office ought to follow in the discharge of his important functions. There was, therefore, a right to expect that, faithful to the principles which he had traced, he should not be wanting in reducing them to practice.

It is well known that he did not belie the hopes to which his zeal and precocious talents gave rise.

Of the interesting facts which he collected in the dissecting apartments of the rooms, and which he presented to the society of professors, into which he was not long of being admitted, we shall mention only the principal. One of these was, in 1813, the observation of a fœtus born with a very large frontal hernia of the brain, in consequence of hydrocephalus. This case was especially remarkable for the unusual presence of two bones situated between the frontal bones and not far from the articulation of the proper bones of the nose.

Shortly after, he gave a description of a fœtus in which the umbilical cord, greatly dilated at its base, contained a portion of the abdominal organs, and in which the heart adhered to the palate. Conjointly with M. Bonnie, he published the observation of a delivery, by the anus of a child whose conception had been extra uterine. In a memoir on necrosis, he defended and developed the opinion of those authors who think that there is not really a regeneration of the bones. He also made known his reflections on the formation of callus. He demonstrated, with Bonn and Bichat, that the ossification of periosteum is only provisory, and serves as it were for a sheath to the two fractured ends, while they are becoming encrusted with phosphate of lime. It had long been believed that the arch of the aorta impresses upon the dorsal region of the vertebral column the lateral curvature which is observed in it. Bichat had already shaken this explanation by supposing that the curvature might rather arise from the more frequently repeated contraction of the muscles of the right arm. This, however, was nothing more than a supposition, when Béclard transformed it into a positive fact, by pretty numerous researches on the subject. We must not omit mentioning the physiological experiments by which our author demonstrated that the fœtus exercises respiratory motions in the uterus, from which results the introduction of the water of the amnios into the bronchi. At the same time he did not succeed in demonstrating that this water has a chemical action on the blood which penetrates into the lungs. It was also at the same period that he made, in conjunction with Legallois, a series of curious experiments, with the view of determining the action of the œsophagus in vomiting.

In 1813, Béclard presented before the faculty of Paris his thesis for obtaining the degree of doctor in medicine. It was composed of several propositions, which treat, 1st, Of the distinction to be established between the laminar tissue and adipose tissue; 2dly, Of the prominences and depressions of the bones, which he considers as resulting from the original disposition of the cellular frame work of the bone, and not from the action of the muscles which are attached to it. Other subjects already mentioned are reproduced in this thesis, which terminates with a learned interpretation and practical considerations respecting the method which Celsus proposed for the operation of lithotomy. His talents as a surgeon had already been justly appreciated, and during the first invasion in 1814, he was sent by the government to assist the wounded at the ambulance established in the hospital St. Louis. It was in 1815, that the memoir on acephalous monsters appeared. Béclard also made known at this period several facts on pathological anatomy, which he had collected in the apartments of the dissecting rooms.

A vacancy took place in the situation of second surgeon to the Hotel Dieu. For the first time Béclard was unsuccessful, M. Marjolin having obtained the appointment. However, as the two competitors had disputed the palm with nearly equal merit, Béclard was named surgeon of the Hospital de la Pitie. He had already acquired experience in the art of Paré and J. L. Petit under a master who loved him, and with whom he was shortly after connected by more intimate affections. Dubois had taught him the mode of operating at the *Ecole de Perfectionnement*, and Béclard was presently seen to possess surgical talents of the highest order, for the exercise of which he was peculiarly fitted by his natural adroitness and his great skill as a dissector.

In 1816, he became a member of the Philomathic Society, and for the first time delivered a course of general anatomy. In 1817, his inquiries respecting the wounds of arteries made their appearance. The experiments of Jones in England were hardly known, when our anatomist thought it would be important to verify them, and the result of his investigation confirmed the inferences of the English experimenter. Béclard's Memoir occurs among those of the Medical Society of Emulation, of which he was a member. In 1818, he published with M. J. Cloquet a translation of Lawrence's Treatise on Hernia.

It was in this year also that the medical faculty of Paris received him as a member. This memorable circumstance of Béclard's life, by adding a new lustre to his reputation, inspired him with the desire of equalling the celebrated professors of that faculty, old in renown and experience. Accordingly, he was seen to redouble his efforts to discharge in a becoming manner the functions which had been entrusted to him. The keenness with which the students heard his learned lectures on anatomy justified the choice which the school had made of this remarkable man.

He contributed to the formation of a scientific collection then known under the title of *Nouveau Journal de Medecine*, of which the *Archives Generales de Medecine* are now the continuation. In 1819, he published four memoirs on osteosis, in which he exposed its progress with the greatest precision and in the most luminous manner. He co-operated in the compilation of the *Dictionnaire des Termes de Medecine, Chirurgie, Pharmacie*, &c. and was one of the principal editors of the *Nouveau Dictionnaire de Medecine*.

In 1820, he was named President of the Juries of the Departments and Member of the Council of Public Health of the Department of the Seine. When the *Academie de Medecine* was created by a royal edict, (20th December of the same year), all eyes were fixed upon Béclard, who was unanimously appointed to the office of perpetual secretary to that learned society, the duties of which he performed until the moment when ministerial favour decided otherwise.

In 1821, he published a volume of additions to the General Anatomy of Bichat, and the following year consigned in M. Descot's thesis, the results of his experience and researches respecting the local affections of the nerves. In 1823, appeared the *Elemens d'Anatomie Generale*, in which students will for a long time to come find the most valuable and the best composed lessons which have yet been offered respecting the organization of the human body. At this period, Béclard was involved in the general disgrace of the old faculty of medicine, and after the re-organization of the new school, he had nearly been excluded from it; but his reputation and talents carried it over intrigue, and the chair on which he had shed a lustre was again given him.

This brief enumeration of the labours with which Béclard's life was occupied, brings us to a period of melancholy remembrance; but, before engaging in this painful part of the task, which we have imposed upon ourselves, let us recur to the particulars of the life of a master who was dear to us, and who honoured us with so benevolent a friendship. We shall therefore consider Béclard in his different capacities of anatomist, surgeon, professor, and private individual.

Anatomy was the first object of Béclard's studies. His excellent memory permitted him faithfully to retain the most minute descriptions; his adroitness enabled him to execute the most difficult preparations; and his exquisite judgment placed him above a great number of pupils whose dexterity was limited to discovering a muscle or pursuing the ramifications of an artery. Possessed of the faculties of dissecting well, seeing acurately and retaining with correctness the disposition of the parts, he had in him all the qualities of a good anatomist. When he went to Paris, anatomy and physiology, already improved by the labours of Haller, Bordeu, and Bichat, and adorned with all the lustre of their genius, were the favourite objects of study to the greater part of the students, who were attracted to them by the new discoveries as well as by the prospect of the numerous applications which might be made of them to medicine and surgery. Our author cultivated these sciences with an ardour which was sustained by the example of Portal, Chaussier and Dumeril. Pinel had already, from anatomical considerations, established important distinctions for the art of healing; and the school of which he was the leader followed with a truly remarkable enthusiasm the impulse given that philosophical physician. The indispensable union of the study of the organization and that of diseases was already cemented; and it was with the object of rendering it still more necessary that Bayle, Laennec, Richerand and Duyputren, made us better acquainted with the action of our organs in the state of health, and the different kinds of alterations which they may undergo.

It will readily be conceived that Béclard entered into the spirit of the times with so much the more ardour that he was capable of foreseeing all the good that might result from it. He did not therefore limit himself to the bare and dry study of anatomy, but always viewed it in its relations to medicine and surgery. He devoted his whole time to the study of the relation of the parts to each other, and of the variations of form and direction which certain circumstances may force them to undergo; and as he did not find in the prodigious number of facts which passed under his eyes means sufficiently great to multiply his acquirements, he was seen, in his eager pursuit of knowledge, to extend to the utmost the limits of his erudition. Full of admiration for the German school, to which we are indebted for so many valuable discoveries in the science of the organization, he at an early period made himself familiar with the labours of Meckel, Oken, Tiedemann, &c. He, in like manner, laid under contribution the discoveries of the celebrated anatomists of England and Italy; and it was when he had become possessed of a mass of facts collected, so to speak, from all parts of the world, that he took upon himself the task of submitting to the crucible of his severe judgment and vast experience, all the facts, opinions, and theories which had been denounced or agitated.

Some persons, envious of his glory, accused him of being nothing but a compiler, a mere man of reading, and refused to this remarkable man the least spark of genius. They forgot that in following such a course, and in accomplishing a task so difficult, Béclard required to give proof, at each step, of a quick and accurate apprehension, an uncommon talent for instruction, and a truly superior logic. The parallel that has been attempted to be drawn between Bichat and Béclard cannot really exist. If these two men resemble each other in their rapidly acquired reputation and their premature end, they differ essentially in the spirit with which they cultivated the science which they have equally improved. Rich in his own foundations, and led on by the desire of constructing an edifice of a new form, Bichat hastened to reduce to order materials which he owed in a great measure to his own unaided labours. Béclard, on the contrary, formed the vast project of collecting the facts that were scattered in the domain of science, with the view of forming them into a body of doctrine which should present for its authenticity the authority of the most celebrated names, and the fruit of the investigation of the most estimable observers. To the glory of being an original writer and a discoverer, Béclard preferred the merit of giving lustre to truth, from whatever source it might emanate. He was, without doubt, one of the greatest admirers of Bichat, and if he often combated his ideas, it was because he considered it his duty to do so for the interest of science.

I believe the distinction that was made between Bossuet and Massillon may be applied to Bichat and Béclard. The Bishop of Meaux preached one day before an illustrious audience. Massillon on hearing him, said; "he does well, I admire him; but if I were in his place, I would do otherwise." Such was Béclard, with reference to Bichat. Colder, and less enthusiastic, he came after him to correct the errors that had escaped the inventive genius of that great man. Let us then cease to establish between them a comparison which does not permit the one and the other to be judged, according to his proper merit. They must be viewed separately; it is in their individual and peculiar talent that they are to be admired.

It was in consequence of this plan of reform and improvement that Béclard first published a new edition of Bichat's General Anatomy, with a volume of additions; and it was with the same object that he afterwards published his own General Anatomy, a work remarkable for its clearness, the great number of facts which it contains, the extensive scale on which it has been constructed, and the vast erudition displayed in it. This work has been compared with Meckel's Manual of Descriptive and Pathological General Anatomy. It is true, that the French anatomist has sometimes extracted more or less interesting facts from that great collection; but how much has the imitator surpassed his model, with what art has he avoided those German ideas, those hypothetical explanations, and those forced resemblances with which Meckel's General Anatomy teems. On the other hand, Béclard's work has been compared with Bichat's, the enchanting style of which is incessantly praised; but is it not known that Bichat wrote at a period when it was requisite to draw the readers along, by the charm of diction, while Béclard wrote for men whom science herself enticed without the aid of any artifice. Béclard bears the impress of the period at which he lived. Bichat, as has been said, wrote the romance of the science; Béclard laboured to trace its code. Thus the General Anatomy of Béclard has its peculiar merit, and may be considered as one of its author's best titles to renown. Béclard studied and improved anatomy, more especially with reference to medicine and surgery, and in laying the foundation of that science upon an extensive erudition, he has really founded a school, the principles of which will long be followed.

To the valuable qualities which we have above traced, Béclard added those of an able operator. He was possessed of an imperturbable coolness, a firmness which never degenerated into harshness, and an address which was the fruit of long and numerous dissections. Unforeseen circumstances often render it necessary to deviate from the rules of art, and Béclard knew, on occasion, to modify the methods in use, or to invent others. As his coolness never abandoned him, his memory often recalled, or his genius suggested to him, in the course of an operation, all that he required to render its execution complete. He invented or improved several modes of operating. Such, among others, are his method of curing the fistula of Steno's duct, several modes of partial amputation of the foot, disarticulation of the metatarsal bones, amputation in the hip and shoulder joints. He modified the manner of cutting the soft parts in amputation of the limb, and of sawing the tibia in amputation of the leg; he was the first who completely extirpated the parotid gland; and, lastly, he very advantageously modified Celsus's mode of operating for the stone.

His vast erudition extended equally into the domain of surgery. In the lectures which he gave at the Hospital de la Pitié he developed the most extensive and the most solid information. Those who have only heard his course of surgery, and who did not disdain to assist at the operations which he performed in too obscure a theatre, could at least but consider him as a man highly conversant with surgical literature. In fact, the talent with which he exposed and commented upon the theories of men who have written on this branch of the art of healing has always been admired. It were useless to seek here to clear Béclard of the reproach which was cast upon him as being a surgeon only in theory. Let us refrain from mingling with the pleasure which we feel in tracing the picture of the merits and talents of this excellent man, the bitter remembrance of the ridiculous hatreds and envies of which he was the object.

Béclard's reputation as a lecturer daily increased. He possessed the very rare faculty of exposing with order, clearness, and simplicity, all that his immense memory brought to his mind. He knew especially how to clothe his ideas in suitable words, and to construct his sentences with admirable order. He preferred accuracy and vivacity of expression to elegance. His speech was not garnished with metaphors, but he developed his ideas by a gradation of words, rising above each other in clearness and precision, so that his last expression, always stronger and more energetic, left the image of the object or idea deeply impressed upon the mind of the hearer. As he prepared his lectures carefully, and with long study, attained a profound knowledge of the matter which he treated before his pupils, and was always master of his subject, he pursued his descriptions in an imperturbable manner. Continually adding to his acquired knowledge the fruit of his own reflections, he interested and enticed his audience, without having recourse to the vain display of words, by which the deluded multitude is sometimes captivated.

In his last course, he gave the anatomical and physiological history of the nervous system; a delicate and truly difficult subject. His descriptions, however, were so clear, and there prevailed so great a degree of order in them, that it was impossible not to understand them. He exposed in the most lucid manner, the immense series of opinions emitted on this subject, from Praxagoras to our own times. His lectures were more brilliant, and more solid than ever, and as if he had felt a presage of his approaching end, he always exceeded the time that was assigned him for his lectures, and could not leave the chair over which there were soon to be spread the emblems of death.

If Béclard had rivals worthy of him in certain branches of the art of healing, he surpassed the greater part of his contemporaries in his career as a teacher. He recalled the knowledge and eloquence of Hallé, and walked at least the equal of M. Cuvier, whom he felt delight in imitating, and to whose height his vast acquisitions were daily raising him. There was only wanting the talent of rendering his descriptions still more impressive by the aid of drawing, and then Béclard would have been the most remarkable lecturer which the medical sciences have to this day had as an interpreter.

It is not very common to find private virtues combined with great talents, because ambition, the common source of our errors, often accompanies genius, and because, in satisfying it, one is exposed to deviate from the rules of social morals; but such was not Béclard; if he was desirous of occupying a distinguished rank among his fellows, it was never by acting to the prejudice of his rivals that he attained it. His successes in competition had withdrawn him from the multitude, and he kept himself in the elevated rank which he occupied by his personal merit and his indefatigable labours. He has sometimes been taxed with ambition, but his noble emulation has been ill interpreted; he was desirous of increasing his fortune only that he might scatter its benefits over a numerous family, of which he was the glorious stay. Was the man ambitious, who, neglecting to enter upon an extensive practice, which his great reputation would have ensured to him, devoted two-thirds of the day to public instruction? Moderate and simple in his tastes, he was contented with living quietly in the bosom of a family which was adorned by various kinds of excellencies.

Béclard was naturally melancholy and grave. His health, exhausted by long labours, required, on his part, the strictest attention. From having his mind always occupied with abstract ideas, he seemed at first cold, and his conversation was very laconic; but when diverted from his meditations, he then displayed in a mind adorned by the reading of philosophy and history, all the charms that a man of intellect is capable of infusing into his conversation by the variety and extent of his acquirements. His cheerfulness appeared only in flashes, and an irresistible attraction soon caused him to withdraw within the circle of his habitual meditations. For some time he had been greatly addicted to the reading of works on philosophy and political economy; he had also engaged deeply in the study of languages; so that he could display in society accomplishments of a different nature from those which obtained admiration for him in the medical world.

Béclard was beneficent without ostentation. Numerous students received benefits of all kinds from him, and he often left them in ignorance of the source from which the services which he rendered to them proceeded. He more than once, by the disinterested transference of his medical opinions, supported or created the reputation of young students, who afterwards did honour to their illustrious master. He co-operated with zeal in their labours, encouraged their attempts, lavished on them the riches of his vast erudition, and aided them with the greatest willingness in the cultivation of a science, the field of which he ardently desired to see extended, by whatever hand it might be done.

It was in the midst of so many labours, and when he had begun to enjoy a reputation which, brilliant as it was, was only in its dawn, that the celebrated Professor, of whose life we have presented a sketch, was struck by a fatal disease.

On the 6th March, 1825, an erysipelas formed upon his face, and presently extended to the integuments of the head. From the commencement, a cerebral excitement manifested itself, and gave rise to the greatest fears for the life of the patient. In despite of every care that could be taken, the disease went on with frightful rapidity, and on 16th March Beclard was no more.

In the prolonged delirium which terminated his life, his intellect had acquired an astonishing activity. More than once, we saw him imagine himself in the midst of a numerous audience, and develope, with a surprising energy, ideas which, incoherent as they were, did not the less denote the lofty mind which could conceive them. These were, in some measure, the last efforts of his expiring genius. At length, after a long and cruel agony, he breathed his last in the arms of his numerous friends, whom grief had for some days chained to the pillow of his death-bed. When the melancholy news spread in the school, the pupils, who for several days had not ceased to wander about Béclard's house, to find out if there were still any hopes, and who but a short time before, had saluted their learned and modest Professor with unanimous applauses, were deeply affected by the loss which they sustained.

On the 17th March 1825, the day of Béclard's funeral, two thousand students betook themselves to his house, and, unwilling to leave in the hands of strangers the care of conducting his corpse to its last asylum, took charge of it themselves, and carried it to the church of Saint Sulpice, which was in a moment filled with men of science, professors, and students. On issuing from the church, Béclard's remains were seized with the same eagerness, and the coffin, supported by a mass of pupils anxious to pay a last tribute of admiration and gratitude, was in this manner borne to the cemetery of Pere La-chaise. Those who were unable to obtain the honour of carrying this precious burden followed it in mournful silence, and thus formed a more imposing train than is generally presented by the mercenary crowds which surround the funeral car of the rich and powerful.

The Royal Academy and the School of Medicine directed eloquent speakers to render the last honours to the manes of Béclard; and the pupils, anxious to give their master a lasting testimony of their sorrow, opened a subscription on the spot for the erection of a funeral monument. The School of Medicine and the friends of our celebrated professor imitated the example of his young admirers, and there was presently seen to rise upon his tomb a monument which will always recall to mind the talents of Béclard, the public grief of which he was the object, and the noble admiration of a studious youth for a man of science, to whose lessons they listened with avidity, and who, the victim of his ardour in the pursuit of knowledge, perished at the age of 39, when on the point of attaining the summit of his glory.*

Paris, 15th December, 1826.

* While the School of Medicine was deploring the loss which it had sustained in the person of Béclard, the city of Angers, not less afflicted by so melancholy an event, and desirous of honouring the memory of a man who had done so much for the glory of his country, charged M. David, his countryman and friend, equally celebrated in his art, to retrace in marble the features of the rival of Bichat.

ERRATUM.

Page 210, line 30, *for* inspiration *read* expiration.

INTRODUCTION.

1. Anatomy has for its object the investigation of organized bodies. It is the science which treats of organization, and all substances possessed of organic structure belong to it. Man, the most complex of all animals, is the principal subject of this science. The knowledge of the human body, of the various parts of which it is composed, and of the mutual arrangement of these parts, is in fact the essential end of anatomy.

Comparative Anatomy, which might with equal propriety be named *General Anatomy*, embraces within its domain all organized bodies. It seeks to discover, by comparison, what they possess in common, and in what they differ from each other. *Phytotomy* is the general anatomy of vegetables; that of animals bears the name of *Zootomy*. Anatomy is also general, when it has for its subject, a class, a genus, or a group of organized beings, as that of the domestic animals, or veterinary anatomy. *Particular Anatomy*, on the other hand, has for its subject a single species of organized bodies. Such is the anatomy of the elephant, of the horse, of man, &c.

In human anatomy, the term general anatomy has a different acceptation, which will be pointed out as we proceed; but we must first endeavour to acquire a correct idea of organization in general, and of the bodies which are possessed of it.

SECTION FIRST.

OF ORGANIZED BODIES.

2. Bodies, which are capable of extension and possessed of mobility, form the subject of a science, immense in its extent, and which is called natural science, natural philosophy, or physics; but they may be considered in two different points of view, in the state of rest, or in the state of motion or of action. In the first of these two modes of viewing objects, it is the form, whether external

or internal, of bodies, that occupies the attention. It is to this kind of investigation, which has by some been named *Morphology*, that anatomy belongs. The other, which is generally denominated *Physics*, takes cognizance of their appreciable changes, in other words, of their phenomena or motions, whether of masses or of molecules, and is accordingly divided into two principal branches, *Mechanics* and *Chemistry*.

3. The bodies which have common or general properties, differ also from each other in many respects. Organization and life constitute a very precise character, which separates them into two perfectly distinct series, that of inorganic or brute bodies, and that of organized and living bodies.

4. Inorganic bodies not having a complicated structure, their particles being perfectly independent of each other, and lastly, these bodies not being the subject of anatomy, it were useless to insist more upon their nature and qualities. It will suffice to say, that the general motions or phenomena which these bodies perform or exhibit, and which belong to the science of mechanics, take place with a regularity and constancy, which permit us not only to observe them, to reproduce and repeat them in our experiments, and to determine the laws according to which they are produced, but also to subject them to mathematical analysis ; that the molecular phenomena of these same bodies, which belong to chemical science, may be observed, and are capable of being produced or determined at will in experiments ; that certain laws, according to which they are produced, may even be deduced from observations and experiments, but that these phenomena have not yet been subjected to calculation, an instrumental science so well adapted to accelerate the progress of the branches of knowledge to which it is capable of being applied. The science of organization and life is nearly reduced to the laws of observation.

5. Organized or living bodies are the only ones of which anatomy takes cognizance. Besides the characters which they possess in common with inorganic bodies, they have others which are peculiar to themselves, and which modify the former ; they possess organization and life. They have each a peculiar form, which is constant and generally rounded, the latter circumstance appearing to be dependent upon the fluids which they contain. Their internal form, or their structure, in fact presents a mixture of heterogeneous parts, solid and fluid. The solid parts are named *Organs*, which means instruments, on account of the action which they exercise. Their particles are interlaced and interwoven, on which account their arrangement is named texture. They are areolar and spongy, or form particular cavities which contain fluids. These parts are in general extensile, or susceptible of elongation, and retractile, or possessed of the faculty of returning upon themselves. When these parts or organs are multiple, as is generally the case, each has its determinate form, its particular texture, and its peculiar situation. The fluids or humours are contained in the solids,

and penetrate into all their parts. All the parts, whether solid or fluid, are mutually and necessarily connected, and it is from their union that the organized body results. The solids and the fluids have a similar composition: they contain much water, and some particular combinations or immediate products, and may be almost entirely resolved into gas. Their matter has nothing peculiar, but is also found in the inorganic bodies from which it is derived, and is much less distinguished by its nature than by its arrangement. The idea of its differing essentially from brute matter is altogether erroneous. Oxygen, hydrogen, carbon, azote in many, and a few earthy substances, constitute its elements.

It is this proper form, this structure common to all living bodies, this areolar tissue containing fluids, more or less abundant, and of the same nature as itself, that is called organization.

6. The aggregate of the phenomena proper to organized bodies is called *Life*. Life consists essentially in the circumstance that organized bodies are all during a determinate time centres which are penetrated by foreign substances which they appropriate to themselves, and from which issue others which become foreign to them. In this motion of momentary formation, the matter of which the body consists continually changes, but its form remains the same. It is in the state of fluids that foreign substances penetrate into organized bodies, and it is under the same form that the superfluous particles issue from them. The fluids and solids are in unintermitting motion in the organization; the fluids passing through the cavities of the solids, and the latter, by their dilatation and contraction, determining a great part of the motion of the fluids. They change incessantly into each other, a part of the mobile matter becoming fixed for a time, and a part of the solids becoming fluid again, which agrees with the similarity of their composition. Organized bodies undergo changes during the whole course of their existence. From the moment of their origin, they increase in size and in density. The latter kind of change continues to the end, when the structure of the body being insensibly altered, the vital motion becomes languid and ceases, which constitutes *death*. After death, the elements which composed the organized body separate, and form new combinations. Each organized body having not only its external form, but its proper and peculiar structure, each of its parts concurs by its action to produce the general result. The action of each organ or of several organs, which have a common end, is called *function*.

Nutrition, a function comprising absorption, assimilation and excretion, of which we have just made mention, is not the only phenomenon common to organized bodies. *Generation* is another phenomenon as general, without which the species would not subsist, death being the necessary consequence of life. All organized and living bodies spring from bodies like themselves, and all produce their like. For this purpose, a part of the organized body which has acquired its development, after adhering to it, separates from it and forms a being having the same aspect. This part, which is to possess the same form, and is to present the same phenomena as its parent, obtains the name of *germ*, so long as it forms part of its body. This second general phenomenon is but a consequence of the first. The germ, so long as it forms part of the body of its parent, is nourished and grows like one of its organs; and its separation constitutes a kind of excretion.

Organized bodies also for the most part reproduce certain of their parts when they are removed from them. They also repair to a certain extent the lesions which they may happen to experience.

The aggregate of individuals produced by the same parents, and of those which resemble them as much as they resemble each other, constitutes the *species*. External circumstances, such as the atmosphere, the food, and others, according as they are more or less favourable, exert an influence upon organization and its phenomena; whence result a greater or less perfection in the development, and differences of similitude, which are in general pretty limited among the individuals of the same species. It is this that constitutes *varieties*. From this also result various individual alterations in organized and living bodies. These alterations of organization and its phenomena are *diseases*.

It is this series of phenomena common to all organized bodies: an origin from a similar being, a termination by death, the maintenance of the individual by nutrition, that of the species by generation; in a word, an action of momentary formation, exercised in a body which has received it from a parent, and which transmits its principle to descendants, that is called life.

It is by these two characters, organization and life, common to all, and peculiar to them alone, that organized and living bodies are distinguished.

7. The form and action of organized and living bodies, organization and life, are in such strict connexion, that they may be considered each as a necessary condition of the other, the one always supposing the other. Life is seen in organized bodies only, and it is in living bodies only that organization is seen. In fact, in order that life may take place, there must be solid parts to preserve the form, and fluid parts to keep up motion; in a word there must be organization. In like manner, before organization can support itself in the midst of causes tending to produce destruction, a continual motion and renovation of its parts are necessary. Organized bodies spring in a living state from bodies like themselves. In all, and during the whole course of their life, the vital phenomena are in an exact relation to the state of the organization; and when the latter is altered, whether as a consequence of life itself, or by accidental circumstances, life languishes and ceases, and the organization is destroyed by the chemical action of its proper elements. All the efforts of philosophers have not yet enabled them to perceive matter organizing itself, or life establishing itself, whe-

ther spontaneously, or through external causes, in a word, elsewhere than in a body already organized and living. Life, in fact, neither consists solely in a collocation of molecules previously separated, as that which chemical attraction might produce, nor solely in an expulsion of elements previously combined, as that which the repulsive action of caloric might produce ; but in a motion of temporary formation, in which elements remain united, which would separate did life cease, and in which elements separate without their being removed from each other by the action of caloric. Now, this vital action exists only in organized bodies. This intimate and reciprocal connexion of organization and life, has caused them to be in their turn considered each as the cause or the effect of the other. This is assuredly erroneous, and the idea of organization and life is a complex idea, which can no more be divided, unless in an abstract sense, than these two things themselves can be separated from each other. Life is organization in action, or, according to Stahl's expression, it is organism. The object of this work, however, being the examination of organization in a state of rest, life will be considered in it only in a very brief manner.*

8. Organized bodies having a heterogeneous structure, their history is composed of those of their various parts. This study is what forms the proper object of anatomy. In like manner, the physics of these bodies comprehends not only mechanical or chemical phenomena, but also those which belong peculiarly to them, and which are foreign to inorganic bodies, viz. nutrition and generation, in other words, organic or vital action. This department of physics assumes the name of *physiology.*

Anatomy† may therefore be defined the knowledge of organized bodies, or the science of organization. The etymological signification of this word is different, as it means simply *dissection ;* but it has been consecrated by use, and is preferred to the words morphology‡ and organology,§ which some have proposed to be substituted for it. In fact, anatomy is purely a science of observation, and dissection is the principal means by which the parts of organized bodies are exposed for the purpose of observing them.

Physiology‖ is the knowledge of the phenomena of organized bodies, or the science of life. It is also called Zoonomy¶ and Biology.** Physiology, like anatomy, is a science of observation ; but it considers the phenomena of living organized bodies.

Anatomy and physiology are very intimately connected. Observation having shown that organization, and the phenomena of life, are in constant and mutual relation ; the objects of the one may be inferred from those of the other.

* See Richerand's *Elemens de Physiologie.*

† From Ανατεμνω, *to dissect.* ‡ A discourse on form.

§ A discourse on organs.

‖ From Φυσις, *nature,* and Λογος, *a discourse.*

¶ The law of life. ** A discourse on life.

9. Organized and living bodies, which form the subjects of anatomy and physiology, are distinguished into inanimate bodies or *Vegetables*, and animated bodies or *Animals*, according to differences which are very distinctly marked between the animals and vegetables, whose organization is complicated, but which are scarcely appreciable between those whose organization is the most simple.

10. The most compound vegetables are in general formed of two parts, separated by a horizontal median line, and of which the one, descending and contained in the earth, is the root; while the other, ascending and contained in the atmosphere, is the stem which bears the leaves and flowers. Their structure consists merely of an areolar tissue, vessels and spiral tubes, which are named tracheæ. They have no other organs than those of nutrition and generation. Their most important parts are all situated externally. Their chemical composition is simple; azote rarely occurs in them, or exists only locally. Their vital actions are confined to growth and reproduction. Their nutrition, the materials of which are derived from the soil and atmosphere, water and air, consists of an absorption exercised by the roots, a motion of transportation which the fluids undergo in the vessels of the stem, and a kind of respiration which takes place chiefly in the leaves. In these various actions, vegetables retain hydrogen and carbon, preserve little or no azote, and exhale the superfluous oxygen. Their reproduction is performed in various ways. A considerable diversity, moreover, exists in the organization of vegetables, the exposition of which would be out of place in a work like the present.*

OF ANIMALS.

11. Animals, at the head of which is placed man, who bears a great resemblance to some of them, besides the general characters of organized bodies, have others which are peculiar to themselves, which consequently distinguish them from vegetables, and which exert an influence upon and modify the former. But animals differ so much from each other, that their common characters are not very numerous or well defined. The following are the characters peculiar to animals, some being common to all, the rest more or less general.

Besides the rounded form which belongs in general to all organized beings, it is observed that most animals, externally at least, are symmetrical, and divided by a vertical median line into two similar lateral portions, and that their length, in the direction of this line, is greater than their other dimensions, sometimes in a high degree. The proportion of the fluids to the solids is very great. The areolar or cellular tissue, which forms the mass of the body, is very soft and contractile. The body contains an internal

* See Richard's *Elemens de Botanique*.

cavity or intestine, into which the food is received. This cavity, like the exterior, is invested by a membrane or skin which limits and envelopes all the rest of the body. In many animals there are circulating vessels which carry, in determinate directions, the nutritious matter from the intestine into all the other parts of the body; respiratory organs, in which this matter is subjected to the action of the atmosphere, and secreting organs, by which a part of it is separated from the mass. They have genital organs, which consist in general of a cavity, from which the germs separate and make their exit. Lastly, in most animals, there are muscles for performing the apparent motions, senses for receiving the impressions of external objects, and a nervous system, consisting of cords or filaments, immersed and spread out by one extremity in the integuments and muscles, and of ganglions or enlargements, with which the other extremities of the cords are connected.

11. The solids, or the organs of animals, have for their principal base the areolar or cellular tissue, a soft, extensile and contractile substance, permeable to the fluids. This substance becoming condensed at the two surfaces of the body, forms externally the skin, and at the interior the mucous membranes, or internal skin. It is this same membrane, the skin, differently arranged, that constitutes the organs of respiration, secretion, and generation. It also forms the organs of sense. Formed into branched canals, in the walls of which it assumes a considerable consistence, the cellular tissue constitutes the vessels. The same substance, variously modified, without however losing its distinctive characters, forms several other kinds of organs in animals. The muscular fibre constitutes a second kind of solid, differing essentially from the cellular tissue in this respect, that in the middle of the soft substance which forms the common mass, there occur linear series of microscopic globules. It contracts when irritated. The substance of the nerves is also formed of globules, which are different however from those that compose the muscles. It transmits the impressions received to centres, and conducts the influence of the centres to the muscles.

The animal fluids, or humours, are numerous and abundant. In many animals, there is a fluid in circulation in the vessels. This fluid is the blood, and constitutes the central mass of the nutritious humour. There are also fluids absorbed at the surfaces, or in the mass of the body itself; and, lastly, other fluids secreted or separated from the blood. The latter consists essentially of an abundant serous vehicle, in which are immersed microscopic particles, similar to those of the solids. The composition of the blood is precisely the same as that of the solid parts; and it requires but a change of condition, or some slight changes in the proportion of the elements, to convert the materials of fluids into solids.

The last anatomical elements of the humours and organs of animals appear, therefore, to be an amorphous substance, fluid in the blood, in which it constitutes the serum or albumen, and concrete in the organs, in which it constitutes the cellular tissue; and a substance formed into globules, which are free and swimming in the blood, and fixed in the organs, in which they constitute the muscular fibre and the nervous substance. The chemical composition of the animal body is more complicated than that of the vegetable, and consists of more volatile elements. Azote enters into it as an essential part, and is added to the other general elements of organization. Lime is the earthy element that exists most generally in it.

12. The general organic phenomena, nutrition and generation, occur in animals, but in them are modified by the phenomena peculiar to these beings. Nutrition, in place of resulting from external absorption alone, results at the same time, and chiefly, from an internal absorption which is performed in their intestinal cavity. The nutritious fluid obtained in the intestine is submitted to the action of the atmosphere. There results from this respiration a production of water and carbonic acid, which is the reverse of what takes place in vegetables. Besides this, the nutritious fluid has to be continually freed from superabundant matters by the secretions. These take place at the external and internal surfaces, and are sometimes performed by vessels merely spread out upon broad surfaces, which allow the secreted fluid to perspire. Sometimes the fluid oozes from the bottom of the small cavities formed in the skin or mucous membrane; while in other places, the circulatory vessels communicate with proper vessels or ramified excretory ducts, which are also formed by the envelope of the body, and which pour out the secreted fluid. Of the fluids which result from these various secretions, some are used in the performance of functions, while others are rejected as superfluous matters, forming a kind of depuration. The nutritious fluid is continually renewed by the intestinal absorption, is kept in a fit state by respiration and the secretions, makes its way into all parts of the body, and there effects nutrition, a wonderful operation, in which it is decomposed in such a manner that in each part a portion of the blood becomes solid, and forms part of an organ; while, at the same time, and in all parts of the body, a portion of the organs becomes fluid, and enters into the general mass of the circulation. Generation, or the production of a new being, is so diversified in its modes that it presents no character peculiar to animals, and common to them all. The separation of the sexes, which is subordinated to motion, is in fact neither peculiar nor common to the animal kingdom. Animals also possess, although in a less degree than vegetables, the faculty of reproducing, by a kind of vegetation, certain of their parts when they have been removed.

13. Muscular motion, sensation, and nervous action, give in some degree a new life to animals; and these functions are distinguished by the name of *animal life*, in opposition to the other functions, which are named *organic* or *vegetative life*. The impression made by external agents upon the organs of sensation,

that is to say, upon the external or internal skin, or upon some of its parts, organized in a particular manner, determine actions in these organs which are propagated by the nerves, to the central masses of the nervous system. There is not even a part of the body which, in certain cases, may not be the seat of some sensation. When the animal has received a sensation, and this sensation determines a volition in it, it is by the nerves that the volition is transmitted to the muscles, whose contractions produce the motions of the animal.

The nervous action is not confined to transmitting the impressions received by the senses and the volitions to the muscles; the central nervous masses are also the organs of instinct, and of the cerebral functions.

The functions in question are not only in animals superadded to the organic or vegetative functions, but also modify the exercise of the latter in a singular degree. Thus, in nutrition, it is in general by muscular motions that the introduction of the food is determined; muscular fibres, with which the intestine is supplied, cause it to move in them; muscles, with which in many animals the vessels are furnished at their centre of union, propel the blood in them; muscles also, by their motion, determine the application of the atmospheric fluid to the respiratory organ. Senses are placed at the entrance of the organs of nutrition, nerves are also distributed to the organs of nutrition, and although, in the ordinary state, these nerves transmit neither sensations nor volitions, and although the motions are immediately determined in them by impressions or irritations, yet, in the violent affections of the nervous centres, the motions are deranged, and in morbid cases their functions are accompanied by sensations. Generation, like nutrition, is modified in its acts by the animal functions.

14. There is in fact among all the organs and functions of animals a concatenation which indeed exists in all organized and living beings, but which is more distinctly marked in animals, and especially in certain tribes of them. In organized beings which possess no other functions than nutrition and reproduction, the latter is the continuation and consequence of the former. In animals which possess motion and feeling, nutrition requires to be executed by means of a digestive process, for the animal could not at the same time possess the faculty of locomotion and be rooted in the soil. In such animals generation is sexual. In proportion as each order of functions becomes more complicated, the organs which are added to those whose existence is more general, keep the latter under subjection. Thus, in the order of the nutritive functions, the circulation, and in the latter, the action of the heart, keep, when they exist, all the other phenomena under their influence. In like manner, in the animal functions, the action of the nervous centres holds in control phenomena whose existence is more general. So also, the animal functions keep under their direction all the nutritive and reproductive functions; but these, in their turn,

also keep the former in dependence upon themselves, the organs of the animal functions requiring to be nourished in order to perform their functions, and these functions determining the exercise of the organs of the vegetative functions. In this manner, in the animals which are high in the scale of organization, life seems essentially to result from the reciprocal action of the vegetative functions, and of the principal organ of the animal functions, of the circulation and of the nervous action, or of the action of the blood upon the nervous system, and of the nervous system upon the organs which move the blood. The other phenomena keep up these two principal actions, which may be considered as the two essentially vital actions of animals.

15. To all these characters, the first very general or common, and the last much less general, are to be added the derangements of the organization and of the phenomena of life, in other words diseases, which are much more frequent in animals than in vegetables. The reason of this frequency will easily be found in the complexity of their organization, the connexion of all the parts with each other, and the exercise of central and predominant organs whose action cannot be disturbed without inducing derangement in all the others. Whence the study of the circumstances and external objects that act in a useful or injurious manner upon the animal organization, and the act of preserving or restoring health by the well directed use of external influences, or the science of medicine.

Such are the most general characters of animals; but these beings present in their organs and functions a multitude of variations or of degrees of complication which it is of importance to examine.

16. The external form or configuration which is capable of giving an idea of the structure, of which it is in some degree the expression, presents the following varieties. Some animals are punctiform or globular, as the Monads; others have the form of a filament, as the Vibrio; some have a flattened form like that of a small membrane, of which kind are the Cyclides; last, others belonging, like the last mentioned, to the group of Infusoria, have no determinate form, the configuration changing each moment in the most singular manner, as is the case with the Protei. These elementary forms, which belong to all the most simple animals, recur in some animals of a higher order, and in certain parts of all the others. This is equally observed of the stellular or radiated form which belongs to a certain number of classes of animals, and which occurs in various parts of those which have a different external form.

The radiated form begins to show itself in the Rotiferæ and in the other Polypi. In the Acalepha and Echinodermata, the radiated form is not confined to the exterior, which resembles a radiated flower or a star, but all the parts are disposed around an axis, and upon a greater or less number of rays. In other animals, the axis being longer, the radiated form becomes cylindrical. The cylindrical Echinodermata, the intestinal worms, and the Annelides exhibit this transition of the radiated form, of which they still participate, to the symmetrical form and the articular arrangement, which they also present; and the Tunicata, the transition of the radiated form to the symmetrical form without articulation.

The symmetrical form occurs, with some slight exceptions, in all the other animals. In this form, the body is divided into two similar lateral parts or sides, by a median plane; but it is subdivided into two other very different parts. In the Mollusca, the body is never divided into segments, and there are no articulated feet. These animals are inarticulated. The other symmetrical animals, on the contrary, are articulate, in other words, their trunk is divided into segments capable of moving upon each other, and their limbs, when they have any, are divided into several parts by articulations. The articular arrangement first occurs in the cirripeda, which in all respects belong to the mollusca. Its principle is also found in the cylindrical echinodermata and in the vermes; but this kind of form belongs more especially to the annelides, insecta, crustacea, and arachnides, which for this reason are called articulated animals, and to all the osseous or vertebrate animals. Thus the various forms exhibited in animals may all be referred to the following: the symmetrical or binary form, with or without articulations, the radiated form, and the simple globular filamentary forms, &c.

17. The external form of animals presents other differences also. The body is divided into the trunk, a central part which contains the organs essential to life or the viscera; and the appendages, parts which are in general subservient to motion and sensation. The trunk is divided into the trunk proper or middle part, and the extremities, which are the head and the tail. The trunk itself is sometimes subdivided into the abdomen and thorax. The head is the part which, besides the mouth, contains the principal nervous ganglion, or brain, and the organs of the particular senses. The thorax, in the articular animals, is the part of the trunk to which the limbs are attached. In the vertebrate animals, it is the part which contains the heart and lungs. The abdomen always contains the principal organs of digestion and generation. These different parts of the trunk, which do not always exist, present different varieties.

In the radiated animals, the acephalous mollusca, and the intestinal worms and annelides, the trunk, which is reduced to its middle part, consists of a single cavity which contains all the organs. In the cephalopodous mollusca there is a distinct head. This is also the case in the insecta, crustacea and arachnides, which have moreover a thorax, sometimes distinct from the head and abdomen, and sometimes confounded with one or both these parts of the trunk. In the vertebrate animals the head is always distinct, but the thorax is sometimes confounded with the abdomen. The appendages also present numerous varieties. In some infusory animals, there are small appendages, which are named ciliæ. The radiated animals have the mouth surrounded by appendages, called tentacula, which are destined for motion and feeling. This is also the case with some mollusca which have tentacula possessed of sensibility, and other fleshy productions, called arms or feet, for motion. The crustacea and insecta have antennæ, which are jointed filaments, differing greatly in form, attached to the head, and appearing to be organs of sensation. This is also the case with their palpi, which occur equally in the arachnides. The lateral, paired appendages, essentially destined for motion, and which are called limbs or members when they are jointed, exist in a rudimentary form in the cirripeda and the setigerous annelides. They occur in great number in the myriapoda, and in considerable, but variable number, in the crustacea. There are eight in the arachnides, and six in the true insecta, which, for the most part, have also wings to the number of four or two. In the vertebrate animals, there are never more than four limbs.

18. The organs of nutrition are greatly diversified. In the simplest animals, the infusoria, this function consists simply of an absorption from the surface, the matter inhaled by which penetrates into all parts of the animal's body, and is immediately assimilated and afterwards excreted. This simplicity of organization is also observed in some intestinal worms and acalepha.

In the next degree, there is an intestinal cavity formed in the substance of the body, and henceforth absorption takes place at two surfaces, and especially at the inner. This simple cavity occurs in some polypi. At a still higher stage, the cavity consists of a membranous bag, distinct from the mass of the body, formed by an internal membrane or skin, similar to the external skin, and continuous with it. This kind of cavity first makes its appearance in certain polypi and acalepha, as well as in some intestinal worms. In other animals of the same classes, the gastric cavity has prolongations which extend into the mass of the body for the purpose of distributing nutriment to it. In some acalepha and intestinal worms, the stomach is wanting, and there are only ramified prolongations which open at the external surface. In all these first appearances of an intestinal cavity, the cavity is limited to an elongated bag, having a single opening. Several echinodermata and intestinal worms have a distinct intestinal canal, a mouth and an anus; an arrangement which is henceforth observed in all the higher classes, in which the canal, more or less dilated or contracted, and exhibiting various forms, traverses the body. The existence of this canal shows itself at the same time with the cylindrical and elongated form of the body.

The mouth presents several varieties, of which the principal are those of a simple orifice; an aperture furnished with muscles, and sometimes with hard parts, but disposed solely for suction; an aperture furnished with muscles and hard parts for dividing the food.

19. In many of the lower animals, the nutritious juice, absorbed by the walls of the intestine, which is simple or prolonged into the body by ramified appendages, is carried immediately by the areolar substance into all parts of the body. Such is the case with all the radiated animals, and the immense class of insecta. In all the latter, in fact, there are no vessels, and the nutritious fluid passes from the intestine by *imbibition* into all parts of the body.* There is only a dorsal vessel, which seems the rudiment of a heart, but there are no branches for circulation.

In the higher animals, the nutritious fluid, absorbed by the walls of the intestine, circulates in closed vessels, whose ultimate ramifications alone allow the molecules by which the body is to be nourished to escape into its substance. The vessels which proceed from the centre of the circulation into all the other parts, are called arteries. Those which return from all the parts of the body to the centre, are called veins. At the point where these vessels meet, there exists in many animals a muscular organ, the heart, which by its contractions assists the motion of the fluid, and which, as well as the general mass of vessels, exhibits various degrees of complication. The first rudiments of vessels are observed in some intestinal worms, and the first rudiment of the heart occurs in the insecta.

In the annelides, the only invertebrate animals that have red blood, there are arteries and veins for circulation, but the heart is merely in embryo. In the arachnides, which are furnished with tracheæ, the organs of circulation are not more advanced than in the insecta; but in the other arachnides, or those furnished with lungs, there is a heart or great dorsal vessel, which has branches on each side. The crustacea have a more distinct heart. In some of them, it is elongated into a large fibrous vessel, which prevails along the whole of the tail, giving off branches on both sides, and which still resembles the dorsal vessel of insects; but in other crustacea, there is a dorsal ventricle, together with a large ventral vessel, and true circulatory vessels. In the mollusca, there is a heart having various degrees of complication, together with a double system of arteries and veins. The blood is white or bluish. Lastly, in the vertebrate animals, besides the arteries, veins, and heart, there is a separate system of lymphatic and chyliferous vessels which carry the nutritious fluid from the intestines into the veins.

The simplest kind of heart consists at least of a ventricle which impels the blood into the arteries, and frequently of an auricle or venous sinus at the place where the veins enter the heart. It is

* The term *imbibition* was probably first used by Baron Cuvier in his great work on Comparative Anatomy, who, observing, as had been demonstrated by Swammerdam, Lyonnet and others, that insects have, properly speaking, neither veins, arteries, nor absorbents, supposed, with a great show of probability, that the nutritive fluids, when prepared, must filtrate through the parietes of the intestinal canal into the general mass of the body. The recent discoveries of Carus, as to the existence of vessels in the larvæ of certain insects, even should they be ultimately fully confirmed, do not affect Baron Cuvier's views as to the mode of absorption and nutrition in the adult or perfect insect. R. K.

aortic when it sends the blood to the whole body, and pulmonary when it sends it to the respiratory organ. It is double when there are two ventricles, which may be separate or connected. The heart is simple, destitute of auricle, and pulmonary, in all the articulate animals which are furnished with one. This is also the case in fishes, only that in them it has an auricle. It is simple, but aortic, in most of the mollusca; triple in the cephalopodous mollusca, in which there are two pulmonary ventricles and an aortic ventricle, separate and destitute of auricles. In all the class of reptiles, there is a single ventricle, more or less partitioned, which sends the blood into a single trunk, which is at once aortic and pulmonary. Most of these animals have two auricles; the batrachia have only one. Lastly, in birds and mammifera, the heart is double, with two auricles and two ventricles adherent to each other, the one aortic and the other pulmonary.

20. Before the nutritious fluid is rendered fit for its office, it requires to be submitted to the action of the atmosphere in which the animal lives. In animals which have no circulation, the water acts at the surface of the body. Such appears to be the case in the infusoria, polypi and acalepha. The intestinal worms are equally destitute of respiratory organs. In another degree of organization, the air or water penetrates into all parts of the body by elastic canals called tracheæ, and which are lined by prolongations of the skin. The echinodermata have aquiferous tracheæ. In the insecta there are two longitudinal tracheæ occupying the whole extent of the body, presenting at intervals centres from which proceed numerous branches, and which correspond to external apertures called stigmata, for the entrance of the air. In the animals which have a circulation, some of the vessels carry the blood into an organ in which they are subdivided over a large surface of the external or internal skin. This surface is elevated and bears the name of branchia or gill, when the ambient element is water; it is hollowed, and is called the lung, when that element is air. For the branchial or pulmonary respiration, there are in general organs of motion for placing the ambient fluid in contact with the organ. In the arachnides, we find the transition of the disseminated respiration, which still exists in those which are furnished with tracheæ, to the local respiration, which is performed in pulmonary bags. In the crustacea in general, the respiratory organs are projecting branches possessed of various forms, which is also the case in most of the annelides. In the molluscous animals in general, numerous varieties occur in the organs of respiration. Some which respire air have a pulmonary cavity; these are the pulmonary gasteropoda. Others have projecting branchiæ of various forms. Others, again, have their branchiæ in a cavity into which the water has to be drawn. In the class of fishes, the respiration is branchial. It is pulmonary in the other vertebrate animals.

The respiration is partial, and the circulation simple, in reptiles, which have but one ventricle and one aorta, of which latter the pulmonary artery is a branch. In all the other animals which have a local respiration and a circulation, the latter is double and the circulation perfect; in other words, at each course of the blood, the whole fluid passes through the respiratory organ. In the articulate animals and the mollusca, the circuit is single. In the former, the blood proceeds from the heart to the whole body, passing entirely through the branchiæ, which is also the case in fishes. In the mollusca, it goes from the heart to the branchiæ, passing previously through the whole body. In birds and the mammifera, the two hearts being coherent, the circle is double, or, more properly speaking, the circuit is crossed, and may be represented by the figure 8, at the centre of which is the heart.

21. The nutritious fluid, besides being subjected to the action of the atmosphere, has also to be freed of superabundant matters by the secretions. In the animals which have an internal cavity, and therefore two surfaces, these two surfaces are subservient to excretion as well as absorption in their whole extent. The internal skin and the external skin present small cavities or depressions from which the fluid issues. Lastly, in the same animals in which there is no circulation, if some particular fluid is to be produced, the cavities or depressions of the internal or external skin are extended and ramified into proper vessels or excretory ducts in the body, and inhale from the nutritious fluid the elements which enter into the composition of that substance. In like manner, in the animals which possess a circulation, sometimes the vessels are simply spread out upon broad surfaces, and allow the secreted fluid to escape by perspiration; sometimes it is from the bottom of small cavities or follicles formed in the internal or external skin that the fluid oozes; in other places, the arteries, at the point where they change into veins, communicate with excretory ducts which are ramified and always formed by the internal or external skin. It is from the union of these canals with the blood vessels that the glands result. These latter organs of secretion are peculiar to the animals which have a heart. The liver, for example, the most general of these organs, only exists in the tracheal arachnides under the form of disunited vessels, as in insects. In the pulmonary arachnides and crustacea, on the contrary, there is a liver which is still separated into distinct lobes, and in some species into bundles or bunches of vessels. The mollusca have all a liver of large size. Most of them have salivary glands, but neither pancreas nor kidneys. Several have secretions peculiar to themselves. The vertebrate animals are all furnished with glands, and in addition to those which the others possess, they have kidneys which are organs that are closely connected with those of generation. Of the fluids which result from the different secretions, some have uses in the exercise of functions, as the saliva, the bile, &c.; others, as the urine especially, are rejected as superfluous or noxious matters.

Thus the organs of the nutritive functions in their extreme diversity, consist of a permeable substance which absorbs, assimilates, and excretes; of one or two surfaces, the skin and the intestines through which the foreign matters have to pass from without inwards, or from within outwards, by absorption or by secretion; of vessels which establish communications between the surfaces of the body and all parts of its substance, and between the latter and the former; of respiratory organs, which are parts of the surfaces in which the fluid is placed in contact with the atmosphere, and of secreting organs which are other parts of the surfaces, by which a part of the fluid is rejected.

22. Generation, or the production of a new being similar to that from which it derives its origin, the second function common to all organized and living bodies, also presents in animals a great diversity in its organs and phenomena. This function, in the simplest state, has no particular organ destined for performing it; the whole body, which is very simple and homogeneous, separates into several fragments each of which retains the properties of the whole. This is the fissiparous generation. It belongs essentially to the infusoria, but exists accidentally in others. In other animals of the same group there are perceived in the substance of the body globules or corpuscles which appear destined for reproduction. This is the subgemmiferous generation, or the first indication of a production of buds. In a higher state the generation is, in fact, gemmiparous; a bud grows upon the outer surface of the body, upon the skin, and is afterwards detached to form a new being distinct from its parent, or continues to remain upon it, and forms a branch. This kind of generation belongs to the polypi. There is also an internal gemmiparous or suboviparous generation. Its organ consists of cavities prolonged into the mass of the body, and in the interior of which, grow buds or ovula which separate spontaneously, and issue by a canal which opens at the surface. This mode of generation is that of the acalepha, the echinodermata, and perhaps, the cestoid intestinal worms. The acalepha and some gasteropodous mollusca differ from it only in having a true ovarium. In all these cases, there are, properly speaking, no sexual organs.

23. In all the higher organizations there are genital organs, existing in two distinct sexes, which require to come together for the vivification of the germs; of these, the female organs consist of an aggregation of germs or an ovarium, a canal by which the germs, after becoming detached, are carried out of the body, and which is named the oviduct, and, in several species, a cavity in which they remain a certain time, become attached to it, and grow before they are expelled. This cavity is the uterus, and the orifice by which they escape, is the vulva. The male organs are glands called testicles, which secrete the sperm, or fecundating fluid; and when this fluid is to be introduced into the body of the female, the male is also provided with a penis. In this kind of organization the concurrence of the two sorts of organs is necessary for generation. The first appearance of it occurs in certain

intestinal worms; but these animals having no circulation, their ovary and testicles consist solely of secreting vessels which are free or floating. The genital organs are also of two kinds in many mollusca, in the annelides and other articulate animals, and in the vertebrata; only in those which have a circulation, the ovaries and testicles are glandular masses. Among these animals, some are hermaphrodites, or provided with male and with female organs; but this hermaphroditism is incomplete, or rather insufficient, for to produce fecundation they require a reciprocal copulation with another individual of the same species. Such is the case with some annelides and mollusca. In a still higher order of organization, the genital organs are separated and borne by different individuals, a circumstance which constitutes the distinction of sexes. This is observed in some intestinal worms, in many mollusca, in the classes insecta, crustacea and arachnides, and in all the vertebrate animals.

24. In the sexual generation, the germ is inclosed along with nutritive matters in an envelope generally membranous, but sometimes more solid, and even calcareous. Sometimes the egg contains nutritious matters in sufficient quantity for the complete development of the embryo, and only receives the influence of the atmospheric air, and at the most that of humidity, through its envelope. The animal is then oviparous, whether the egg be laid entire, and the development of the embryo take place after its deposition, or development precede the expulsion of the egg, and the latter break at the moment of birth. In the oviparous generation, the germ is not in general detached until after fecundation. In some cases, however, it becomes detached previously, and the egg is fecundated during the act of expulsion, or even after it has been deposited. The egg does not always contain materials sufficient for the development of the embryo; in which case it becomes attached to the internal surface of the uterus, and there absorbs nutritious matters. The young is born alive, accompanied with the remains of its membranous egg, but in a state of feebleness which renders it necessary to be fed with an animal fluid which the mother secretes, and which is the milk. The mammifera are the only animals that produce their young in this manner. At the period when they issue from the egg, some young animals bear no resemblance to their parents, and before attaining their perfect state, undergo changes which are called metamorphoses. Of this kind are the larvæ of insects, and the tadpoles of the Batrachia. The others, on the contrary, are similar at birth to their parents, or at least exhibit only differences of proportion which vanish as they advance in age.

25. Nutrition and generation are not the only modes of production or formation of animals; they also possess, although in a lower and less general degree than vegetables, the faculty of reproducing, by a kind of vegetation, the parts that have been removed or destroyed. But all animals have not this faculty in the

same degree, the most simple kinds presenting it in the most remarkable manner. The polypi, and especially the hydræ, constantly and indefinitely reproduce the parts that are removed from them, so that individuals may be multiplied at pleasure by cutting them. The reproductive power of the actiniæ is not less; they reproduce the parts that are removed from them, and may even be multiplied by division. The asteriæ also possess this power in a high degree. They cause the rays that have been torn off to sprout again; and even a single ray, provided it be whole, is capable of reproducing all the others. The faculty which the tæniæ possess of reproducing the posterior rings of their body is well known. Among the annelides, the naiades also possess a high reproductive power. The faculty which the crustacea have of reproducing their legs when they have lost them, or when they have been mutilated, has been determined in the crab. It appears that the arachnides also have the faculty of reproducing their feet when they have lost them. The aquatic salamanders possess an astonishing power of reproduction. They cause to sprout again several times in succession the same limb when it has been cut off, and that with all its bones, muscles and vessels. The limbs and tail of tadpoles are also regenerated nearly as those of salamanders. The tail of the saurian animals, when it has been broken, sprouts again, although sometimes a little different from what it originally was. In warm-blooded animals, reproduction is nearly limited to the epidermic and horny parts. With reference to the other parts, it only effects the healing of wounds, and produces a cicatrix similar to the skin, when the latter has been cut into or destroyed.

The organs and functions proper to animals, present, like the preceding, many degrees of complication or varieties in the beings which compose the animal kingdom.

26. In the most simple animals, the body being homogeneous, or appearing to be so, no particular organ is seen for motion, and yet these infusory animalcules move with great velocity. Other animals somewhat more compound, as the rotifera, which have a particular rotatory organ, and the polypi, which have around the mouth appendages or tentacula, the motions of which agitate the water, attract and seize nutritious substances, and of which some have moreover general motions, are still destitute of any distinct muscular organ. The proper organ of sensible motions, the muscular fibre, exists in the acalepha and echinodermata, whose muscular system is sustained by a well organized skin, and in all the higher animals, in which the apparent motions, general or partial, are produced by the action of these organs. The muscular fibres, in all animals that are provided with them, strengthen the external and internal skin. They form the heart in every animal that has one. Some animals have the skin as soft as the other parts of the body. In many, it contains in its substance hard parts, whether calcareous or horny, which defend the animal against external attacks, and which, being capable of moving upon each other, trans-

mit to the parts which they sustain the motion which they have received from the muscles. In the vertebrate animals, the latter office is performed by articulated and mobile bones situated in their interior, and which for this purpose are furnished with a great mass of muscles, which are wanting in the invertebrate animals, or are attached to their hardened skin.

27. The organs of sensation, in the most simple animals, have no distinct existence, the whole body appearing to receive the impressions, as it executes the motions. In the animals which have an external skin and an internal skin, different from the rest of the mass, and all above the polypi are in this condition, the skin, besides absorbing nutritious matters, receives the impression of external bodies. In those which have the skin very soft and differing little from the rest of the body, it is equally sensible in all its parts. But the skin which is moistened in many animals with mucous or sebaceous matter, is in a great number of them furnished with an epidermis, hairs, horny scales, or calcareous crust, and thus becomes an organ of defence or support. In this latter case, some parts remain destitute of these envelopes, are possessed of great mobility, and form particular organs of touch. Of this kind are the tentacula of the echini, those of the mollusca, the antennæ of insects, and crustacea, the filaments of certain fishes, &c.

The organ of taste does not occur distinct in all animals that digest, and yet the sensation seems to exist in all. Nothing is seen in the radiated animals at the entrance of the alimentary canal, that seems to constitute the organ in question. This is equally the case with respect to the mollusca and the articulate animals. In some insects, however, the extremity of the proboscis or palpus is supposed to be the organ of taste. Lastly, it is even far from being the case that all the vertebrate animals have a tongue organized in such a manner as to render it proper for exercising this function.

The organ of smell seems to be wanting in a great number of animals; yet the insects, crustacea, and arachnides are sensible to smells, although the precise seat of this sensation is unknown. This is also the case with the mollusca. In the vertebrate animals themselves, the nasal fossæ do not perforate the face in all the classes.

The organ of hearing, or the ear, does not exist in the lower classes of animals, and sound appears to be perceived by them only as an impression of touch. Of the articulated animals, all of which hear, the crabs are the only ones in which the ear has been perceived. In them it consists of a bag filled with a gelatinous lymph, receiving a distinct nerve. Among the mollusca, the cephalopoda are furnished with this organ, which exists in all the vertebrate animals, and in them presents numerous varieties.

In all animals light exercises an action upon the whole skin and upon all the parts that are exposed to it, but vision takes place only by means of the eye. The radiated animals are destitute of this organ. The vermes and part of the annelides are also destitute of it, and in the other annelides it is merely rudimentary, existing under the form of a small black dot. Those of the articulata, which are furnished with feet, viz. the crustacea, arachnides, and insects, are all furnished with eyes, which may be of two kinds, more or less numerous, and always symmetrical; simple eyes, of which the cornea has only one facette, the iris a single aperture, and the optic nerve a single filament; and compound eyes, having several facettes, with a corresponding number of pupils and filaments of the optic nerve. Sometimes the eyes are pediculate or placed upon articulated appendages. The acephalous mollusca are destitute of eyes; most of the gasteropodous species have these organs, but very small and rudimentary, and placed either upon the head itself, or upon the posterior tentacula. The cephalopodous mollusca have two large eyes covered by the skin, which in this place is transparent. Among the vertebrate animals there are only a few species that are destitute of eyes.

28. The nervous system is not known, and does not appear to exist, in the infusory animals. The first traces of it are perceived in the radiated animals. The hydræ, among the polypi, have microscopic globules in their substance, whose nature is little known; but in the asteriæ and holothuriæ there are ganglia disposed in a circular manner around the mouth, communicating with each other by soft filaments, and sending out others in a radiating manner into the divisions of the body, where they are distributed to the external skin and the internal skin. In some intestinal worms there is observed a nervous ring which surrounds the mouth, and from which proceed two cords running along the whole length of the body. In the articulate animals, the nervous system presents a pretty general character. There is a small bulging, called the brain, which is placed upon the œsophagus, and furnishes nerves to the parts about the head. Two cords which embrace the œsophagus like a collar, are continued under the alimentary canal, and unite at intervals into as many double ganglions or knots as there are rings in the body, and from which proceed the nerves of the trunk and limbs, when the latter exist. Nearly the same arrangement is observed in the cirripeda. In the mollusca there is a greater diversity than in the articulate animals. In them, however, the nervous system always consists of ganglia communicating by cords, and sending filaments to the different external and internal parts. In the acephalous mollusca there is above the mouth a principal ganglion to which the name of brain is improperly given, and another towards the opposite extremity of the body. Behind the mass of the intestines, two nervous branches establish a communication between the ganglia, and embrace the viscera in their course. Other filaments are distributed to the different parts of the body. In the mollusca which are furnished with a head, there is a principal ganglion or medullary mass, named the brain, situated transversely upon the œsophagus, which

it envelopes with a nervous collar terminating beneath in another larger ganglion. These ganglia send off filaments to the parts of the head and to the different viscera. In certain other animals, there are, moreover, some other small ganglia. The cephalopodous mollusca alone have their brain enveloped by a kind of cartilaginous skull.

The general characters of the nervous system of the invertebrate animals consists especially in the dissemination of nervous centres, and in the circumstance that all the parts, whether external or internal, whether those which belong to the vegetative functions or those which belong to the animal functions, receive their nervous filaments from the same centres. It will be seen that in the vertebrate animals, on the contrary, the nervous system is disposed in quite a different manner, and in one that entirely separates it from that of the other animals.

29. The nervous action or innervation presents in animals variations corresponding to those which are observed in the disposition of the nervous organs. In the animals in which there is no nervous system, and in those in which that system is destitute of a centre (the radiated animals) the impressions are immediately followed by motion. Those animals and parts whose motions are determined by impressions are called irritable. In the radiated animals, it is the mouth, or the orifice by which they take their food, that is the most irritable point. It is there also that the nervous system begins to appear in the radiated animals which have one. All the other animals are also provided with irritable parts. In the mollusca and insects, in which the different ganglia of the nervous system are connected by cords, so as to form a centre, and in which there are particular organs of sensation, the impressions received by the senses give rise to sensations, and the motions are determined by volition. The internal motions, however, are produced by irritation, but the irritability in these animals is in dependence upon the nervous system. There is also observed in these animals, and especially in insects, a faculty which is called instinct, and which, like an irresistible impulse, makes them produce, without instruction or imitation, very complicated actions which are essential to their preservation, and to that of their species. The vertebrate animals, besides irritability, sensibility, voluntary motion and instinct, have also cerebral functions, which, to a certain degree, assume the appearance of intellect.

30. The varieties or degrees of complication, which exist in each functionary apparatus, are combined in various ways, which constitutes varieties of the general organization. The combination or coexistence of the different apparatus of organs is determinate, a certain state of the organs of nutrition or generation requiring, before life can take place, a certain corresponding state of the organs of motion, sensation, &c. In conformity to a very prominent difference in the organization, animals are divided into ver-

tebrate and invertebrate. Man belongs to the first of these divisions.

31. Although the invertebrate animals differ greatly from man, yet their examination is of much interest to the anatomist and physiologist. In them organization and life are seen in their greatest simplicity, and in a multitude of varieties. They even differ so much from each other, that they possess no common and positive character. From the general consideration of their organization, they are divided into three great sections, which differ from each other as much as they differ from the vertebrate animals. These sections are those of the radiaria, mollusca, and articulata. Besides these three divisions there is also a class of doubtful beings which zoologists describe under the name of infusoria, and to which the botanists lay claim as referable to the Confervæ.

32. These equivocal and microscopic animals have very simple forms, differing from each other, and sometimes changeable. They are homogeneous, transparent and diffluent. They have no cavity, nor any distinct organ; and yet they move in the waters which contain them, imbibe the nutritious matters which float around them, and multiply by splitting spontaneously.

33. The *Radiated Animals* constitute a particular type, the essential character of which is found in their form, which is that of a centre with the parts disposed around it in radii. Their structure, which is somewhat simple, presents several varieties from the hydræ or tentaculated polypi, the most simple among them, to the asteriæ. They all live in water.

34. The Polypi form an extremely numerous class of radiated animals. They are in general elongated, having a single aperture or mouth furnished with radiated appendages. They have an alimentary cavity, digest very quickly, and absorb by imbibition. They produce buds or gemmæ, which sometimes remain adherent, forming compound phytoid animals, and sometimes separate. The two surfaces, the external and internal, are similar. The intermediate substance is homogeneous and resembles gelatine. No particular organ is distinguishable in them, they having only microscopic globules. They are so reproductive that when cut into pieces, each piece becomes an individual. Light, noise, and other external causes, produce impressions upon them followed by motions. Some are fixed to the ground, others free. The most simple of all are those which are naked, as the hydræ, &c., which have a simple alimentary bag, and multiply by external buds. Others which are aggregated, excrete from their outer surface a bony or calcareous substance, to which the name of polyparium is given. In others again, which are compound animals, the common body envelopes a secreted substance, which varies from the consistence of jelly to that of stone.

35. The Acalepha or sea-nettles have a still more marked circular or radiating form, and have been compared to rosaceous or radiating flowers. Their structure is varied, some being as simple

as the simplest of the polypi, and others much more complicated. The mouth is central, furnished with tentacula, and leads to a stomach, which is frequently branched, but which has no other issue. For generation there are masses of ovariform internal buds in particular cavities.

36. The Echinodermata are the radiated animals whose organization is most complicated. In this class we find the stellular, spheroidal and cylindrical forms. They have an internal cavity in which there float distinct viscera. Their intestine has prolongations resembling vessels, which are ramified in the body. Some of them have a distinct anus. The organs of respiration are ramified aquiferous canals; those of generation are ovariform masses of internal buds which end at the mouth or anus. They have muscles, and in most of them there are particular organs for motion, consisting of numerous tentacula terminated by cups, and which are called feet. The skin is well organized, and often solid. Some of them have even nervous filaments.

37. The *Articulate Animals* constitute a division of the animal kingdom in which the body is symmetrical, divided externally into a certain number of rings or segments moveable upon each other, and formed by the more or less firm and sometimes hard skin, excepting in the intervals of the rings, where it always preserves its softness and flexibility. Their muscles are attached internally to the skin; their nerves are cords which swell at intervals, and are situated beneath the intestinal canal. This type comprises organizations extremely diversified; some are vermiform, destitute of head, and reduced to the motion of creeping; of which kind are the vermes and annelides.

38. The Intestinal Worms or Helmintha, which, in some respects, present an affinity to the radiata, have, in general, the body elongated, cylindrical or depressed, naked and soft. They have no organ of respiration or circulation. Their generation is internal gemmiparous, and sexual oviparous. They inhabit the bodies of other animals. Very different degrees of organization are presented by them. The most simple of all, the cestoid species, (the Ligulæ) resemble a long striated ribbon, marked with a longitudinal line. No external organ is perceived in them, not even suckers; and internally there is nothing but oviform corpuscles in the mass of the body. Others whose forms are very diversified (the Trematodes and Tœnioid species) have only at their exterior suckers varying in number, sometimes ramified in the body, which also present other gemmiferous or ovariferous canals. The Acanthocephali (Echinorhynchi) have a proboscis armed with hooks to which muscles are attached. They have two small intestines without apertures, and are also furnished with distinct oviducts or spermatic receptacles according to the sexes, which are separated. The Nematoid species, as the Ascarides, &c. have a still more complex organization. They have a mouth, an anus, and an intestinal canal floating in a distinct abdominal cavity. Their ex-

ternal skin is furnished with muscular fibres, and is, in general, transversely striated. They have distinct genital organs, consisting of very long canals. The sexes are separated. They have a nervous ring which surrounds the mouth, and two long cords, the one dorsal and the other ventral. They have also two spongy lateral vessels.

39. The Annelides, or red-blooded worms, are vermiform animals, whose elongated body is divided into numerous rings, of which the first differs a little from the others, and is named the head. The mouth is either a tube or maxillæ. They have an intestine of variable length which traverses the body, and a double system of arteries and veins without distinctly marked hearts. The blood is red, and the respiration branchial. They are hermaphrodite, with reciprocal copulation. They have muscles, and most of them have stiff hairs which serve for feet. Their head is furnished with tentacula, and some have black points which are considered as eyes. Their nervous system is a ganglionated cord.

40. The other articulated animals are all furnished with a head, and have simple or compound eyes. Their mouth, which is very complicated, is of similar construction in all, and presents two modifications. In the one, there are for bruising, several pairs of lateral maxillæ, of which the anterior bears the name of mandibles, and frequently palpi or articulated filaments, which seem adapted for distinguishing the food. In the other modification, there is a proboscis for sucking. The organs of digestion are complicated and very diversified. They possess the sense of smell, but its seat has not been well ascertained. They have all an abdomen and a thorax, to the latter of which are attached at least six articulated feet. Their skin is encrusted and solid. Each joint of the feet is tubular, and contains the muscles of the next joint. All the articulations of the feet are ginglymi. Their generation is sexual and oviparous. This section contains three great classes, the insecta, arachnides, and crustacea.

41. The Insecta, or hexapodal articulate animals, have the body composed of numerous segments or rings, and divided into three principal portions, six articulated feet, a distinct head furnished with eyes and two antennæ, a thorax which bears the feet and wings, when the latter exist, and an abdomen which contains the principal viscera. The mouth is a very complex part. In some which bruise their food, there are lateral maxillæ, while in others which suck there is a proboscis. The intestinal canal, which is more or less long, inflated, contracted, &c. terminates in an anus. There is a vestige of heart which consists of a vessel attached along the back, divided into segments by the approximation of its walls, and experiencing alternate contractions, but no branches have been discovered. The fluid which it contains is white, and appears to penetrate into it as into the rest of the body by imbibition. Respiration is performed by means of ramified tracheæ, which unite into two principal trunks. The secreting organs consist of long ves-

sels or spongy canals folded upon themselves, immersed in the mass of the body, and terminating in the intestine or elsewhere, according to the use to which their product is applied. The sexes are separated. The genital organs terminate in the anus. These animals copulate only once in the course of their life. The fecundated female deposits her eggs in a suitable place. The egg produces a vermiform animal, to which the name of larva is given; the larva changes into a chrysalis, which is in a state of apparent death; from the chrysalis issues the perfect insect, which immediately reproduces and dies. These great changes of external form, accompanied with other somewhat less remarkable changes in the structure, are called metamorphoses. All insects, excepting the Thysanouri and Parasites, which by their resemblance to the mites, approach to the arachnides, undergo these metamorphoses, although some do not go through them all. The organs of motion are muscles and the skin hardened by a horny matter which it contains in its substance. There are six articulated feet, four wings in the greater number, only two in some, while a few only are destitute of wings. The motions are very diversified, consisting of walking, running, leaping, and flying. The organs of sensation are compound eyes, and in several smooth eyes, commonly to the number of three, antennæ and palpi. They possess the senses of smell and hearing, but the organs are not known. The nervous system has the disposition described in § 28, and terminates anteriorly by a small ganglion or brain, situated upon the œsophagus, and which supplies the eyes and other parts of the head.

42. The Arachnides or octopodal articulate animals, whose head, which is destitute of antennæ, is confounded with the thorax, have eight feet and no wings. The alimentary canal commences in some by a mouth with two lateral mandibles, in others by a mouth having the form of a sucker. Most of these animals have palpi. They are subject to sheddings of the skin, but do not undergo metamorphoses. The sexes are separated, and their mode of generation is oviparous. Most of them have visible eyes, which vary as to number and situation.

They present two degrees of organization. The first or most simple is that of tracheal arteries, in which there are no organs of circulation more apparent than in insects, and the organs of respiration are branched tracheæ distinct from each other. The most compound is that of the pulmonary or branchial arteries, (spiders, tarantulæ, scorpions.) They have a simple muscular heart, placed in the dorsal region, elongated, cylindrical, branchial or pulmonary, whence issue vessels for the respiratory organs, which are pulmonary sacs, and from thence for the whole body. There is also a liver composed of grains or lobules collected into clusters. The sexual organs are double in each sex. Some of them copulate several times and live several years. The scorpions are ovoviviparous.

43. The myriapoda or centipedes form a small group of animals intermediate between the crustacea, which they resemble in their

configuration, and the insecta, to which they approach in their structure, although at the same time they differ from both. Their body is elongated and formed of a series of rings, generally of considerable extent, each bearing one or two pairs of feet. Their mandibles and maxillæ are similar to those of the crustacea. Their respiration is tracheal. When they issue from the eggs, the young have six feet and seven or eight rings; the other feet and the rings which bear them are developed as they advance in age.

44. The Crustacea are the most complex in their organization of all the articulated animals with jointed feet. The head is sometimes confounded with the trunk, sometimes distinct. They have a tail of variable length, divided into segments, and are in general furnished with four antennæ. Most of them have the mouth adapted for bruising, and for this purpose have several maxillæ, six at the least, which are always lateral. They have always at least six pairs of feet for motion, but the form of these feet varies according to the kind of motion. The number of the locomotive feet is in the inverse ratio of that of the maxillæ. In fact, the anterior feet are placed near the maxillæ, assume their form, perform part of their functions, and may even take their place entirely. For respiration they have pyramidal, lamellar, filamentous or tufted branchiæ, which are generally connected with the bases of some of the feet, or even replace them in part. Their circulation is double. The blood which has been submitted to respiration passes into a large ventral aortic vessel, which distributes it to the whole of the body, whence it returns in another large vessel or even a true dorsal ventricle which transmits it to the branchiæ. They have a liver, which is more or less divided, or even formed of disunited canals, according to the state of the heart. Their generation is sexual and oviparous, without true metamorphoses. Most of them transport their eggs. They all live in water. Considerable variations are exhibited in their organization. The maxillæ, feet, and branchiæ are so strictly related that these appendages have been considered as being of the same nature, the first resulting from a transformation of the two latter. Most of them have a shell, more or less solid, like the rest of the skin, which covers the trunk, and in some species even the head also. In several orders, the very muscular stomach is furnished with a cartilaginous skeleton, and tubercles or teeth. The intestinal canal is in general short and straight. The position of the genital organs varies. These organs are double in some genera. The eyes present several varieties; they are wanting in a small number; in others the two eyes are placed very close to each other, and even confounded so as to form but one; others again have compound eyes supported upon a moveable pedicel. Lastly, in some decapodous crustacea, there are distinct organs for hearing.

45. The *Molluscous* animals form a division of the invertebrata in which there is generally presented a symmetrical or binary form, but without articulations. They have simple or multiple

stomachs, sometimes furnished with hard parts, and intestines variously elongated. Most of them have salivary glands; all, a voluminous liver, and many particular secretions. Their circulation is double: there is always at least one fleshy ventricle, which is aortic, receives the blood from the organs of respiration, and sends it into the arteries of the body. In those which have more than one ventricle, they are not united into a single mass, but form several distinct hearts. The blood is of a bluish colour. The organs of respiration vary in so much that some respire air and others water. Generation also presents its varieties, some being without sexes, and producing living young without copulation, others hermaphrodite with reciprocal copulation, others again distinguished into sexes. The eggs of those which have sexes have sometimes a mere viscosity for their envelope, at other times a shell more or less hard. These animals are possessed of great fecundity, and are very tenacious of life. Their muscles are attached to the interior of a soft and contractile skin. Their motions are produced by parts destitute of solid levers. They are very irritable. Their naked skin is covered with a mucous humour which exudes from it. Almost all of them have a development of their skin, which covers the body like a mantle, at the same time assuming various forms. Sometimes this mantle remains soft, but most commonly there are formed in its substance one or more laminæ, sometimes of a horny nature, but generally calcareous. This substance is ordinarily of sufficient extent to enable the animal to envelope itself entirely with it. This is what is called the shell. Many of these animals have no eyes, some have them in a rudimentary state, while in others they are highly developed. Their nervous system consists of medullary masses dispersed through the body, and of which the largest lies across the œsophagus, which it surrounds with a nervous collar. They possess little instinct, and most of them live in water. They present various degrees of organization: some are allied to the radiated animals, others to the articulated, while others approach the vertebrate animals by the complexity of their organization.

46. The acephalous mollusca without shells, or the tunicated mollusca, have some resemblance to the radiated animals. There are some which are collected into a common body, like polypi. Of these some are stelliform, the anuses being at the centre, and the mouths at the circumference; others form a cylinder in which the anuses terminate, the mouths opening externally; others have the viscera prolonged into a common mass, and the radiated mouth and the anus carried towards the free extremity of the body. There are others which only remain united long after their birth. When separated, they have the form of a contractile tube, open at both ends. Others, again, which are fixed to the rocks, have the form of two tubes, the one inclosed within the other, and containing water in their interval. They all have an alimentary canal with two orifices, branchiæ, a liver, a heart, and ovaries, or internal

buds, which, without copulation, produce living young. All of them have also nervous ganglia and filaments.

47. The Cirripeda form a small group of animals intermediate between the mollusca and articulata. Their shortened body, without head or transverse rings, is furnished with a mantle and a multivalve shell, which resemble those of the acephalous mollusca. They have lateral jaws at the mouth, and along the belly articulated appendages, disposed in pairs, with a horny skin, which resemble the fin-feet of the tail of certain crustacea, and which are named cirri. The stomach is furnished with numerous small cells which appear to perform the office of a liver. The intestine is simple. They have a dorsal heart and lateral branchiæ, together with a double ovary or aggregation of internal buds, and a serpentine canal for the passage of the young outwards. These animals are sessile or pedunculate, but always fixed. Their nervous system is a series of ganglia under the belly.

48. The Acephalous mollusca, or Conchifera, have the body destitute of head, containing all the viscera, and wholly enveloped, like a book in its cover, by the mantle which is folded in two, and provided with a calcareous shell, which is generally bivalve, although sometimes multivalve. The mouth is furnished with tentacular folia concealed under the mantle; the anus is in like manner concealed at the other extremity. There are four very large branchial laminæ. The liver is of great size, and embraces the stomach and part of the intestine, which latter varies greatly. The foot, when it exists, is attached between the four branchiæ: it is a fleshy mass, which moves in the manner of the tongue in the mammifera. The heart is generally single, aortic, and situated on the side next the back. They have one or two muscles which close the shell, and an elastic ligament which opens it. They have a principal ganglion situated above the mouth, united by two nervous cords to another opposite ganglion, together with several other nerves and ganglia. They produce living young, without copulation.

The Branchiopoda are other acephalous mollusca, existing in small number, which, in place of feet, have two fleshy arms. They appear to have two aortic hearts, and a folded intestine which surrounds the liver. Their mode of generation, and their nervous system, are not very well known.

49. The Gasteropoda are cephalated mollusca, which generally creep upon a fleshy disk, placed under the belly, and whose back is covered by the mantle, which varies in extent and figure, and which generally produces a univalve or multivalve shell. There are mollusca in this class, whose organs of respiration and shell are not symmetrical. The head, placed anteriorly, and more or less disengaged from the mantle, is commonly furnished with tentacula to the number of two, four, or six, placed above the mouth, which constitute organs of touch, sight, and perhaps smell. There are

also commonly small punctiform eyes, situated on the head or tentacula. The organs of digestion are very diversified. There is never more than one heart, which is aortic. In those which are not symmetrical, it is on the left side for the most part, and on the right in the reversed species. The respiratory organs vary much: the greater number have branchiæ, while some respire air. The organs of generation present all the varieties, unisexual, without copulation, hermaphrodite, with reciprocal copulation, and with separated sexes.

The Pteropoda form a small group of mollusca, between the acephalous and cephalated tribes.

50. The Cephalopodous mollusca form a small class, which comprehends the inarticulated animals that have the most complex organization, and which, as well as the crustacea among the articulated animals, approach nearest to the vertebrata.

They are soft animals, having the body enveloped in a bag formed by the mantle, which at its sides is extended more or less into fins, and whose aperture gives passage to a rounded head, crowned with fleshy feet or arms, furnished with cups, which are employed by the animal for walking, seizing, and swimming. The mouth, which is situated between the bases of the feet, is armed with two strong horny jaws, like a parrot's beak, and furnished with a tongue covered over with horny points. There is an œsophagus which enlarges into a kind of crop, besides which there are two other stomachs, the one muscular like a gizzard, the other membranous. From the latter proceeds a short and simple intestine, which terminates in the opening of the sac on the fore part of the neck. There is a double system of arteries and veins, two branchial ventricles, and an aortic ventricle. The respiratory organs are two branchiæ situated in the sac, into which the water enters, and from which it again issues for respiration. There is a very large liver, which pours the bile by two ducts into the third stomach. These animals have a peculiar secretion of a black colour, produced by a gland, and deposited in a reservoir. The sexes are separated. In the one, there are an ovary and two oviducts, which take the eggs from the ovary, and carry them through two large glands, which envelope them with a viscid substance, and unite them into clusters; and in the other, a testicle and a vas deferens, which terminates in a fleshy penis beside the anus. There are also a vesicle and a prostate gland, which open in the anus. It appears that fecundation is performed, by shedding the spermatic fluid upon the eggs. The eye is formed of numerous membranes, and covered by the skin, which is there transparent, and even sometimes forms folds or palpebræ. For each eye, there is a large ganglion, whence issue innumerable nerves. The ear is a small simple cavity on each side, near the brain, without external canal, and to which is suspended a membranous sac, which contains a small stone. The brain is contained in a cartilaginous cavity, which constitutes a rudimentary kind of skull.

51. Such is the immense series of the Invertebrate animals.* They form, as we have said, three different branches or types. It has been seen, that there is in each type a general resemblance, and also various degrees of complication and of perfection, in the organization.

The Radiated animals are evidently the most simple. Some of them approach the Infusoria, and even the most complicated among them have no central organ of circulation, and no predominating nervous organ. Being destitute of central organs, they are destitute of organic or vital unity.

After the Radiaria, come the Mollusca and Articulata. It is somewhat difficult to decide which of these two branches ought to stand highest in the scale of organization; for if, on the one hand, the Articulata are inferior to the Mollusca, in respect to the vegetative organs and functions, many of them being destitute of a true circulation, a function, which on the contrary exists in the Mollusca; on the other hand, the latter are inferior to the Articulata, in respect to the development and approximation of the nervous masses, and especially in respect to instinct, which exhibits so great a degree of perfection in some articulated animals, as to bring them near the vertebrata.

Of the Vertebrate Animals.

52. The Vertebrate Animals constitute a type or mode of organization, to which belong man and the animals which resemble him most. They approach the invertebrate animals in the organs of the vegetative functions, but differ greatly from them in those of the animal functions. Their external conformation is, with the exception of one genus, perfectly symmetrical; that is to say, their organs of sensation and motion are disposed in pairs on the two sides of an axis, or a median plane. They attain a great size, it being among them that the largest animals are found, which they owe to the bones which sustain their soft parts. Their body is always composed of a trunk, and, with very few exceptions, members. The trunk is supported in its whole length by the spine, a column composed of vertebrae capable of moving upon each other, at one of the extremities of which is the head, and of which the other extremity is generally prolonged into a tail. This column, which is in part solid, contains a canal in which the spinal marrow is lodged. The head is formed of the skull which contains the brain, and the face which is composed of the jaws and the receptacles of the organs of sense. The rest of the trunk forms one or two great cavities which contain the organs of the vegetative functions. In the greater number, there are on the sides of the column bony arches or ribs, which guard the visceral cavity,

* See De Lamarck, *Hist. Nat. des Animaux Sans Vertèbres.*

and in most of these animals the ribs are joined anteriorly to the sternum. The members are never in greater number than two pairs, one or other of which is sometimes wanting, and in some cases both. Their forms are various, being adapted to the kinds of motions which they have to perform.

The vertebrate animals have all two horizontal jaws, furnished in the greater number with teeth, which are hard bodies resembling bones in their chemical composition, and horns in their mode of formation. In those which are destitute of teeth, (birds and tortoises), a true horny substance occupies their place. In all the vertebrate animals, the intestinal canal, extending from the mouth to the anus, and presenting various enlargements, is furnished with secretory glands, viz. the salivary glands, the pancreas, and the liver. In all of them there are arteries, veins, a heart of varied form, and chyliferous and lymphatic vessels. In all, the blood is red. In one class only (fishes) there are branchiæ; in the others the respiratory organ is a lung. The respiration varies in extent and perfection in the different classes. The organ by which the bile is secreted, the liver, receives, in all the vertebrate animals, blood carried to it from the intestines and spleen by the vena-portæ. All these animals have kidneys also, which secrete the urine, and most of them have a bladder or reservoir for this excrementitious humour. The sexes are always separated. The female has one or two ovaries from which the eggs detach themselves. The male fecundates them by the spermatic fluid, but the mode of fecundation varies greatly, as do the other phenomena of generation.

The muscles, besides those which form the heart, and those which belong to the skin, the mucous membrane, and the organs of sense, are very numerous, and are attached to internal bones capable of being moved upon each other. All those which have a lung have also a larynx, although all have not a voice. The organs of sense are in all, two eyes, two ears, the nose, the tongue, and the skin, this membrane being besides furnished with various protecting parts. But it is essentially the nervous system that, by its arrangement, distinguishes the vertebrate animals. In the invertebrata, the same nervous masses, more or less separated, furnish filaments at once to the organs of the vegetative functions, and to those of the animal functions. Here, on the contrary, besides these ganglia whose filaments are confined to the organs of the vegetative functions, there is a particular centre with which the ganglia communicate, and from which proceed, or rather in which terminate, the nerves of the organs of sensation and motion. This centre, which is perfectly symmetrical, consists of a large cord contained within the spine, and prolonged into the cranium, where it presents various bulgings, and is surmounted by two complicated organs, varying in size, which are called the cerebellum and cerebrum. This nervous centre is enveloped by bones, firmly united to each other, and which protect it against external violence. This function of the bones may be regarded as one of the most important which they perform.

53. Besides the kinds of humours and organs which are common to all, or at least to the generality of animals, there occur others in the vertebrata which do not exist elsewhere. These are the red blood, the chyliferous and lymphatic vessels, the bones, ligaments and tendons, and the serous and synovial membranes.

In all the invertebrate animals, the nutritious fluid is of one colour only, and white or bluish, excepting in the annelides, in which it is red. In the vertebrate animals, on the contrary, the arteries, the veins, and the heart contain red blood, a fluid composed of colourless serum, in which float minute bodies formed of a central globule and a coloured envelope. It is more compound than in the invertebrate animals. A nearly colourless or whitish fluid is contained in the chyliferous vessels which commence at the intestine, and in the lymphatic vessels which take their rise in all parts of the body. Both sets of vessels have a great resemblance to the veins, and terminate in them.

The bones are hard parts peculiar to the vertebrate animals. They are situated internally, and are of an organic nature, consisting of a mass of condensed cellular substance, impregnated with a large proportion of phosphate of lime. They serve as an envelope to the nervous centres, receive and transmit muscular motion, support all the parts, and hence determine the form of the body. In the invertebrate animals, the hard parts are in general transuded at the surface, and consist of shells, crusts, or scales of carbonate of lime, or horny matter. This latter kind occurs in the vertebrate animals also, in which it affects extremely diversified forms, as those of scales, feathers, hairs, and horns, parts all resembling each other in their composition and mode of formation. There occurs also in the vertebrate animals a kind of organs which is nearly peculiar to themselves, consisting of the tendons by which the muscles are attached to the bones, and the ligaments which surround the articulations of the latter. These organs consist of very condensed cellular substance, the whole of whose function resides in their tenacity.

The serous and synovial membranes are also parts formed by the cellular substance condensed and disposed in the form of bags with contiguous walls wherever the continuity is interrupted between the parts. In the splanchnic cavities they separate the viscera from the walls, and in the moveable articulations they contain a fluid which moistens the contiguous extremities of the bones.

54. But what distinguishes the vertebrate animals from the others, is not merely the action of the organs which are peculiar to them, namely, a more concentrated nervous system, whose central parts are larger, whence result an appearance of intellect which is distinguished from instinct, a certain capability of receiving education, &c.; nor is it alone the influence which these organs

have upon the others in directing their influence; but more especially the concentration of life in the central or predominating organs, in the heart and nervous centre, and in the action of these two parts upon each other. In this respect, however, there are considerable differences among the vertebrate animals.

55. Greatly as these animals in fact resemble each other in their characters, they yet present great differences. Their mutual resemblance exists chiefly in the central part of the nervous system and in its envelope, that is to say in the medulla and spine; and their differences exist in the extremities and at the surface: in the brain, the skull, the organs of sense, the face, the organs of motion, the limbs and the skin. In like manner, in the organs of the vegetative functions, the heart presents many differences; but the most remarkable are exhibited in the organs and phenomena of respiration; and as the action of the muscles and nervous system depends much upon respiration, the differences in that function produce corresponding varieties in the animal functions. Thus in the mammifera, in which the circulation is double, that is to say, in which all the blood brought from the body is sent to the lung before returning to the body, and in which air is respired, muscular action is energetic. In birds, where the circulation is double, and where the respiration, which is also aerial, is not confined to the lung, but extends to various parts of the body, the vigour of the muscles is still greater. It is weak, and the motions are slow and often interrupted in reptiles, where the circulation is single, and the respiration consequently partial, since only a part of the blood is submitted to the action of the air before returning to the body. Fishes, indeed, have a double circulation, but their respiration cannot be perfect on account of the small quantity of air contained in the water which they respire, and accordingly they remain nearly balanced in the water. The animals of the first two classes have the blood much warmer than those of the other two, which are on this account called cold-blooded animals. The generation also presents a very remarkable difference, according to which the vertebrate animals are divided into oviparous, viviparous, or mammiferous animals.

56. The oviparous vertebrate animals resemble each other especially in their mode of generation; they have also some common characters of organization in the nervous system and in the bones which envelope it.

The oviparous generation consists essentially in the circumstance that the germ is inclosed in its envelope, with a sufficient quantity of nutritious matter for its nourishment until the period of exclusion, so that if the egg remains in the interior, it does not attach itself to the walls of the oviduct, but remains separated. The nourishment of the young animal is contained in a bag which forms part of its intestine, and which is called the vitellus or yolk of the egg. The germ is at first merely an imperceptible appendage of the egg, but in proportion as it is nourished it increases in size by the absorption of the yolk, while the latter suffers a proportional diminution, and at length disappears when the period of exclusion is at hand. The fœtuses of the oviparous animals which are furnished with lungs (birds and reptiles, excepting the Batrachia), have moreover a very vascular membrane which appears to be subservient to respiration, and which is a prolongation of the bladder. This membrane is the allantoid: it does not exist in fishes, nor in the batrachial reptiles, the young of which have the general form of fishes. Certain reptiles and fishes retain their eggs within their bodies until they are hatched. These animals are said to be ovo-viparous.

The prolongation of the spinal marrow within the skull presents, in the ovipara, tubercula quadrigemina of great size, whereas the cerebellum and cerebrum are very small, and there are neither pons varolii nor corpus callosum. The bones of their cranium are very soon united, or remain separated for a very long time; their organs of sense are not so perfect as in the viviparous animals; their lower jaw, which is very complex, is articulated by a concave surface to a projecting part of the temporal bone, which is distinct from the petrous bone; their orbits are only separated by a membrane or by an osseous plate of the sphenoid bone. When they have anterior limbs, the clavicles frequently unite and form a fourchette, and the elongated coracoid processes are articulated to the sternum. The larynx is rather simple and wants the epiglottis and other parts; and there is not a complete diaphragm between the thorax and abdomen.

The ovipara are divided, according to their respiration, their temperature, the atmosphere which they inhabit, their kind of motion, the appendages of their skin, and other circumstances, into three classes: Fishes, Reptiles, and Birds.

57. Fishes have a mode of organization evidently adapted for swimming, and are suspended in a fluid of nearly the same specific gravity as themselves. Many of them have in the body, under the vertebral column, a membranous bag filled with air, by compressing or dilating which the animal can render its body heavier or lighter. The head, which varies in form, is of a very complicated structure, as regards the skull, the jaws and the distribution of the teeth. The limbs are greatly reduced in extent, and formed into fins. Other fins occupy the back, the under part of the tail, and its extremity. The number of the limbs varies. More commonly there are four, sometimes two, and in some cases none at all. Their position and their connexion with the trunk are also subject to great diversity. The organs of digestion are equally variable. The pancreas is generally substituted by intestinal appendages. The circulation is double, that is to say, the whole of the blood passes through the respiratory organ, but the atmosphere respired is aerated water. For this purpose they have on the sides of the neck an apparatus of organs called branchia or gills, which consist of plates attached to lateral arches of the hyoid bone, and

composed of numerous membranous laminæ covered by a lace work of innumerable vessels. This aperture is moreover furnished with a branchial membrane supported by rays from the hyoid bone, and an osseous operculum. The water which the fish draws into its mouth to be swallowed, escapes between the divisions of the branchiæ, and acts upon the blood. The heart has but one auricle which receives the veins of the body, and one branchial ventricle. The blood, after traversing the branchiæ, passes into a large vessel situated under the dorsal spine, and which, performing the offices of ventricle and aorta, sends it to all parts of the body. Fishes have kidneys of an elongated form placed along the sides of the spine, and a bladder. Their testicles are two enormous glands vulgarly known by the name of melt; their ovaries are not less voluminous. In most of them the eggs are first deposited, and the male sprinkles them with the fecundating fluid; in some species copulation takes place with intromission of spermatic fluid. These are for the most part ovo-viviparous. The muscles which form so large a portion of the mass of their body are white, very irritable, and possessed of a less perfect organization than in the other classes. This is also the case with the bones. In some fishes, the chondropterygii, the bones remain cartilaginous, the calcareous substance not forming filaments, but remaining in isolated grains. In some, the articulations of the spine are even wanting. In others, the bones, although fibrous and calcareous, vary greatly in solidity, and differ in a remarkable degree from the bones of the other classes. The ribs are often united to the transverse processes. The organs of sense are not highly developed. The nostrils are merely rudimentary and form small cavities at the end of the snout; the eye has a flat cornea, little aqueous humour, and a nearly spherical crystalline lens; the ear consists of a vestibular sac which contains suspended a number of hard bones, in three membranous semicircular canals, generally situated in the cavity of the skull; some genera only have a fenestra ovalis, situated at the external surface; their tongue is most commonly osseous and furnished with teeth, or horny; most of them have the whole skin covered with scales; some have fleshy filaments appended to the lip, which may serve as organs of touch. The prolongation of the spinal marrow into the skull terminates anteriorly by bulgings from which are given off the olfactory nerves.

The class of fishes presents, in the nature of the skeleton, accompanied by a difference in the mode of generation, a well marked division into cartilaginous fishes and osseous fishes.

In this class of vertebrate animals there occurs a genus, that of the flounders or flat fishes, in which there is so great a want of symmetry in the head that the two eyes are placed on the same side.

58. The reptiles present much greater differences than any of the other three classes of vertebrate animals, in their configuration, structure, and functions. In fact, some of them have four feet,

others two fore feet, others two hind ones, and others none at all. In some, the body is scaly, in others naked. Some are pisciform in their fœtal state, and undergo a true metamorphosis when they pass into the perfect state. The organs of digestion are greatly varied. The circulation is simple, and the respiration partial, that is to say, the heart, which varies considerably, sends the blood into an artery of which a branch only goes to the lung, whence there results, that in each course of the blood a portion of that fluid only is submitted to the action of respiration. Their lungs have the form of bags, or at least have large cells. They can suspend their respiration without stopping the circulation. Their blood is cold. The quantity of respiration is not the same in this class, the pulmonary artery not bearing in all the same proportion to the aortic trunk which furnishes it. They have a trachea and a larynx, although they have not all a voice. The females have a double ovary and two oviducts. Some males have the penis bifurcate, and some are destitute of that organ. None of them sit upon their eggs. Their muscles have an irritability which remains for a long time after their separation from the nervous system, and even from the rest of the body. Their sensations are rather obtuse. They have nostrils which traverse the face; but their ear is not complete, being limited to the vestibule which contains soft bones, the semicircular canals, and, in some, a rudiment of cochlea. There also occur rudimentary bones of the tympanum, under the skin. The crocodiles alone have an external aperture for the ear. The brain, which is rather small, may be removed, as well as the head, without causing the motions to cease. Many species remain torpid during a great part of the year.

The reptiles are divided into several families, according to differences in their organization, which are very marked.

The chelonia, or tortoises, have a heart with two auricles, which receive each a different kind of blood, and a single ventricle, having two unequal cells communicating with each other, in which the two kinds of blood are mixed. These animals are enveloped by an upper shell or scutum formed by the ribs and the plates of the vertebræ, and a breast plate formed by the sternum, both covered by the skin, and a horny or scaly substance transuded by the skin. The air for respiration is drawn in by the nostrils, and pushed into the larynx by a kind of deglutition. The male has a simple channelled penis. The female deposits eggs which have a very hard shell. They live without eating for months, and even years, and survive decapitation for several weeks.

The sauria or lizards, crocodiles, &c. have the heart as in the former division. The ribs are moveable for respiration, and the lung is of great extent. The eggs have a more or less hard envelope. These animals are furnished with teeth, claws, and scales. The penis is single or double.

The ophidia, or snakes, have two auricles in their heart, and are destitute of feet. Some of them are venomous. Those which are so have large hooked fangs separated from the other teeth, and a peculiar disposition of the jaw. Their upper maxillary bones are very small, and borne upon a long pedicel resembling the external pterygoid process, and possessed of great mobility: there is attached to it a tooth, which contains a small canal, through which issues the venomous fluid, secreted by a large gland situated under the eye. This tooth, which together with several subsidiary germs is placed upon the maxillary bone, is concealed by means of the mobility of that bone, in a fold of the gum when the animal does not make use of it.

The Batrachia, or frogs, toads and salamanders, have a single auricle, and a single ventricle in their heart. They have lungs, and, in early age, branchiæ resembling those of fishes. In this first state, the circulation is like that of fishes; the artery divides in the branchiæ; the vessels afterwards unite into an aortic trunk for the whole body and even for the lungs. When the branchiæ disappear, their arteries become obliterated, excepting two branches which unite to form the aorta, and which give each a small branch to the lung. The eggs are membranous, and are fecundated, during, or after deposition. The young, when excluded, have branchiæ, and are destitute of feet. As they grow, the former are obliterated, and the latter develope themselves. Some species retain their branchiæ during life.

59. Birds have an organization evidently disposed for flying. Their general form, the proportion of their parts, their abundant respiration, whence result their specific lightness and a great degree of muscular vigour, all unite to adapt them for this mode of motion. They have only two feet, their anterior members being alone destined for flying. The thorax and abdomen form a single great cavity, the vertebræ of which possess little mobility. The sternum is of very great extent, which is further increased by a plate that projects like a keel. The sternal part of the ribs is bony like their vertebral portion. In this part of the trunk every thing is so disposed as to give a firm support to the wings, and afford points of attachment to their muscles. The shoulders are formed by the fourchette, the coracoid bones, which are very large, and elongated and feeble scapulæ. The wing is sustained by the humerus, the two bones of the fore-arm and the hand, which is elongated and has one finger, and two others in a rudimentary state. It bears a row of elastic quills. The pelvis, which is very elongated, furnishes attachments to the muscles of the inferior extremities, and its bones are sufficiently separated to leave a space in which the eggs are developed. The inferior extremities are formed of the femur, the tibia, and the fibula, which are joined to it by a spring articulation, keeping themselves extended without muscular effort. There are also muscles which go from the pelvis to the toes over the knee and heel, so that the weight of the body itself bends the toes. The tarsus and metatarsus are formed by a single bone terminated below by three pulleys. There are gene-

rally a pollex and three toes, having various directions, and of which the number of articulations increases from the pollex, which has two, to the outer toe which has five. The neck is elongated, formed of numerous vertebræ, and possessed of great mobility. The coccyx is very short and furnished with feathers, like the wings. The brain, which presents the same characters as that of the other oviparous vertebrate animals, is remarkable for its great size in proportion to the body, but this does not depend upon the hemispheres, which are small. The skin of the bird is in general covered with feathers composed of a hollow shaft and barb. It is scaly on the upper part of the toes and callous on their under part; the sense of touch must consequently be very feeble in them. The eye is furnished with three moveable palpebræ, the cornea is very convex, the crystalline lens flat, and the vitreous body small. The crystalline lens is furnished with a membrane which appears intended for moving it. The fore part of the eye is provided with a bony circle. Birds see objects distinctly far and near. The ear, which is a little more perfect than in the other ovipara, has no small bones in the vestibule; the cochlea is a little arched; there is a small bone between the fenestra ovalis and tympanum, which is destitute of a concha excepting in the nocturnal species. The organ of smell, which is concealed in the base of the beak, has commonly three cartilaginous horns and no sinus. The tongue is much less muscular than in the mammifera, and is supported by an osseous prolongation of the hyoid bone. The trachea has its rings entire. At its bifurcation there is a glottis or inferior larynx in which the voice is formed. The upper larynx is very simple. The lungs, which are destitute of lobes, and attached to the ribs, allow the air to pass into several cavities of the abdomen, thorax, axillæ, and even of the bones, which lightens the body and increases the extent of the respiration. The upper jaw is principally formed by the intermaxillary bones, and is prolonged posteriorly into two arches, an inner, formed by the palatal bones, and an outer formed by the maxillar and jugal bones, and which both rest upon the os quadratum or tympanal bone, which is mobile. It is joined to the skull by elastic plates. Both maxillæ are covered with horny matter which is substituted for teeth, and sometimes has the form of these bodies. The stomach is composed of three parts, more or less distinct; the crop, which is sometimes wanting; the membranous stomach, furnished with numerous secreting follicles; and the gizzard, which is provided with powerful muscles, and lined with a coriaceous membrane. In the rapacious birds, however, the gizzard is very thin and differs little from the other stomach. The spleen is small, the liver has two ducts, and the pancreas is of great size. The rectum has two appendages, sometimes only one, and in some genera none. They appear to be the remains of the allantoid membrane. The rectum, ureters, and spermatic ducts, or the oviduct, terminate in a bag called the cloaca, which opens into the anus. The testicles are placed internally, under the kidneys. There are but one ovary and one oviduct. In most birds copulation is performed by the mere application of the anuses; some genera, however, have a regular penis. The egg when detached from the ovary has only the yelk and germ; it becomes enveloped by the white in the oviduct, and at the lower part of the same canal acquires the shell. The heat of the climate, or more commonly the incubation of the parent bird, develope the young in it.

Of the Viviparous Vertebrate Animals.

60. The viviparous vertebrate animals or Mammifera, not only differ from the oviparous in their mode of generation, and in their quantity of respiration, but are especially distinguished from them by more perfect animal functions, and a greater degree of intellect, which is less controlled by instinct, and more capable of improvement.

Their general conformation is that of the vertebrata.

The splanchnic cavity of the trunk is divided into two by a complete muscular septum, called the diaphragm. With a single exception, they have the neck formed of seven vertebræ. They have a sternum to which the first ribs are attached. Their head is always articulated by two condyles with the first vertebra. Their skull has the greatest similarity in its composition. There are always found in it an occipital bone, a sphenoid bone, an ethmoid, parietal, frontal and temporal bones. Several of these bones are in the fetus divided into pieces. The face is also pretty constant in its composition. It is essentially formed by the upper maxillar bones, the intermaxillar bones, the palatal bones, the vomer, the nasal bones, the inferior turbinated bones the jugal bones, and the lacrymal bones. These bones by their union form the upper jaw, which is fixed to the skull. The lower jaw, which is composed of two pieces, is articulated by a projecting condyle to the temporal bones. A hyoid bone, suspended to the skull by ligaments, sustains the tongue, which is always fleshy. The fore limbs commence with an osseous cincture or shoulder formed by the scapula, which is not articulated to the spine, but in many mammifera is supported upon the sternum by means of a clavicle. The arm is formed of a single bone; the fore arm of two, the radius and ulna, the hand, by which these limbs are terminated, is composed of two rows of small bones, to which the name of carpus is given, a row of bones named metacarpus, and fingers formed each of two or three bones, which are called phalanges. The hind limbs are similarly composed, and this similarity is more or less great according as the limbs are destined for similar or different functions. In all the mammifera, excepting the cetacea, the hind limb commences with a bony girdle or pelvis formed by the haunch bones, which are attached to the spine; and in youth these bones are formed of three distinct parts, the ilium, pubes and ischium. The thigh is formed of a single bone, the leg of two principal bones, the tibia and the fibula; the foot, which terminates the limb, is composed of a tarsus, a metatarsus and toes.

The muscles possess great power of contraction; but their irritability is greatly dependent upon the nervous system. The motions are those of walking. Some species can also fly by means of elongated limbs with membranes extended between them. Others have the limbs very short and can only swim. The nervous system of the mammifera is especially characterized by the state of the cerebellum and cerebrum. The cerebellum has large lateral lobes or hemispheres, and there is always a pons varolii beneath the medulla oblongata. In like manner the brain has always corpora striata, and is always formed of two large hemispheres, furnished with circumvolutions, forming two lateral ventricles, and connected together by the corpus callosum.

The eyes, which are lodged in the orbits, are protected by two palpebræ, and a vestige of a third. The sclerotica is simply fibrous, and the crystalline lens is fixed by the ciliary processes. The ear in all has a complete labyrinth, with a cochlea, a tympanum, a membrana tympani, and ossicula. The nasal fossæ traverse the face, have turbinated bones, and extend into sinuses of the bones. The tongue is fleshy and attached to the hyoid bone. The skin of the mammifera is generally covered with hair, the cetacea alone being entirely smooth.

The intestinal canal is invested by the peritonæum, suspended by the mesentery, a reduplication of that membrane which contains the conglobate glands of the chyliferous vessels, and covered with a floating prolongation of the same membrane, which is named the epiploon or omentum. They have a urinary bladder, the orifice of which, with hardly any exceptions, is in that of the genital organs. The lungs, which are cellular, and the heart, are contained in a cavity formed by the ribs, separated from the abdomen by the diaphragm, and in which their surface is free. Their circulation is double, and their respiration simple and aerial. They have a larynx at the upper extremity of the trachea which opens into the back part of the mouth and nostrils, the communication of which depends upon a moveable fleshy veil, called the velum palati.

What especially distinguishes the organization of the mammifera is their generation, which is essentially viviparous; in other words, the membranous egg descends and is attached to the uterus, after conception, which requires a copulation by which the spermatic fluid of the male is propelled into the organs of the female. They have, indeed, like all the oviparous vertebrate animals, at least at the very commencement, an umbilical or intestinal vesicle; they have also, like the pulmonate ovipara, an allantoid membrane; but they have moreover envelopes, of which the outer, the chorion, is attached to the walls of the uterus by one or more plexus of vessels called placentæ, which establish between it and its parent a communication by which it receives its nourishment and probably oxygen also. When the fetuses have acquired the necessary development, they are expelled along with their lacerated envelopes. The mammæ, which are secreting glands, produce milk for nourishing the young so long as they require it.

It is to this kind of organization, which still presents certain varieties, that man belongs.

61. The mammifera thus present some organs which are peculiar to them, of which kind are the hairs upon their skin and the mammæ. In all the other circumstances of their organization, they differ from the other vertebrate animals only in having certain organs, for example the ear, the brain, &c. more developed, or in possessing different combinations of the organs of circulation, respiration, and motion.

The blood of the mammifera differs from that of the ovipara in respect to the form of the coloured particles, they being circular or lenticular in the mammifera, whereas in the ovipara they are generally oval or compressed ovoidal.

The hairs of the mammifera do not differ essentially from other horny appendages of the skin. They are, like all the organs of this kind, produced by an excretion at the surface of that membrane.

The mammæ are also entirely of the same nature as the other glandular secreting organs.

62. The mammifera still present considerable variations in their organization, whether in the organs of touch, which are so much the more perfect the more numerous and mobile the toes are, and the less they are enveloped by the nails; or in the organs of manducation, and consequently in the rest of the digestive organs; or lastly, in the organs of generation. The different combinations of these variations, which induce many others in all the functions, and even in the intellect, have given rise to the division of this class into several orders, among which is that of the bimana, formed of a single genus, man.

63. Man is distinguished from the other mammifera by some not very important differences in the organs of the vegetative functions, by some others of a more decided character in the organs of the animal functions, but more especially by his superior *intellect.*

The intellect which constitutes man is especially characterized by consciousness, reason, a free will, the moral sentiment, and the sentiment of a divine cause.

Man, moreover, of all animals has the hemispheres of the cerebrum and cerebellum most developed and most abundantly furnished with circumvolutions. This great size of the hemispheres becomes still more apparent when it is compared with the spinal marrow, the nerves, the organs of sense, and the muscles. His cerebral functions are greatly developed, and very distinct from instinct. He is possessed of speech, and lives in society.

He is the only animal truly bimanous and a biped. His whole body is organized with reference to the vertical posture; and his hands are evidently reserved for other purposes than standing.

The heart has an oblique direction with regard to the diaphragm, and the aorta is somewhat differently disposed from what it is in quadrupeds. The organs of digestion are adapted for a diversity of food, but chiefly for vegetable food. The penis is free, and without an internal bone; the uterus is a simple and oval cavity; the mammæ, which are only two in number, are situated at the fore part of the thorax.

But as all the rest of this work is devoted to the study of the human body, it would be superfluous to insist upon characters which will be exposed in their places.

SECTION SECOND.

OF THE HUMAN BODY.

64. Man, as will be perceived, participates in the general characters of bodies, of organized beings, of animals, of vertebrate animals, and of mammifera. Like every other being, he has also characters peculiar to himself. It is the study of all these characters, whether of external and internal conformation, or of phenomena or functions, that forms the subject of anthropology or the science of man. Human anatomy, which is also called anthropotomy, has for its particular object the knowledge of the human body, that is to say, of all the parts which enter into its composition, and of their mutual arrangement.

65. The anatomist may study the human body in two different states: in the most ordinary state, that which is proper to the species, and alone compatible with the state of health; or in its deviations from the natural state. In the former case, he studies the anatomy of man in health; in the latter, morbid anatomy.

In the study of anatomy, the human body may be considered in its entire state; the general characters of all its organs, all its humours, &c. may be contemplated. This is the general view of its constitution. The multiple organs may be brought together into genera or systems, according to their resemblances of texture, and the generic characters alone may be taken into consideration, all the specific differences of the organs being kept out of view; and of those which, without being multiple, are extended to the whole of the body, there may only be considered the general characters, the local differences which they present in the various regions being overlooked. Such is the object of general anatomy: it affords a somewhat more precise knowledge of the subject than the most general consideration above mentioned. But to know the human body in a positive and profitable manner, it is necessary to join to this a correct knowledge of each organ in particular, and of each region of the body. Such is the twofold object of special or particular anatomy.

General Anatomy, viewing together the organs which resemble each other in their texture, and confining itself to what they possess in common, has for its especial, but not its only object, their texture. The special anatomy of organs, improperly called descriptive anatomy, takes cognizance particularly of their conformation; for it is in this especially that they differ from each other. Their respective situation forms the essential object of the anatomy of regions or topography.

66. The external conformation of the human body is symmetrical:* it is divided into two similar lateral portions by a vertical median line. This line even appears defined in some places, where it forms what are called raphæ or seams, which seem, in fact, to result from a kind of seam, or meeting of two lateral parts originally separated. The symmetrical disposition is not equally distinct in all parts of the body: it is more so in the organs of the animal functions, and less in those of the vegetative functions, those of nutrition in particular. In fact, the bones, the nervous system, the organs of sense, and the muscles, are the most symmetrical parts; and the organs of digestion, circulation, and respiration, are less so than the genital organs. It would not, however, be correct to say, that symmetry belongs to the former, and is foreign to the latter: it belongs more to the external parts in general, and is less distinct in the deep-seated parts. Thus, the lacrymal and salivary glands, the thyroid gland, the mammæ, the testicles, and all the organs of the functions of nutrition and generation, are symmetrical; while the nerves of the larynx, stomach, and intestines, and the diaphragm, are not. It is also observed, that certain parts which are developed at a later period, are less symmetrical than those of the same kind which are sooner developed. Thus, in the nervous system, the spinal marrow, which is first developed, is more symmetrical than the brain; the ribs are more symmetrical than the vertebral shaft or the sternum. Lastly, it is observed that the parts are more symmetrical at the epoch of their formation, and that this kind of regularity afterwards alters: the stomach, intestine, and liver, are at first much less irregular than they afterwards become; the vertebral column, which is at first precisely in the middle, is turned a little to the left, from the predominance of the right arm, and from this also result the inclination of the nose, the unequal elevation of the testicles, the frequency of herniæ on the right side, &c. There is sometimes observed such a derangement of symmetry, that the organs of one side occupy the opposite side, and vice versa: this is what is called transposition of the viscera. In this case, which occurs about once in every three or four thousand subjects, and which I have seen four or five times, the right lung, the liver, and the cœcum are placed on the left side, and the two-lobed lung, the apex of the heart, the spleen, the sigmoid portion of the colon, &c. are

* See among others, Bichat, *Rech. Physiol. sur la Vie et la Mort.*— Meckel, *Beitr. Zur Vergl. Anat.* Leipzig, 1812.

on the right side. The individuals in which this transposition occurs, are not, however, left-handed. The diseases which affect the symmetrical organs, and those which have their seat in the parts that do not possess symmetry, present remarkable differences. It has even been asserted, but from hypothetical views, that the two sides of the body are each more disposed for certain diseases.* †

Comparisons have also been established, and resemblances searched for, between the upper and lower halves of the body. The resemblance that the limbs bear to each other, is evident: the shoulders and pelvis, the arm and leg, the hand and foot, are constructed on the same plan, and differ from each other, so far as the difference of their functions goes. As to the analogy that has been supposed to exist in man, as in the articulate animals, between different sections of his trunk, and between the limbs and jaws, it rests upon a comparison between objects which differ too much to admit comparison.

Led by a forced resemblance to the radiated animals, some persons have sought in the fore part of the trunk for parts corresponding to the vertebral column, and these they have imagined to exist in the sternum. Observation here discovers no reasonable approximation except between the anterior and the posterior muscles of the vertebral column. Let us, therefore, relinquish comparisons which can lead to no useful result.

67. The human body, like that of the other vertebrate animals, is divided into the trunk and limbs. The trunk is the central and principal parts, that which contains the organs most essential to life, or the viscera. These parts are lodged in three cavities, the lower of which is the abdomen, and contains the organs of digestion, the urinary secretion and generation; while the middle, which is the thorax, contains the organs of respiration and circulation; and the upper cavity, the head, communicating with the interior of the vertebral column, lodges the nervous centre and the organs of sense. It may already have been remarked how this distribution of the viscera accords with their importance in the animal kingdom; and it will be seen, as we proceed, that it is equally relative to the order of their development. Considered in its general constitution, the trunk, which is flattened from before backwards, presents an anterior or sternal face, a posterior or dorsal face, and two sides. It also presents two extremities, the one superior or cephalic, the other inferior or pelvic. The limbs, which are jointed appendages, destined for motion, are distinguished into superior or thoracic, and inferior or abdominal. Both kinds are divided by articulations into several parts. The different parts of the trunk and limbs are also subdivided into a certain number of regions, or distinct portions, which require consideration on account of the organs which are situated in them. The

* See Meblis, *de Morbis Hominis dextri et sinistri.* Göttingen, 1818.

† I have two or three times in counting the number of cases of ulcerated limbs occurring at one and the same time in a large hospital, observed that ulcers seem to happen most frequently on the left leg.—R. K.

divisions of the body, and the subdivisions are principally determined by the bones. The knowledge of the regions is necessary for determining the precise situation of the organs, and their minute study is the surest or rather the only means of knowing the relative situation of the parts. This knowledge constitutes a kind of topographical anatomy of the highest interest.

68. The human body, like all organized bodies, is composed of solid parts and of fluids, which have a similar composition, and continually change into each other. The fluids exist in very large quantity, their general mass greatly exceeding that of the solids. Their relative proportion however cannot be exactly determined; first, because certain fluids, as oil, are with difficulty separated from the solids; secondly, and that more especially, because many solid parts are susceptible of being rendered fluid, and in drying, mingle with the fluid parts, and are dissipated with them. It has, however, been attempted to determine the proportion which the fluids bear to the solids, and this in two ways, first by desiccation in a furnace or stove, and secondly, by mummification. Some think the proportion of the fluids to the solids to be as 6 to 1, while others consider it to be as 9 to 1. The examination of an adult mummy has yielded a still greater predominance to the fluids, it having weighed only seven pounds and a half. But although the proportions might be accurately determined in one case, they would still vary in different individuals, as differences of age, sex, constitution, &c. would induce great modifications in them.

The solids and fluids are formed of globules, and an amorphous substance, which is fluid in some and concrete in others.

69. The chemical composition * of the solids and fluids of the human body, results from a certain number of immediate substances, the principal of which are gelatin, albumen, mucus, fibrin, oil, water, sugar, resin, urea, picrocholine, osmazome, zoohematine, phosphate of lime, carbonate of lime, &c. These substances themselves are compound, and the elementary principles which occur in the human body are oxygen, hydrogen, carbon, azote, phosphorus, calcium, sulphur, potassium, sodium, chlorine, iron, and manganese. There are even found in it magnesium and silicium.

These elementary substances, to form the immediate principles, and the latter to compose the solid and fluid parts of the body, are combined in the acts of nutrition and generation in a manner which chemistry is unable to imitate; and it is precisely this act of formation or of organization that characterizes life.

OF THE HUMOURS.

70. The fluids or humours of the human body † are contained in the solids and penetrate all their parts. They are composed of

* See Orfila, *Chimiè Medicale.*

† See Plenck, *Hygrologia corporis humani.*—Chaussier, *Table Synoptique des Humeurs.*

molecules which have come from without for the support of the body, and of those which are detached from the body in order to be ejected. Their fluidity is not due to caloric and water alone, like that of bodies foreign to the organization, but depends like their composition, upon the vital action. The fluids differ from each other, some being gaseous, others in the state of vapour, others again liquid. They also differ in colour. Their composition varies in like manner, but it is peculiar to themselves, and cannot be imitated by art.

The humours may be divided into three kinds: 1st, the blood, the central mass into which flow, or from which proceed all the others; 2dly, the humours, which come to the blood from without; 3dly, those which emanate from it.

71. The blood is a fluid of a red colour, having a peculiar smell, and a somewhat salt and nauseous taste. Its temperature is that of the body, of which it is even the warmest part. It is viscid to the touch, and its specific gravity is about 105. It is contained in the heart and blood-vessels. Its quantity in the adult is great, but variable, and has been estimated at from eight or ten pounds to eighty or a hundred.

72. Those who occupy themselves with microscopical observations have discovered the following circumstances with reference to the blood: it is composed of a serous vehicle in which microscopic particles of a red colour are held in suspension. In general these bodies have been considered as spheres marked with a luminous point in their centre, or as being perforated, and consequently of an annular form. Hewson, on the contrary, found the red particles of the human blood to be lenticular. The important observations of MM. Prevost and Dumas, as well as those made by myself, have yielded the same result. Sir E. Home and Dr. Young are of opinion that the flattening is posterior to the extravasation of the blood, and depends upon the separation of the colouring part. The particles are, in fact, composed of a central transparent globule of a whitish colour, and a less transparent red envelope, having the form of a depressed spheroid. In the human species, the diameter of the particles is about the hundred and fiftieth part of a millimetre. So long as the blood is contained in the vessels and is there in motion, things remain in this state.

73. When extracted from the vessels which contain it, the blood, during the whole time that it retains its heat, exhales a vapour formed of water and animal matter susceptible of putrefaction. It presently coagulates, probably gives out a little caloric, and also disengages a great quantity of carbonic acid gas. This disengagement, which is not very manifest when the blood is exposed to the atmospheric pressure, and is then only rendered sensible by the production of tubes in the interior of the coagulum, is distinctly observed at the exterior of the clot, when the blood is placed under the receiver of an air pump in which a vacuum is formed. This disengagement of vapour and gas from the blood,

when removed from the vessels, must not be confounded with an alleged gas that is supposed to circulate with it.

Shortly after the coagulation of the blood into a single mass, it separates into two parts. The coagulum contracts and presses out the fluid part or serum which it contained. The continued contraction, and, consequently, the quantity of serum expressed, increase until the period of putrefaction commences. The upper surface of the coagulum generally contracts more than the rest, and becomes concave. If the clot is washed under a thin stream of water, and at the same time gently pressed for a considerable period, the water carries off the colouring matter or cruor, and there remains a white fibrinous mass. Thus, by coagulation and washing, the blood is divided into serum, cruor, and fibrin.

But the following are the circumstances which take place in these operations. As soon as the blood is out of the vessels, the colouring matter of the particles leaves the white central globule, and the particles, freed of their envelope, unite together and form filaments which collect into a network in which are found contained the colouring matter and many entire particles which have not undergone this decomposition. When the clot is kneaded and washed, the water carries off, at the same time, the free colouring matter, and the particles which have remained entire, and which still contain a white globule in their interior.

There are therefore in the blood three principal substances, the serum, the white globules and the colouring matter which envelopes them. The two latter, which are united in the blood when flowing in the vessels, and thus constitute the coloured particles, separate in a great measure not many moments after the blood is withdrawn from the vessels. These substances exist in very different proportions, depending upon the circumstances of age, sex, constitution, disease, &c. In the adult and healthy man, the coloured particles form a little more than an eighth of the total weight of the blood.

74. The serum has a pale greenish-yellow colour. It has the taste, smell and feel of the blood, is alkaline, and coagulates at about 69° Cels. It then resembles the boiled white of an egg, and contains in small vacuities a substance which has been taken for gelatine, but which appears to be mucus. The constituent parts of the serum are water, albumen, soda, and salts of soda. According to M. Brande, the serum, which is nearly pure fluid albumen, may be considered as an albuminate of soda with excess of base. The coagulation appears to depend upon the neutralization of the soda necessary for its fluidity. Alcohol and most of the acids produce this coagulation by removing the soda; and by the action of the galvanic pile as well as by heat, the soda transforms into mucus a small part of the albumen, while the rest coagulates. The albumen and the serum itself present several peculiarities which deserve notice. The coagulum of albumen presents globules to microscopic inspection, and the serum, when kept fluid in a vessel for

some hours gradually discloses globules which are deposited at the bottom, and which experience a singular motion of ascent and descent when the vessel is warmed by holding it in the hand. Lastly, it is to be remarked that the coagulated albumen has the greatest resemblance to fibrine, from which perhaps it does not at all differ.

75. The cruor of the blood, or the colouring matter obtained by washing, is always a mixture of free red matter, globules enveloped by the same matter, and serum. The labours of the most expert chemists have as yet disclosed little respecting the colouring matter of the blood or zoohematine. This substance, which is insoluble in water, but capable of dividing in an extraordinary degree, and so as to pass through the filters, is formed of an animal matter in combination with peroxide of iron. The red colour of the blood varies in its shades.

76. The fibrine of the blood, or the coagulable lymph of some, presents the appearance of confused, tenacious, and elastic fibres, having the aspect of muscular fibre under the microscope, and is composed of white globules similar to those of the coloured particles of the blood. The fibrine, like the muscular fibre, when placed in water, is resolved into globules before putrefying. This substance, which is coagulable or plastic, appears to be, as well as the albumen, the means of agglutination which produces adhesions and unions in the economy.

The blood also contains a fat or oily matter.

77. The blood contained in the arteries, the veins, and the heart, undergoes in them a continual motion which is called circulation. In this motion there are experienced constant and regular alternations, which balance each other and keep it in a mean state of composition. It receives new fluids prepared by digestion and intestinal absorption ; molecules separated from the organs are incessantly added to its mass ; it is subjected to the action of the atmosphere in the lungs, where it is revivified ; it is sent into all the parts, where it experiences an alteration of an opposite kind, furnishes materials which enter into the composition of the organs, and is deprived of some of its principles by the secretions. Of these alterations the most striking are that which it undergoes in the lungs, where it becomes of a bright red, and that which takes place in the other parts of the body, in which it assumes a brownish red colour. These alterations of colour are accompanied with and appear to be owing to an absorption of oxygen in the former case, and an absorption of carbon in the latter. Besides distributing nutritive matter to all the organs, the blood is also the vehicle of the principal of heat.

78. The blood presents constant variations depending upon age, sex, and other circumstances ; it also presents accidental alterations.

In the fœtus, the blood, which is of a very dark colour, has scarcely any coagulable matter. This is also the case with the menstrual blood of the female. The arterial blood presents more coloured particles than the venous blood. In persons who make use of succulent food, the blood abounds in albumen, and in opposite circumstances is more serous. The repeated abstraction of blood diminishes the proportion of coloured particles in it, and even that of albumen, and augments the proportion of water.

In diseases, the blood undergoes alterations which have not yet been sufficiently examined. In inflammations, the clot of the extracted blood becomes covered with a white crust, which consists of fibrine, and a great quantity of free colouring matter is found in it. In other diseases, as scurvy and putrid diseases, the blood loses its coagulability and remains fluid after abstraction. There are many diseases which an attentive examination of the blood would tend greatly to elucidate.

79. The fluids which arrive in the blood are the chyle and the lymph. The first comes from the chyme, a grayish, pultaceous substance, into which the food is converted into the stomach, and in which some small globules begin to be perceived. On being absorbed by the walls of the intestine, and when it has arrived in the first chyliferous vessels, it is whitish and scarcely coagulable. In the glands of the mesentery it becomes more coagulable, and assumes a reddish tint. Lastly, in the thoracic duct, and when on the point of passing into the mass of the blood, it is distinctly rose-coloured, decidedly coagulable, and contains naked globules and particles which differ from those of the blood only in having a less intense colour. It would then seem only to require being submitted to the respiratory action to become perfect blood. The lymph, a cloudless, viscid and albuminous fluid, but little known, is the other humour which enters the mass of the blood.

80. The humours which emanate from the blood are separated from it by secretion. To those humours may be referred the nutritive mass left by the blood in all the organs by a kind of nutritive secretion, as well as those which are produced and deposited as in reserve, by a secretion which may be called intrinsic, in the closed cavities of the body, as the fat, the serous fluids and the synovia. But those which are especially referrible to this kind are the humours secreted at the surface of the external or internal integuments and their more or less distant dependencies. They are distinguished, according to their mode of formation, 1st, Into perspiratory humours, which are immediately formed and deposited at the surface by the vessels, of which kind are the matters of the cutaneous transpiration, sweat, and pulmonary perspiration; 2dly, Into follicular humours, which are at first deposited in folliculi or ampullæ of the internal or external skin, of which kind are the mucus and sebaceous matter; 3dly, Into glandular humours, formed in glands, which are particular organs having branched excretory ducts, which have their orifice on the skin and mucous membranes, of which they are branched prolongations, of which kind are the saliva secreted by the salivary glands, the bile secreted by the liver, &c., the secreted humours are also distinguished according to

their destination into those which perform some purpose in the organism, as the tears, the bile, the spermatic fluid, &c. and those which are rejected without being applied to any use, as the urine and sweat, and which are called excrementitious. These latter are acid, while the others are alkaline.

OF THE ORGANS.

81. The organs are the solid or containing parts of the body.* It is by them especially that form is determined, and motion impressed.

The figure of the organs is greatly diversified. In general, however, their contours are rounded, their surfaces never very plain, nor their lines and angles very straight or entire. In most of the organs the length greatly exceeds the breadth and depth. Some are broad and flat. The name of membranes is given to those which have this form and are soft, whatever their texture may be. Others again present little difference in their three dimensions. The external form of the organ is determined by the relative size of their three dimensions, and for this purpose comparisons more or less trivial are employed, for it is in general rather difficult to determine the form by comparison with geometrical figures.

At their interior, some organs are hollow and form reservoirs or canals communicating with the exterior. Others form cavities closed on all sides; others ramified and closed canals; while others are full or massive. All of them, however, are areolar, and more or less permeable.

Of the organs, some extend in a radiatory manner or by ramifying, from the centre to the circumference, of which kind are the vessels, the nerves, and even the bones. No organ is isolated, but all are interlaced and have communications with each other. Lastly, there exist strong resemblances between the organs, as between the regions; and certain organs, presenting a perfect similarity, constitute genera by their association.

82. The colours of the organs are white, red, and brown. Some are transparent, others opaque. Their consistence varies from a great degree of softness to an extreme hardness. They are extensile and retractile, compressible and elastic, but in very different degrees. Some have but a feeble degree of cohesion, while others are so tenacious that it requires a strong force to break them. These properties of colour and cohesion depend greatly upon the fluids which they contain in great proportion. Thus opaque parts, as the ligamentous tissue, become transparent by desiccation. This substance, which is highly tenacious and possessed of but little elasticity when moist, becomes highly elastic when dried. Elastic parts, as the tissue of the arteries, become brittle by desiccation, &c.

* See Chaussier. *Table des solides organiques.*

83 The organs also differ greatly in their texture. At first view, it is seen that several of them are formed of the assemblage or union of bundles of parallel or interlaced threads. These are said to have a fibrous texture. Others are formed by the union of layers or laminæ more or less numerous and distinct, and commonly very closely united together. Some have in appearance a very compact, uniform, or homogeneous texture, but this is only in appearance, for all the organs are areolar and permeable in a more or less distinct manner, and all are more or less complicated.

84. This first view is not sufficient to make known the intimate texture of the solid parts. On examining the organs more nearly, we find that the apparent fibres, these membranous layers, and these granulations are compound; and as the solids contain the humours, people were generally led to imagine that they consist entirely of vessels. This idea, which is evidently erroneous, since the vessels are themselves compound parts, has been very recently again brought into notice in a posthumous work of Mascagni's. Others have admitted that the organs are entirely formed of cellular tissue, which is itself formed of interlaced fibres and laminæ, or by cellules and vesicles placed in contiguity. But the cellular tissue, although indeed the principal element of all the parts, is not the only element. As to the idea of a parenchyma forming the basis or generative element of all the solids, it is extremely vague and unintelligible. Haller* admitted in the composition of the organs, besides the cellular tissue formed by the union of fibres and laminæ, and which is the most general and the most extensively distributed, the muscular fibre and the medullary substance. This division has been pretty generally adopted, with some slight modifications more or less accordant with truth. Thus Walther admits a membranous or cellular, a fibrous or vascular, and a nervous texture; Pfaff, a vascular, a fascicular, and a cellular texture; others, a cellular, a vascular, and a massive texture, or one without cellules or vessels. M. Chaussier has added to Haller's three compound parts a fourth, under the name of albugineous fibre, which forms the basis of the ligaments. M. Richerand has added to these the epidermic or horny substance. Of the twenty-one tissues admitted by Bichat, there are three which he considers as generators of the others: they are the cellular, the vascular, and the nervous. M. Meyer† also admits these elementary organs; 1. the cellule, the vessel or the gland; 2. the irritable, cellular or muscular fibre, 3. the sensible fibre or nerve.

85. Admitting with Haller the existence of three simple organs, three elementary tissues, or three fibres distinguished from each other by essential characters, viz. cellular tissue, muscular fibre, and medullary or nervous substance, we have not in this attained the ultimate stage of anatomical analysis. If the microscope be

* *De Corporis humani fabrica et functionibus.* T. I. Lib. i. sect. 3.
† *Weber Histologie, &c.* Bonn. 1819.

called in to our assistance, we see that these simple organs, and all their modifications, as well as all those compounded of them, may be reduced to two anatomical elements. They are formed of a permeable, areolar animal substance, and of microscopic globules similar to those which occur in the humours. The first substance alone forms laminæ, and most commonly fibres, which differ from each other only in having an elongated and filiform figure in the former case, and an extended form in the latter, and which although sometimes separate, are most commonly associated together. It is from their union that the cellules or areolæ, &c. result. This first element, which of itself, but variously modified, constitutes the greater part of the organs, when united with the other whose particles it brings together and connects, forms the muscular fibre and the nervous substance.

86. The organs further differ from each other by the phenomena which they present during life, and which we shall presently examine. Here it is sufficient to observe, that the cellular substance is especially remarkable for its constant condensation, which may be increased by impressions or imitations; that the ligamentary tissue and the elastic tissue, its two principal varieties, are characterized, the one by a great degree of tenacity, the other by a power of resiliance; that the muscular fibre is, by its contraction, the organ of all the great motions; and that the nervous substance is distinguished from all the others, by the faculty of conducting the impressions to the centre, and the action of the nervous centre to the muscles and other organs.

87. The organs being different from each other in their conformation, their texture, their physical properties, their chemical composition, and in the state of life in the action which they exercise, they have been divided into a certain number of classes or genera. These genera ought to be determined according to the aggregate of the characters, and not by the form alone; otherwise very different organs will be brought together, as the membranes and parts will be separated which are perfectly similar excepting as to form, as the broad and the long bones, the aponeuroses with the tendons and ligaments, the nerves and the ganglia, &c.; the fibrous or fasciculate form, and the lamellar or membranous form, being found to occur in parts which in all other respects are entirely dissimilar.

88. The ancients divided the solid parts of the body into similar and dissimilar or organic parts. The similar or homogeneous parts are those which can be divided into particles similar to each other, as the bones, the muscles, the tendons, &c. The dissimilar parts are those which are formed by the association of similar parts, as the hand, the viscera, the organs of sense, and other organic compounds. This idea of Aristotle, which was again proposed with new developments by Coiter, is the origin and foundation of all the divisions subsequently proposed among the organs. The division generally admitted in anatomical books, into bones, muscles,

nerves, vessels, and viscera, together with some other kinds, is well known. But these genera of organs comprehend parts which are compound, and some which are so in a high degree; and, on the other hand, these genera, and especially that of the viscera, contain organs very different from each other, which destroys all the advantages of their classification. M. Pinel in France, and Carmichael Smith,* in England, having observed that the simple tissues which enter into the composition of dissimilar or compound parts might become diseased, and especially might be affected by inflammation separately, and that their inflammation is the same, of whatever compound organ they form a part, paved the way to a more complete anatomical analysis of the organization than that which had previously been made, especially with respect to the viscera. Bichat,† developing this fecund idea, worthy of his genius, classed all the simple organs under the name of tissues or systems, into twenty-one genera. M. Chaussier has arranged the organs under twelve genera, the twelfth comprehending the viscera or compound organs. Various authors have since modified the classifications of these two anatomists, although they have always adopted their principal bases.‡

89. Amid all these variations, the following is a classification or division of the organs into genera according to their anatomical, chemical, physiological, and pathological characters taken together.

The cellular tissue, the principal and universal element of the organization, merits the first rank. It exists in the whole organic kingdom, enters into all the organs, and forms the basis of the whole organization.

This tissue, a little modified in its consistence, its form, and the proportion of earthy matter which it contains, forms several other kinds of organs.

Disposed in the form of membranes closed on all sides, in the substance of which there is more firmness and less permeability, it constitutes the serous and synovial systems.

It also forms the tegumentary tissue, which comprehends the skin and the mucous membranes, as well as the follicles of these two kinds of membranes and the organs which produce the hairs, the teeth, &c.

It is the same also with the elastic tissue, which forms the base of the vascular system, which comprehends the arteries, the veins, and the lymphatic vessels, and which also belongs to the same order, approaching in its nature to the muscular tissue.

The glandular system, which is formed by the union of the tegumentary and vascular systems, also belongs to the same order of organs.

* On Inflammation in Medical Communications, v. ii.

† *Anatomie Generale, appliquée à la physiologie et la Medicine*, par Xav. Bichat.

‡ See almost all the works on anatomy and physiology published since 1801, and in particular, J. F. Meckel, *Handbuch der Menschlichen Anatomie, Ester Band. Algemeine Anatomie, Halle und Berlin*, 1815. J. Gordon, System of Human Anatomy, vol. i. Edin. 1815. P. Mascagni, *Prodromo della grande anatomia, Firense*, 1819. C. Meyer, *Opusc. cit.*

The ligamentous or desmeous system, which comprehends organs possessed of great tenacity and adhesion, also results from a modification of the cellular tissue.

Lastly, the cartilaginous and osseous systems also belong to the cellular tissue, and owe their solidity to its condensation, and to the great quantity of earthy salts which that substance contains.

The second order of organs is formed essentially by the muscular fibre. It comprehends the muscles, whether those which belong to the bones, or those of the external and internal integuments, and of the organs of sense or those of the heart.

The nerves and the central nervous masses constitute the third and last order of organs, which is formed essentially by the nervous substance.

It will be seen that this classification rests upon the foundations laid by Haller, and which truly exist in nature.

90. As to the successive order in which the genera of organs ought to be arranged, it may be founded on various bases. If regard be had to the greater or less universality of the organs in the series of animals, the cellular tissue must always be placed first. After it would come the tegumentary organs, then the muscles and nerves, then the vessels, and then the glands. The cartilaginous and osseous tissues, the ligamentous and serous, would come last, as peculiar to the vertebrate animals. Another order would be followed, were the genera of organs which belong to the common or vegetative functions put first, and those which form the apparatus of the functions peculiar to animals in the second place. Another order still would be established, were we, like Bichat, to take the general systems first, as the cellular tissue, the vessels and nerves, and then the particular systems. It is not, indeed, of great importance, but it is preferable to rank the organs according to their similarity. This is the order followed above.

91. Some physiologists still place the horny or epidermic substance among the primitive fibres; but that substance, being almost inorganic, and the product of excretion, cannot be considered as an anatomical element. The characters which are assigned to it are the following. It contains no distinct cellulosity; maceration reduces it to a kind of mucilage; chemistry demonstrates in it albumen according to some, or mucus according to others, in which there is perhaps little discrepancy, as mucus appears to be albumen united with soda. This substance is that which constitutes the epidermis, the nails or claws, the hairs, and all the horny parts of animals. Although there may appear to be a slight difference between the horny and epidermic matters, the difference is not so great as to prevent their being referred to the same substance. M. Meyer, who has lately given a new classification of the solids of the human body, considers the membrane of the tympanum, the cornea and the crystalline lens, as formed of this substance, which he calls the scaly or foliated tissue; but these parts, and especially the two first, are widely different from it. The epi-

dermic substances are remarkable for the ease and celerity with which they are reproduced.

92. The names of fibre, tissue, organ, &c. designate in general the organic solids. It is necessary, however, to limit the sense that is to be attached to them. A tissue is any part that possesses a peculiar texture. The tissue differs from the fibre only in the latter being finer and forming its component part. A tissue may be formed by similar or different fibres. An organ commonly results from the association of several tissues. These distinctions, however, are not absolute. Thus the cellular tissue represents at the same time a peculiar fibre, a tissue formed by that fibre, and an important organ of the economy. In general, the fibre is the element, the tissue indicates the arrangement of the parts, and the organ is a compound part which exercises a proper function. Almost all the solids are formed by the cellular fibre and its two modifications. Some tissues have for their basis the muscular and nervous fibres; and one only, which is the tegumentary, contains epidermic substance. The organs are almost always more or less compound parts. Thus, in a muscle, there occur the muscular fibre, the cellular tissue which surrounds it, and at the extremities the tendon in which it terminates. In like manner, in a nerve, there is in the centre a soft and medullary substance, and at the exterior, a peculiar membrane which bears the name of neurilema. Certain parts, as the stomach and eye, are still more compound. In general, every organ or acting part contains cellular tissue, vessels and nerves. The cellular tissue is the most generally diffused, there being no part in which it is not met with in one form or other; next to this tissue, the vessels are of most general occurrence. With a small number of exceptions, vessels of different kinds, white or red, are found in all parts. The nerves are less abundant than the vessels, and of course still less so than the cellular tissue; most of the organs, however, are furnished with them. The latter may, therefore, be regarded as parts into the composition of which there always enters cellular tissue, almost always vessels, and most commonly nervous tissue.

The viscera or splanchnic organs derive their name from the importance of their uses. They are the organs most essential to life, those by which we live; they are the most compound organs; and are situated in the three cavities of the body, which are named splanchnic. They comprehend the organs of digestion, generation, and urinary secretion, which are contained in the abdomen; those of circulation and respiration, which are contained in the thorax; and the sensorial and nervous organs, which are lodged in the head and vertebral canal. It is especially to the thoracic and abdominal organs, and more particularly to the latter that the name of viscera is given.

93. By system or genus is meant, the association of parts resembling each other in their texture, as the bones, the muscles, the ligaments, &c. This corresponds to the similar parts of the an-

cients. By this name there have also been designated parts, such as the skin, the cellular tissue, &c. extended over the whole body, and for that reason presenting regions and divisions, but not like the preceding, distinct portions. Bichat in particular has employed the word system in this acceptation. The study of the genera of organs or systems forms the subject of general anatomy, which embraces in this manner all that the parts resembling each other present in common, and at the same time, what the generally distributed tissues have in common in their different parts.

94. The apparatus are collections of organs sometimes very different in their conformation, their situation, their structure, and even their particular action, but which concur toward a common object, which is one of the functions of life. It is erroneous to confound this association of facts with that which constitutes a system or genus of organs. The classification of the apparatus rests entirely upon the consideration of the functions, while that of the systems or genera rests upon the mutual resemblance of parts. The genera of organs have been enumerated above; the following is the manner in which the organs are associated so as to form apparatus for the performance of functions.

The bones and the parts connected with them, viz. the periosteum, the marrow, the greater part of the cartilages, the ligaments, and the synovial capsules, form an apparatus of organs which determines the form of the body, serves to support all the parts, and especially envelopes the nervous centres, and which, through the mobility of the articulations, receive and communicate the motions determined by the muscles.

The muscles, tendons, aponeuroses, and synovial bursæ, form the apparatus of motion.

The cartilages and muscles of the larynx, and various other parts, form that of phonation, or the apparatus of voice.

The skin, the other organs of sense, and the muscles by which they are moved, &c. form the apparatus of the sensations.

The nervous centres and the nerves, form that of innervation.

The alimentary canal, from the mouth to the anus, and all its numerous dependencies, constitute the apparatus of digestion.

The heart and vessels, that of circulation.

The lungs, that of respiration.

The glands, the follicles, and the perspiratory surfaces, form the apparatus of the secretions; but most of these organs being subservient to other functions, are comprehended in the apparatus of these functions. There remains only the urinary secretion, the organs of which form of themselves an apparatus.

The genital organs constitute a different apparatus in each sex.

Lastly, the egg and the fœtus which it contains, form the last group or apparatus of organs.

OF THE ORGANISM.

95. The human body, during life, presents very numerous phenomena, and of different kinds. Mechanical and chemical actions take place in it, as in all bodies; but they are modified by the vital actions. There are in fact in the human body, as in every organized and living body, the essential phenomena of life, viz: nutrition and generation, organic actions whose exercise is subordinated to other actions proper to animals, namely, the muscular motions and the sensations, which are themselves subjected to innervation. These animal actions, in short, are directed by functions of a higher kind, which are those of the intellect. Besides this remarkable order of subordination among the phenomena of life, there also exists among them such a concatenation that the functions of an inferior kind also hold in subjection the functions of a higher order, and all the functions are so mutually dependent that the phenomena of life may be compared to a circle, which, when once traced, has no longer either beginning or end. This circle of organic actions, as has already been said, is what is called the organism of life.

96. The term function is applied to the action of an organ or apparatus of organs having a common object.* The functions have been classed or distributed into several kinds, not that the divisions thus instituted are perfectly correct, nor that they are of much use in aiding the memory, as the objects to be classed are not numerous; but because in their exposition it is necessary to follow some particular order, and because it is better to follow a natural order than one entirely arbitrary. The division of the ancients, adopted with some modifications by Haller, Blumenbach, Chaussier, and some other moderns, consists in arranging the functions in four classes: the vital, animal, natural or nutritive, and genital. Another division which is also derived from the ancients, since the first idea of it is found in Aristotle, which has also been mentioned by Buffon, Grimaud, &c., and which has been adopted and developed by Bichat and Richerand, consists in referring the functions to those of the species and those of the individual, and the latter to relative or animal, and nutritive or organic functions.

97. The following is a very natural order, according to which the functions may be arranged. Some functions are common, if not in all their acts and all the organs, at least in their results, to all organized bodies, vegetable as well as animal. They are the common, organic or vegetative functions: 1st, Nutrition, which comprehends digestion, absorption, circulation, respiration, and the secretions, and of which the final result is the maintenance of the individual in its form, composition, and temperature; 2dly, Generation, which comprehends the formation of germs, that of

* See Chaussier, *Table Synoptique des Fonctions.*

the spermatic fluid, fecundation, and the development of the fecundated germ, and of which the result is the maintenance of the species, or the keeping up of a succession of similar individuals. The other functions are peculiar to animals, and are, 3dly, Muscular action, the results of which are locomotion, gesture, and the voice, and moreover, the muscular motions necessary for the performance of the two preceding functions; 4thly, The sensations; and 5thly, Nervous action or innervation. Another order of functions still belongs exclusively to man. These are the intellectual functions, which have only an apparent existence in the animals which most resemble him. Lastly, man does not exercise individual functions only, but, living in society, he exercises collective actions, the observation and arrangement of which do not belong to physiology or medical science.

98. In bodies in a state of rest, we perceive only the qualities by which they strike our senses. In bodies in action or in motion, we still distinguish only phenomena or changes perceptible to our senses. Of the qualities and phenomena, some are common to all bodies, others peculiar to organized and living bodies. The latter are their proper qualities and phenomena, in a word, their properties. The properties are, in fact, nothing else than sensible qualities and phenomena. When phenomena take place in an order of which all the conditions can be determined, the law of these phenomena is known, in other words, the rule which they follow, and to which they appear to us to be subjected. This law, when it is general, receives the name of theory. Beyond this we know nothing. But we admit, in general, that matter is inert, and whenever we see it in action, we suppose a cause of motion which makes it act, and which we call a force or power. Thus organic matter being in action during the whole period of life in organized bodies, it has been said that life has a vital power for its cause. *

This power has been considered as a substance different from the organs, and of which the latter are the instruments, and it has been sometimes described as rational, sometimes irrational. It has also been considered as a faculty or activity proper to matter, whether of solid organic matter, or of fluid matter. It has also been regarded as resulting from organization, that is from the assemblage of all the solid and fluid parts of an organized body, &c.

It would no doubt have been better, in a physical science like that of organization and life, to have stuck to the observation of bodies and facts, without letting the imagination loose.

99. The organic or vital phenomena being different from each other, the vital or organic powers which have been admitted, are also of several kinds.

There are phenomena of organic formation, such as those of nutrition and generation, the reparation of injured parts, reproduc-

* See *Reil. Von der Lebenskraft, in Archiv. furv die Physiologie.* B. 1. Halle, 1795.—Chaussier, *Table Synoptique de la Force Vitale*, &c.

tion, &c. There has also been admitted, under the name of plastic force or power, formative power, or vital affinity, a power of formation, which is common to all organic bodies and to all their parts. *

100. The solid parts of organized bodies, and especially of animals, receive from various agents impressions which are immediately followed by more or less appreciable motions. These have been called motions of irritation, and the power or cause to which they are attributed is named irritability. † All animal parts are susceptible of them, but in very different degrees. Three principal varieties of these motions are distinguished. In the cellular tissue, where it exists in a feeble degree, it is called tonicity; in the vessels, where it is more observable, it is called vascular contractility; and in the muscles, where it exists in the highest degree, it is named muscular irritability or myotility.

It is to be remarked, that all these motions consist of contractions. It has been imagined, however, that certain motions depend upon an expansion, elongation, or turgescence;‡ but this opinion has resulted from imperfect observation.

101. In man, and those animals which have distinct nerves and a nervous centre, the impressions received are transmitted by the nerves, and felt at the centre; and the centres transmit their action by the nerves to the muscles. The cause to which these phenomena are referred, is called the nervous power, and, in a word, sensibility. Of the sensations, some are extremely obscure and vaguely perceived.§ They are almost generally diffused, but especially in the mucous membranes. In the state of health they constitute a general feeling of comfort; and when exalted by certain causes, give rise to a morbid sensation, which is called pain. There is no part of the body that may not be the seat of this morbid sensibility. The other sensations are distinct, and some of them entirely special.

The nervous action applied to the muscles directs their irritability. It also acts upon the vessels, especially the smaller ones.

The intellectual and moral actions differ so much from the organic phenomena, that they cannot depend upon the same cause; for were it so, they would be blind and necessary, in place of being open and free. Physiology, which, on the one hand, approaches physics or natural philosophy, here touches moral philosophy or metaphysics.

102. The functions are not exercised, or, in other words, the vital powers do not enter into action spontaneously, but through the action of stimulants or excitatives, whether these stimulants be the bodies which act upon the external and internal surfaces of our body, or the blood which penetrates into all its parts: with

* See Blumenbach. *Uber den Bildungstrieb*, Göttingen.
† See Gautier, *de Irritabilitatis Notione, Natura et Morbis*, Halle, 1793.
‡ See Hebenstreit, *de Turgore Vitali*. Lipsiæ, 1795.
§ See Hubuer, *de Cœnæsthesi*; Halæ, 1794.

reference to their effects, stimulants are very different from each other. With respect to the subjects on which they act, their variety is not great, and depends upon age, sex, and especially the diversity of the organs which experience in a greater or less degree the action of the same agent.

In the organization all the parts having a mutual connexion, the action of no organ is isolated, those which are centres exercising an influence upon all those which are subordinate to them. Others enter into play by association. Some perform the action which is interrupted in another, for the purpose of supplying it. There is not a single organ which, on being excited in an extraordinary manner by an appropriate stimulus, does not exercise a greater or less influence upon the entire organism.

OF THE DEVELOPMENT AND DIFFERENCES OF THE ORGANIZATION.

103. Each organ, each action, and consequently the entire organism, presents stages or degrees of development or perfection. The first period is that of youth, of growth, and successive development. The second, which is very short, is that in which the organization remains in a state of maturity. The third and last is that in which the organism progressively changes, and naturally arrives at death and decomposition.

104. It is at the commencement of life that the resemblance between the lateral parts is greatest. The heart is then vertical and median, the lobes of the liver are nearly equal, the stomach is vertical, &c. The upper and lower limbs are perfectly similar, at the moment when they first appear, and for a short time after. The genital organs of both sexes are also at first alike. It is at the commencement of life, too, that animals most resemble each other. The relative size of the parts changes with age: thus the nervous system, the organs of sense, the heart, the liver, the kidneys, &c. bear at first a very great proportion to the rest of the body; while, on the contrary, the intestine, the spleen, the genital organs, the lungs, the limbs, &c. are very small in proportion to the rest of the body and the other organs. This, joined to the circumstance that certain parts disappear or become greatly diminished with age, constitutes a kind of metamorphosis. Thus the membranes of the egg and the placenta, the membrane of the pupil and the milk teeth, cease to exist; and the surrenal capsules and the thymus gland greatly decrease, and almost entirely disappear.

105. The organs and humours are not always in the same proportion: at the commencement, the embryo is nothing but an almost entirely fluid molecule; the proportion of solids increases with time, and continues increasing to the end. The colour is also gradually developed: all the parts are at first white; the

colouring of the blood, as well as of the other parts, takes place by little and little. There is at first no determinate texture in the organs; there are not even globules at the commencement. At a later period, the entire mass of the body appears globular or granulated; afterwards, the fibres, laminæ, and vessels become distinct. All the organs are not developed at the same time; nor are all those of the same kind or system formed together. The external form or configuration is determined before the consistence, texture, and composition are fixed; for, as is seen in the fruit of the almond, which already has its form, and which is as yet but a glairy fluid which is successively to acquire the consistence, texture, and composition which are proper to it; so also are the nervous and osseous systems already in part possessed of their configuration, while they are yet in a state of fluidity. The cellular tissue and the vessels permeable to fluids diminish from the commencement to the end of life. It is this change especially, which goes on after the period of growth has terminated, that appears essentially to constitute the period of the deterioration of the organism, and of old age.

106. The organs are formed by isolated parts, which afterwards unite. Thus the spinal marrow is at first a double cord; the intestine and the cavity of the trunk, which are at first open anteriorly, afterwards close, which is also the case with the spinal canal. The vessels are at first isolated vesicles, which elongate and communicate with each other in the mass of the body. The kidneys are at first multiple, and at length unite into a single body. The bones, which in the cartilaginous state elongate by a kind of vegetation, ossify at a later period, in separate pieces, which ultimately unite, &c. There remain in certain places traces of this formation, more in some, in others less. Thus the raphe of the skin, the median suture of the frontal bone, the median line of the uterus, &c. are sufficiently apparent traces of a union of two similar halves. On the other hand, these traces are generally entirely effaced in the upper part of the sternum, and the body of the vertebræ.

107. All the phases through which the human organism passes correspond to permanent states in the animal kingdom. We might here accumulate proofs of this important proposition, by comparing the human fetus at different degrees of development with the degrees of organization of the animal scale; but we shall content ourselves with a few examples. The embryo is at first nothing but a small bud or germ placed upon a vesicle; such are some of the most simple worms. At a later period, it is a small vermiform body without distinct limbs or head: this is the case with the annelides. After this, the limbs are equal and the tail protrudes; which is the case with most quadrupeds. In the nervous system, the nerves with their ganglia are first seen to make their appearance. This is the case with all the invertebrate animals that are furnished with nerves. At a later period, there are

distinguished the vertebral and cranial medulla, the tubercles of the latter, and only as yet rudiments of the cerebellum and brain; this is the case with fishes and reptiles. At a still more advanced period, their latter parts grow much more than the tubercles, and the encephalon is successively that of birds and mammifera; until, at length, from the predominance of the cerebral and cerebellar lobes over the rest, it becomes that of man himself. If we follow the development of the bones, we shall see them at first mucilaginous, then cartilaginous, then osseous, and in this state at first separated into several pieces, which at length unite. On comparing this development with the state of the osseous system in the lamprey, the cartilaginous fishes, and the oviparous vertebrate animals in general, we see another proof of the proposition advanced. We should find similar proofs were we to examine all the different organs, and their collective masses.

108. Man is distinguished from all animals by the great rapidity with which he passes through the first periods of his formation or development. Indeed it is difficult to perceive their first changes in him. This is a point of comparison between man and the other animals, and between man and himself at different ages, which is already rich in facts, and recommends itself, by its importance, to the observation of those medical men who practice the art of midwifery.

109. The organic phenomena, as will readily be imagined, follow the successive development of the organs. In the embryo there are at first only an absorption and an almost immediate assimilation of the nutritive matter. The vessels afterwards become apparent, and it is then the circulation that carries the materials of nutrition to the different parts. The secretions then begin to be performed, and the blood of the fetus, placed in contact in the placenta with that of the mother, undergoes in it a kind of branchial respiration. At birth, respiration of air and digestion join themselves to the other nutritive functions, and the animal functions enter into exercise; and here, as in the whole of the animal kingdom, we see the organs, which are the last developed, and their functions, keeping all the rest in subjection, and life resulting from the concatenation of organic actions.

110. The organization of man presents differences in the sexes.* Besides those which exist in the organs of generation, there are others in the general form of the body, and in the proportion of its parts. The male is, in general, larger than the female: the total weight of his body is about a third greater. The forms are more rounded in the female, coarser and more prominent in the male. The female has the trunk shorter, and the lower limbs longer, so that the middle of the body is lower in her than in the male. She has the abdomen, and especially the pelvis, broader in

* See J. F. Ackermann, *de Discrimine Sexuum Præter Genitalia*. Mogunt. 1787. *Ejusdem Historia et Ichnogr. Infantis Androgyni*. Jenæ, 1805.

proportion to the shoulders and chest, of which the latter is short and narrowed. The organs contained in the abdomen are larger, and those of the chest and neck are smaller, in proportion to the rest of the body, in the female than in the male. The bones and muscles are less developed, and the adipose tissue more so; the general texture of the parts is softer and looser; the hairs are smaller and less numerous. As to the genital organs, the great differences which they present do not destroy essential analogies. The external characters of the sexes which have just been pointed out, appear to depend especially upon the existence and action of the ovary in the female, and of the testicle in the male. In the embryo, where the sex is doubtful, there are no appreciable external differences. In the fetus and child they begin to exhibit themselves in proportion as the genital organs are developed: it is at puberty that the sexual organs are most distinct, and in old age they again exhibit a less decided character. The want of complete development in the ovaries or testicles, their alteration by diseases, and their entire removal, also prevent the general differences of the sexes from assuming their natural character, or obliterate them in a greater or less degree. The causes of the difference of the sexes have been supposed by some to exist in an alleged predominance of the coagulating principle or of oxygen in the male, and of hydro-carbo-azotic nutritive matter in the female.

111. The human species present hereditary differences of organization in the races or varieties diffused over the globe, and which may be referred to five, or to three principal kinds, viz. the Caucasian, the Mongolian and Ethiopian, and the Malay and American races.

112. The Caucasian race, to which the inhabitants of Europe belong, is remarkable for the beauty of the form and proportions of the head, in which the skull is much larger than the face, of which one may be convinced by simple inspection as well as by measurement. The skull is rounded and elevated, the face oval, and its parts little protruded. The colour of the skin is generally white and roseate, that of the eyes brown or blue, while the hair, which is generally close, fine and long, varies from flaxen to black.

This race is peculiarly characterized by the development of the intellectual faculties, by civilization and the cultivation of philosophy, the sciences and arts. The coloured races, on the other hand, are superior to it in the greater perfection of the senses.

113. The Mongolian race is distinguished by the great size of the chest, the smallness of the limbs, the nearly square form of the head and the obliquity of the forehead, the breadth and flatness of the face, the prominence of the cheek-bones, the narrowness and obliquity of the eyes, and the distance at which they are placed from each other. The colour of the skin approaches to olive; the hair is straight, black and short; the beard thin, and sometimes wanting altogether.

114. The Negro race has the trunk slender, especially at the

loins and pelvis. The arms are long, especially the fore-arm; the hands small, the feet large and flat; the knee and foot are turned outwards; the head is narrow and elongated; the lower part of the face is prominent; the nose is flattened; the fore-teeth are oblique, and the lips thick; the skin, the iris and the hair are black; the latter is curled or woolly, and the beard is thin.

115. The American race has less decided anatomical characters, and seems intermediate between the Caucasian and Negro races. The skin is copper-coloured, the hair black, straight and fine, and the beard thin or wanting.

116. The Malay race, like the American, does not possess very distinct anatomical characters, and appears intermediate between the Caucasian and Mongolian. In this race, the skin is brown or yellowish, and the hair thick and curled.

117. Fabulous varieties have been admitted in the human species, which we must here pass over in silence. Albinos are the result of a morbid alteration.* In each race there occur varieties which are more or less distinct. In the different countries of the globe, even such as are very near each other, there is generally observed a national character, at least in the physiognomy. But more than this, in each race, in each nation, and even in much more limited divisions, there sometimes occur individuals very different from others. Thus it is not rare to find in the Negro race all the anatomical and physiological characters of the Caucasian race, excepting the colour; and the same may be remarked of the other races. The varieties also blend together by insensible gradations. These varieties, therefore, in the species, must only be considered as accidental differences, whose causes, indeed, are not easy to be determined; but, in such a matter, how short, and, consequently imperfect, are our observations, for determining the conditions of a phenomenon in producing which nature has not spared time.†

ALTERATIONS OF THE ORGANIZATION.

118. The human body does not always arrive at the final term of its existence by a progressive change of organization. Most commonly the development is arrested, or deviates from the established order; or the organization, after being regularly developed, becomes altered by the action of external agents. The body thus altered in its conformation, texture, and composition, is the subject

* This opinion appears to have been first a theory of Blumenbach's, and notwithstanding his respectable authority, is a mere theory. It is true that albino varieties in men possess very generally but feeble intellect, but neither is this constant. The albino varieties in other animals, and which are extremely numerous speaking with a reference to species, such as the horse, the ox, the elephant, &c. are not observed to show any inferiority as to vigour from the coloured individual of the same species. K.

† See an admirable Letter on this subject addressed by Dr. Edwards to the Count Thierry, Paris, 1829.

of morbid anatomy. To the medical practitioner this anatomy is the necessary complement of the anatomy of the human body in its healthy state. It is to pathology what common anatomy is to physiology. There is no more pathology without morbid anatomy, than there is physiology without anatomy; nor are there morbid phenomena or symptoms without altered organs, any more than phenomena without bodies, or motion without matter. Morbid anatomy, in short, is the foundation of pathology.

119. The derangement of the organization may refer to the conformation of the body in general, or to that of certain organs. This constitutes a first class, that of vices of conformation. Some of these are original or primitive, others secondary or acquired. The latter are numerous and greatly diversified. The attentive observation of the former has led to the discovery of one of the most important laws of the development of organization. These vices, in fact, are essentially nothing else than a permanent state, in one or more organs, of the stages or degrees through which they pass in their successive development. Thus, for example, the numerous vices which consist in a disunion or separation in the median line, as the hare-lip, the separation of the arch or veil of the palate, the opening of the sternum, the diaphragm, the wall of the abdomen, the anterior wall of the bladder, the bones of the pubes, the ureter, perinæum, spina-bifida, cranium bifidum, &c. are the permanent state of a separation which in the ordinary progress of the organization is only temporary.

The joining of the fingers or toes together, the prolongation of the coccyx, the persistence of the pupillar membrane, the bifid uterus, testicle retained within the abdomen, &c. are also situations, divisions, unions or states of organs, which ought only to have been temporary, but which have become permanent. This is also the case with the abnormal communications of the cavities of the heart, the opening of the bladder at the umbilicus, the existence of a cloaca, and congenital umbilical hernia.

Sometimes, one of these vices existing, the rest of the organization is developed nearly in the ordinary way; but in certain cases, one imperfection necessarily induces others; and of this the following is one of the most striking examples: If the olfactory nerve and the ethmoid bone which contains it are arrested in their progress, the orbits and eyes will be more or less intimately confounded, and will constitute what is called a cyclops.* This is equally the case with many other vices of conformation.

This part of pathological anatomy, which has only been looked upon as an object of curiosity, is on the contrary of the greatest interest to the physiologist and pathologist.†

* See Beclard, *Memoire sur le Fœtus Acéphales.*

† The best memoirs on this subject have been written by M. Geoffroy St. Hilaire. The omission of that distinguished naturalist's name seems to be almost the only occasion on which Dr. Beclard has deviated from his usual candour and honourable feeling towards his cotemporaries. It were easy for me to explain the reason of

120. The derangements of the organization may also consist in an alteration of the texture and composition of the organs. Such are the effects produced by irritation, inflammation, and other less known derangements of the secretions and of nutrition. Adhesion in general, and the differences which it presents in the various separated organs; pus and the other fluid extracts of inflammation; the transformations of a tissue into another resembling the healthy tissues; the conversion of an organ into a substance which bears no resemblance to any thing in the regular organization; the soft or hard concretions which form in the ducts and reservoirs of the follicles and glands, and which depend upon an alteration of the secreted fluid, and of the secreting organ, are so many examples of this important class of vices, whose study is not of dubious utility, as that of the vices of conformation might seem to be.

To these two classes must be added that of the numerous intestinal worms and parasitic animals, by which man is infested.

OF DEATH, AND OF THE BODY AFTER THE EXTINCTION OF LIFE.

121. Death is the total and final cessation of the functions of life, followed presently after by the dissolution of the body. It is the necessary and inevitable result of the successive changes of the organism. It is seldom, however, that it forms the last term of life, protracted to extreme old age, being more commonly induced by accidental causes.

Life consisting essentially in the reciprocal action of the circulation of the blood and innervation, death always results from the cessation of this reciprocal action. Death through old age appears to result from the simultaneous weakening of these two functions and the simultaneous alteration of their organs; and accidental or morbid death from the original alteration of one of the two organs of its function. It is always in fact through the interruption of the nervous action upon the organs of circulation, or through the cessation of the action of the blood upon the nervous centre, that death is determined by accidents and diseases. But the blood may cease to act upon the nervous system so as to support life; whether because the heart no longer propels it, and the vessels cease to conduct it; or because it is not cleared of noxious principles by the secretions, and especially by the urinary depuration; or because digestion and intestinal absorption do not supply it with nutritive materials; or, lastly, because deleterious substances are introduced from without into its mass.

this, but now that Dr. Beclard has, unhappily for science, paid the debt of nature, the history of his dispute with M. St. Hillaire, in which, moreover, he was entirely wrong, could scarcely interest the medical student. K.

* See Bichat. Recherches, &c.—C. Himly. Commentatio mortis historiam, causas et signa sistens. Göttingen, 1794.

122. The carcass* or dead body, *(cadaver)* is an organized body that has ceased to live, but the term is applied exclusively to animals. The body in which the vital action has ceased is insensible. Heat and the capability of motion are presently extinguished. For a few minutes there are still observed particular phenomena, the last vestiges of the life which has just been terminated, and which are called the first phenomena of the dead body. But the body in this state has only an ephemeral duration. Putrefaction always, unless under certain peculiar circumstances, seizes it at the end of a short period; its elements disunite, and the bones alone remain for some time longer, to be themselves at length destroyed. Although all dead bodies are exposed to the alterations here mentioned, yet they do not alter in the same time and in the same manner. Age, the constitution of the individual, the proportion of its humours, the kind of death, the circumstances which have preceded it, the season, the climate, the state of the atmosphere, the bodies which surround the carcass, &c. are so many circumstances which exercise an influence, each in its own manner, upon the development of the phenomena exhibited by dead bodies. Each organ besides undergoes alterations peculiar to itself. The following are the most general changes.

123. Heat, as well as the other phenomena of nutrition, sometimes diminish before death and cease shortly after it. The cooling takes place gradually, and commences at the surfaces and extremities. It is produced so much the more quickly, the more the subject is exhausted by old age or disease, the more it is deprived of blood, the thinner it is, and the colder the atmosphere happens to be. It may then be produced in two or three hours; in general, however, it requires from fifteen to twenty hours, and may even take several days. The blood is blackish, and in general retains its fluidity and motion so long as the dead body is warm; the aorta and principal arteries empty themselves; the blood generally accumulates in the venæ cavæ, the auricles of the heart, and the vessels of the lungs, and even in the veins in general, which depends upon the elasticity of the arteries and bronchi, and upon the mechanism of the thorax. The accumulation of blood in the veins varies according to the causes of death. It is very great where there has been dyspnœa or suffocation. There then sometimes result congestions, turgescences, erections, and even bloody transudations. The blood, obedient to gravity and the action of the arteries, accumulates and forms lividities in the parts which are lowest at the moment of death; and, so long as the body remains warm, the other parts are, on the contrary, pale and yellowish. During the whole of this period of cooling, the body is in general flexible and soft, the eyes open, the lower lip and jaw pendant, and the pupil dilated; congestions which had existed during life sometimes disappear; the sphincters are relaxed, and sometimes emis-

* See Chaussier *Table des Phénomènes Cadavériques.*

sion of the feces and even parturition have been produced by the last remains of contractility. The muscles are still excitable by various stimulants, and especially by galvanism.

124. The soft parts remain flexible and the blood fluid, so long as the dead body retains its heat. The moment the latter is extinguished, the blood coagulates, and the soft parts become more or less stiff. The coagulation of the blood varies greatly; in general it forms white or yellowish concretions, which assume the form of the constraining vessels. Sometimes the blood assumes the consistence of jelly, or even remains entirely fluid. The stiffening of the dead body is a constant phenomenon, characterized by the firmness which the soft parts assume, and by the resistance and immobility of the joints. It commences in the trunk, and spreads to the upper extremities, and then to the lower. This phenomenon, which appears to depend essentially upon the last contraction of the muscles, and also upon the general extinction of heat and the coagulation of the fluids, presents great diversities with respect to the period at which it manifests itself, its intensity and its duration. Thus in death by old age, in death by slow exhaustion or by excessive fatigue, after septic, gangrenous, or scorbutic diseases, the rigidity very speedily supervenes, is by no means great, and scarcely lasts for an hour or two. On the other hand, in strong muscular subjects in which death has taken place suddenly, or after asphyxiæ and acute diseases, stiffness does not supervene until from twenty to thirty hours, becomes very great, and lasts three or four days. The stiffness of the soft parts then ceases of itself, and in the same order in which it made its appearance. It is replaced by a softness which gradually increases; the parts abandoned to the action of gravity fall in upon themselves. The fluids which were coagulated become fluid again, and their fluidity even seems to increase. These are the first phenomena of putrefaction.

125. In some cases, and generally after a sudden and violent death, there takes place a rapid and considerable disengagement of gas, whether in the intestinal canal, or in the serous cavities, the cellular tissue, or even the vessels. From this result various other remarkable phenomena. The inflation of the abdomen often causes mucus to issue from the mouth and nostrils, and pushes the blood into the neck and head; whence arise swelling of the face, redness of the eyes, and contraction of the pupil. It also causes the contents of the stomach to flow by the œsophagus into the larynx, the nasal fossæ or the mouth; and determines the reflux of the blood towards the genital organs, the excretion of gas and feces, and even sometimes rupture of the parietes of the abdomen. The development of gas in the cellular tissue constitutes the emphysema incident to dead bodies. Its disengagement in the heart and vessels, determines the motion of the blood, and even its escape at wounds, a phenomenon which is called the bleeding of dead bodies.

126. Putrefaction is an internal motion, the reverse of organic

action, which establishes itself in the dead body, destroys all the combinations that were formed by the vital action, separates the molecules, brings them back to a more simple state of composition, resolves them into gas, vapours, putrilage, and earth, and thus restores them to the general mass of inert bodies. Besides the cessation of life, putrefaction still requires as conditions, the contact of air, and a certain degree of heat and moisture. The degree and combination of these conditions give rise to great variation in the phenomena of decomposition.

127. In general, it commences as soon as the coagulation and stiffness cease. From this period, the fluids begin to decompose, and the soft parts relax and gradually soften. The dead body, which at first exhales a vapour whose loss diminishes its weight, now emits a disagreeable smell. The blood and other humours transude through their reservoirs, and impregnate the walls and neighbouring parts with their colour and smell; whence the red colour of the veins and surrounding cellular tissue, the spots impressed upon the stomach and intestines by the liver, the spleen, and the gall-bladder, the sero-sanguinolent infiltrations in the cellular tissue and serous membranes, their assuming a rose colour, and various tints of red and brown, and the colouring of the parietes of the abdomen with bluish or greenish hues. The humours of the eye transude; whence the flattening of that organ by the sinking of the cornea; and by mixing with the corpuscles which float in the eye, they form an opake covering to it.

At this first period of putrefaction, the muscles redden litmus paper.

128. Putrefaction, which, in reference to the regions, generally commences with the abdomen, on account of the excrementitious matters there accumulated; which, in reference to the organs, commences with the softest and those most imbued with fluids, as the encephalic mass; and which also first attacks the parts distended or altered by disease or the kind of death, soon becomes general. The epidermis separates, and is raised by collections of brownish sanies; the flesh, impregnated by the fluids, becomes glutinous, greenish, pulpy and ammoniacal; and emits a putrid, nauseous odour.

129. At length the texture entirely disappears; the soft parts, becoming confounded with the fluids, are reduced to semi-fluid putrilage, mixed with bubbles of gas, and diffusing the most tainted odour, and the most pernicious vapour. Soon after, nothing remains but the bones, which in their turn become friable and pulverulent, and leave but a very slight earthy residuum.

130. When the conditions of putrefaction are favourable, as after certain diseases, and in warm or moist seasons or places, it commences almost at the moment of death, and runs through its periods with the greatest rapidity. In cases the reverse of this it is slow, and may be protracted for several years. It may even be indefinitely suspended, or greatly modified in its phenomena. Thus,

a body inclosed in ice may be preserved there without sensible alteration so long as the freezing continues. Thus, also, a body dried by a very warm and dry atmosphere, as that of the deserts of Africa, or by an absorbent earth, as in certain vaults, or by the heat of a stove, or by various chemical processes, may become nearly incapable of putrefaction. In like manner, a body immersed and kept in water, in humid earth, or in ground saturated with products obtained from dead bodies, may be transformed into fat, and converted into a kind of soap, by the reciprocal action of its fat and the ammonia which results from the decomposition of its fleshy parts.

131. The body retaining for some time after death, nearly the same organization and composition which it had during life, is the subject on which anatomy is studied. However, as changes begin to take place immediately after death, which continue to go on and increase, the ideas which may be derived from the examination of bodies deprived of life must be rectified by the study of living animals.

All bodies are not equally suited for the study of anatomy. For long and continued dissections, those ought not to be made use of which have died under putrid diseases or fatigue, or which are still warm, or which have rapidly run into putrefaction, or in which putrefaction is already far advanced. Great care and cleanliness are necessary in conducting anatomical researches; if a wound or puncture be made during dissection, and especially in dissecting an improper subject for the study of anatomy, the part ought to be washed and cauterized without delay.

132. The anatomist considers in each solid part of the body; 1st, Its configuration or its form, external as well as internal, if it is hollow, and its symmetrical or irregular disposition; 2dly, Its situation in the body, and with relation to the other parts, as well as its relations of contact or more or less intimate connexion with them; 3dly, The direction of its larger diameter, which may be parallel, oblique, or perpendicular to the axis of the body; 4thly, Its metrical extent, or its extent as compared with that of the body or with some of its parts; 5thly, Its physical proportions, whether relative to the attraction of its molecules, as its density, cohesion, elasticity, &c., or to the manner in which light affects it, as its colour and transparency; 6thly, Its anatomical composition and its texture, or the arrangement of its constituent parts; 7thly, Its chemical properties and composition; 8thly, The fluids or humours which it contains; 9thly, The properties which it possesses during life; 10thly, Its vital action, and the connexion of this action with the others; 11thly, The varieties which it presents, according to age and sex, and in races or individuals; 12thly, Its morbid states; and lastly, the phenomena and alterations which it exhibits after death. Although several of these considerations seem to belong to physics, chemistry, physiology, and pathology, rather than to anatomy, there is none of them that is not calculated to benefit the anatomist, and none that ought to be overlooked by him.

GENERAL ANATOMY.

CHAPTER FIRST.

OF THE CELLULAR AND ADIPOSE TISSUES.

133. These two tissues are generally confounded under the name of cellular tissue. They differ, however, from each other, and require to be separately described.

SECTION FIRST.

OF THE CELLULAR TISSUE.

134. The cellular tissue has been so named on account of the areolæ which it forms, and which, perhaps inappropriately, have been called cellules. It is a soft spongy tissue, generally diffused through the body, which surrounds all the organs, connects them together, and at the same time separates them from each other, penetrates into their substance and exhibits similar appearances in all their parts, and which, entering into the composition of all organized bodies, and of all their organs, is the principal element of the organization.

According to the manner in which it has been viewed, it has received various names, such as cribrous, mucous, glutinous, intermediate, areolar, reticulated, laminar or filamentous substance, body, system, organ, membrane or tissue. Perhaps the name of cellular tissue is not the best that might be applied to it, but as it is in general use we shall adopt it.

135. Notwithstanding the great extent and importance of this tissue, which must have struck the earliest anatomists, we find no description of it in the works of the ancients. Hippocrates speaks of the general permeability of the tissues, when he says that the whole body is obviously perspirable both externally and internally. The first idea of the cellular tissue has been supposed to present itself in this passage. What Erasistratus calls the *parenchyma* perhaps corresponds to this tissue. But we must come down to Charles Etienne, Vesalius and Adrian Spigel, before we meet with any accurate notions respecting the disposition of the cellular tissue; and even they, as well as many of the anatomists who suc-

ceeded them, have only mentioned the cellular tissue in speaking of the different parts in which it occurs, as around the vessels, muscles, fat, &c. Kaaw Boerhaave, Bergen, and Winslow, were the first who gave out any general ideas respecting the continuity of this tissue in the different regions ; but it has only been since the time of Haller that it has been presented in its true point of view. The cellular tissue has formed the subject of numerous works. Schobinger, Thierry, W. Hunter, Bordeu, Fouquet, Wolff, Detten, Lucæ, and De Felici, have expressly written upon it. Their works have added little to the description given by Haller; but several of them are remarkable for containing more or less accurate ideas respecting the nature and functions of this tissue.* All anatomists, and especially those who have written upon general anatomy, have spoken of it in their treatises. Mascagni alone hardly names it. There are no good figures of the cellular tissue, and in fact it cannot be properly represented, because it has no determinate form or colour. Wolff has attempted to figure it, but without success.

136. To facilitate the study of the cellular tissue, it is successively examined in two portions, one of which is considered as independent of the organs, and only fills up the vacuities which they leave between each other, while the other only refers to the organs which it envelopes, and into the texture of which it enters. These portions are only distinct in idea, for the cellular tissue is everywhere continuous with itself.

137. The first portion is the external, general, or common cellular tissue, *(textus cellularis intermedius, seu laxus,)* that which does not penetrate into the organs. The common cellular tissue has the same extent and general form as the body. Were all the organs supposed to be removed, and were the cellular tissue supposed to be able to support itself, it would form a whole, retaining the figure of the body, and presenting a multitude of cavities, for the different organs. The thickness of the layer which it forms around each of them is not the same as in all parts of the body. In the vertebral canal, the cellular tissue exists but in very small quantity, and in the interior of the cranium it forms a layer so extremely thin as to be scarcely visible. Externally of these parts it is more plentiful, and it is especially abundant round the spine, particularly at its fore part. In the head, the different parts of

* Dav. Ch. Schobinger. *De telæ cellulosæ in fabricâ corporis humani dignitate.* Gott. 1748. Fr. Thierry. *Ergo in celluloso textufrequentius morbi et morborum mutationes*, Paris, 1749, 1757, 1788. W. Hunter, *Remarks on the Cellular Membrane*, &c. in Med. Observ. and Inquiries, vol. ii. London, 1757. Th. de Bordeu. *Recherches sur le tissu muqueux ou l'organe cellulaire*, &c., Paris, 1767.—Fouquet and Abadie. *De corpore cribroso Hippocratis*, Montpell. 1774.—C. F. Wolf. *De tela quam dicunt cellulosam observationes*, in Nova Acta Acad. Sc. Imp. Petrop. vol. vi. vii. viii., 1790, 1791. M. Detten. *Beytrage*, &c. *i. e.* Supplement to the study of the Functions of the Cellular Tissue. Munster, 1800.—S. Ch. Lucæ. *Annotationes circa telam cellulosam*, in Observ. circa Nervos, &c. Francof. ad Moen. 1810.—G. M. de Felici. *Cenni di una nuova idea sulla natura del tessuto cellulare.*—Pavia, 1817.

the face, the orbits, the cheeks, contain a great quantity of it. It is also plentiful in the neck, along the vessels and between the muscles, and in the thorax, between the laminæ of the mediastinum, and at the exterior of that cavity, around the mammæ. The abdomen, both in its interior and in the substance of its parietes, contains a great quantity of cellular tissue. In the extremities, it is abundant in the groin, the axilla, the ham, the palm of the hand and the sole of the foot, and forms layers of greater or less thickness between the muscles. In general, the most important organs are those which are most plentifully surrounded with cellular tissue. It is also more abundant in the places which are the seat of great motions. Moreover, as it envelopes all the organs, and everywhere forms the partitions by which they are separated, there is necessarily more of it wherever these organs are numerous. Of this we may mention the neck as an example.

138. The continuity of the cellular tissue is more especially visible in the great vacuities which the organs leave between each other. In the neck, the continuity of this tissue is manifest with that of the head above, and that of the interior of the thorax below. The apertures of this cavity which communicate with the upper extremities, equally present a very marked continuity between the cellular tissue of the thorax and that of the upper extremities. In like manner, in the abdomen, the sciatic notch, the inguinal ring, the crural arch, &c. present, in an obvious manner, the continuity of the cellular tissue from the interior to the exterior of the belly, and from thence to the inferior extremities. Along the vertebrate canal, the invertebral foramina establish a communication between the interior and exterior of that canal. The foramina of the base of the skull, in like manner, establishes a communication between that cavity and the external parts of the head. The continuity of the cellular tissue is not confined to the places alone which we have just mentioned, but is shown by various phenomena, of which we shall speak as we proceed, to be of general occurrence in all the vacuities that are left between the organs, only it is more decided wherever the vacuities are themselves very large. It will readily be perceived that the rounded form of the organs must render these vacuities very numerous.

139. The other division of the cellular tissue furnishes to each organ in particular, an envelope which is proper to it, and penetrates moreover into its substance. This disposition has given rise to two subdivisions. The cellular tissue which forms the envelope of the organs, *(textus cellularis strictus,)* has been considered by Bordeu as a kind of atmosphere which puts limits to their action and mordid phenomena, and prevents their extending from the one to the other. This idea, which has been adopted by Bichat, appears to me to have little foundation. The difference of their organization is the sole cause of this isolation which the organs present in their action, as well as in their diseases. Be this as it may, the cellular layer which surrounds the organs varies in thickness. Those excepted which have envelopes of a different

nature, that is to say of ligamentous tissue, or of serous tissue, all of them present it in a more or less distinct degree. The envelope which this layer represents, is continuous, on the one hand, with the common cellular tissue, and, on the other, with that which occupies the interior of the organ. According to the form of the latter, its cellular envelope varies in its disposition. The skin, the mucous and serous membranes, the blood-vessels and lymphatics, and the excretory ducts, which have only one of their surfaces free, are only in connexion with the cellular tissue on one side. On the contrary, the organs which are destitute of cavities, as the muscles, are on all sides surrounded by it. Under the skin, the cellular tissue forms a layer which extends over the whole body, excepting the places where the muscles or aponeuroses are inserted. This subcutaneous tissue is more or less dense, according to the regions in which it is examined. It is closer in its texture along the whole extent of the median line, excepting in the neck, where that line is very indistinct. Bordeu has exaggerated this disposition when he says that it divides the whole body into two portions; for it is evident that at a certain depth all traces of it disappear. In the places where the motions are very decided, the cellular tissue is looser, as is observed in the palpebræ, the prepuce, the scrotum, and the labia pudendi. It is, on the contrary, of close texture in the places where the skin does not slide upon the parts beneath it, as in the palms and soles, over the sternum, upon the back, &c. The mucous membranes are covered on their adhering surface, by a very dense cellular tissue, which commonly obtains the name of nervous membrane. That which covers the adhering surface of the serous membranes is in general flocculent. That which exists around canals forms particular sheaths for them. Their sheaths are of great importance to the arteries in particular, but equally occur round the veins, the lymphatic trunks, and excretory ducts. Around the muscles, the cellular tissue forms a layer which is called their common membrane.

140. The portion of the cellular tissue which penetrates into the organs, accompanies them and envelopes all their parts, *(textus cellularis stipatus,)* presents different appearances in the different organs. In the muscles, it forms an envelope for each bundle, and furnishes smaller envelopes to the secondary bundles or fasciculi, and the fibres of which they are composed. The cellular tissue of a muscle thus represents a series of inclosed tubes connected with each other by continuity in the same manner as the envelopes proper to the different organs are connected with the general envelope of the body. The glands, in like manner, have their lobes, their lobules, and the granulations of which the latter are composed, surrounded by envelopes becoming successively smaller, and which, if separated from the rest of the gland, would form a kind of cellular sponge. The organs which are composed of several membranous layers, as the stomach, intestine and bladder, contain cellular tissue between their different layers. Certain very compound organs, as the lungs, have more or less cellular

tissue around each of the parts which enter into their structure; the quantity of this tissue being in general proportionate to the number of different parts which the organ contains. In proportion as the cellular tissue divides and subdivides to embrace the most delicate parts of the organs, it becomes itself more delicate, and the envelope which it forms is thinner. Thus the small arteries have a finer envelope of this substance than the trunks. The envelopes formed by the cellular tissue are in general so much the thicker, the greater the motions which the parts perform, and it is for this reason that the cellular tissue is more abundant in the muscles than in the glands. Certain organs, as the ligaments, tendons, bones, and cartilages, do not contain any free or very distinct cellular tissue in their substance. In general, before it assume a decided appearance, the organs must present appreciable intervals between their component parts. Thus, the ligaments which have apparent fibres, also present cellular tissue which separates these fibres, and there is none observed in those apparently destitute of fibres.

141. Not only does the cellular tissue enter into the composition of all the organs, but it even forms the base of all *(textus cellularis organicus, seu parenchymalis,)* and forms several of them of itself alone. It is it, or the fibre or substance which composes it, that constitutes, only with different degrees of consistence, the serous membranes, the true skin, the vessels, the ligamentous tissues, in short almost all the parts, excepting the nerves and muscles, and even these differ from the cellular tissue only in having globules superadded to that tissue. The horny parts and epidermis are the only substances that are entirely different from cellular tissue. Haller and some other anatomists have referred to the cellular tissue the spongy or cavernous tissues, and the air-vesicles of the lungs; but these parts possess a peculiar disposition, which prevents their being confounded with the cellular tissue. The cavities of the hyaloid membrane, which were also by Haller referred to the tissue of which we speak, must also be distinguished from it.

142. Anatomists are at variance respecting the internal conformation of the cellular tissue. Some consider it, with Haller, as having distinct cellules, of a determinate form and magnitude, formed by the crossing of numerous laminæ and filaments. Others, on the contrary, such as Bordeu, Wolff, and M. Meckel, say that this tissue is nothing but a viscous, tenacious and continuous substance, destitute of laminæ and cellules, and consider these latter, when they exist, as the result of the operations made for demonstrating them. The following is what we learn on this subject from inspection.

When the cut edge of a muscle is examined with the lens, it is discovered that its fibres do not touch each other, but are separated by a transparent substance. If these fibres be drawn from each other, the interfering substance forms filaments which elongate as the separation is continued, and at length break. Those who consider the cellular tissue as a kind of glue, remark that the same would take place were these fibres separated by that substance. Around the whole muscle there is observed a distinct lamina, which in like manner assumes the form of filaments, on being distended. When air is blown under this lamina, it is transformed into irregular cellules, separated by a kind of septa. It would, therefore, seem that around the smallest parts, the cellular tissue is really a kind of jelly, while its laminæ are apparent around the larger parts. If, instead of air, water is injected into it, and then frozen, there are obtained irregular pieces of ice which fill the cellules. The same result is obtained on injecting a coagulable substance. But these cellules are never regularly disposed, and have not a geometrical form, as has been alleged: their figure may even vary when they are several times reproduced in the same place.

There remains great uncertainty respecting the question, whether the laminæ, fibres, and cellules are pre-existent in the cellular tissue, or merely depend upon its separation? Although possessed of a pretty distinct organization, in the places where its thickness is considerable, this tissue appears to be inorganic in the places where it is thinner, and even seems as if diffluent between the smallest fibres of the muscles. Admitting the existence of the cellules, should we consider them as closed on all sides, and only communicating together after the rupture of their walls, or rather as cellules perforated with porosities opening into the neighbouring cellules, or lastly, as areolæ, vacuities open on all sides, or irregular spaces which exist between the fibres and laminæ of the cellular tissue? The latter opinion appears to be the most probable. But these areolæ are, in the ordinary state, of extreme minuteness, discoverable only by the microscope, and having their walls in mutual contact, and the enlargement which they undergo from infiltration, insufflation, &c. cannot give an accurate idea of them, as by these modes of treatment they are much altered and torn.

143. The cellular tissue exhibits precisely the same phenomena as if it were spongy: fluids and gases penetrate it with the greatest facility. In fact, 1st, The serosity, in the dropsy of this tissue, always diffuses itself in the lowest parts, or in those which offer the least resistance; the situation of the patient has an influence upon the place which it occupies; external pressure also displaces it, and a single incision is often sufficient to let it run off; 2dly, Water artificially injected gradually spreads in the same manner in the cellular tissue; 3dly, The air infiltrated in emphysema, and that artificially introduced, present the same phenomenon; 4thly, the blood of ecchymoses infiltrates in the same manner, and gradually extends itself, in the cellular tissue. All this demonstrates a general communication among the areolæ. Those who do not admit such a communication account for these facts by the slight consistence of the cellular tissue. Whether the areolæ, fibres, and laminæ of the cellular tissue be inherent in it, or are only the effects of

various distending agents, it presents remarkable variations in this respect. In certain places it is principally filamentous or fibrillous; in others it is especially laminar or lamellar, as in the palpebræ, the prepuce, the scrotum, the labia pudendi, and between the muscles which possess great mobility. It forms so much the larger areolæ, the more lamellar and loose it is, and these wide areolæ seem to be the first rudiments of the serous cavities.

144. The cellular tissue is colourless when it is in thin laminæ, and appears whitish when its thickness is greater, and especially when it is distended. It is semi-transparent. Its power of cohesion varies, it being merely that of a slightly viscous fluid in some places, as between the muscular fibrillæ, while in others its tenacity is nearly equal to that of the fibrous tissue. This tissue is possessed of great extensibility and retractility, as is seen when it is blown into, and an incision afterwards made into it, in which case it contracts powerfully, and expels the air by which it was distended. Its chemical properties have been carefully studied by Bichat. Deprived of water by desiccation, it loses some of its physical properties, and acquires new ones. In this state, it is hygrometrical and susceptible of resuming its first appearance when put into water. This is common to it with almost all the organic tissues. Exposed to heat, it rapidly dries up, crisps, and at length burns, like all the other tissues, but leaving very little ashes. It strongly resists decoction, and only melts after long continued boiling. Its putrefaction is very slow: it requires a maceration of several months, even when care is taken not to renew the water, before it decomposes. It is at length converted into a viscid substance resembling mucilage, and furnishes various products which come to the surface of the fluid. Fourcroy found it composed of gelatine; John met in it, moreover, a small quantity of fibrine, and of phosphate and carbonate of lime.

145. The intimate nature of the cellular tissue has given rise to numerous hypotheses. Ruysch supposed it entirely vascular; Mascagni, who hardly mentions it, says it is composed of white vessels; Fontana, of tortuous cylinders; others regard it as an expansion of the nerves. The only basis which can be admitted in it is the fibre or cellular substance, § 68, 85. It is traversed by a great number of vessels, and especially of serous vessels, but it must not be considered as entirely formed of them, for it is it that ultimately forms the walls of the latter vessels. The cellular tissue has canals or cavities which are proper to it. They are small vacuities or areolæ which are formed in it, or which the fluids form in proportion as they are deposited in it, and which, by their communication, render it a spongy and permiable body. Almost all the anatomists who have much engaged in injections, as Haller, Albinus, and Prochaska, have ranked it among the solid parts or those incapable of being injected; that is to say, it is placed out of the circulatous course of the vessels. The blood may nevertheless pass into its proper canals, or cavities, but then it is in a state of

inflammation. The nerves, in like manner, do not appear to stop short, or to terminate in the cellular tissue. This tissue forms a really distinct substance, traversed in all directions by blood vessels and nerves, and in which alone the former leave a fluid.

146. It is in fact continually bathed and moistened by a very thin fluid which penetrates it, and of which the quantity is so small as to be scarcely discernible. The term vapour is therefore commonly used to designate this fluid. If an incision be made into the cellular tissue in a living animal, this fluid moistens the fingers introduced into the wound. In cold weather, a vapour rises from the divided tissues, condensed and rendered visible by the external air. This vapour comes at the same time from the cellular tissue and the white vessels. In anasarca, the fluid of the cellular tissue accumulated and perhaps altered, bears a great resemblance to the serosity of dropsies. It is coagulable like the latter, and appears, in like manner, to contain a certain quantity of albumen, water, and some salts.

147. The cellular tissue is the first part formed in the embryo, and it is also met with in the lowest animals. At first fluid and very abundant, this tissue diminishes proportionally as the organs develope themselves, and, at the same time acquires consistence. At birth, it is still nearly different in the intervals of the muscles, and very soft under the skin. Its density gradually becomes greater as age advances, and at an advanced period of life it is nearly fibrous in the places where it was very soft in the child. The cellular tissue is looser and more abundant in the female than in the male. Blumenbach gives as a character of the human organization, compared with that of other animals, a softer, and as it were more tender cellular tissue, which renders his motions more easy.

148. The power of formation which the cellular tissue possesses is very great. It is the first part formed; it increases accidentally, forms out of all kinds of substances, and reproduces itself, when it has been destroyed, with the greatest celerity, as is seen in wounds, adhesions, vegetations, &c. It possesses a power of contraction dependently, in part, upon the elasticity with which it is endowed, and in part upon irritability. This last power also receives the names of fibrillar or staminal contractility, and tonicity. It manifests itself by the motion of the fluids which this tissue commonly or accidentally contains, and by the general or local contraction which it experiences in various cases. It is not very evident that the nervous power influences its contractions, or determines them. It is not perceptible excepting in the state of inflammation.

149. The uses and functions of the cellular tissue are highly important. It is it that determines the form of all the parts. It is the only bond by which they are united, and upon its cohesion depends that of all the other tissues. By its elasticity it facilitates the motions, and restores the organs to the state in which they were before displacement, when these motions cease to take place.

The latter also are performed with so much the greater facility, the more the cellular tissue possesses its natural properties.

It is the seat of a perspiratory secretion, which is very abundant from its extent. Does the fluid which the ultimate ramifications of the arteries exhale in it, undergo a kind of circulation; or at least a change of place in it? Of this we are entirely ignorant. It is only in cases of morbid accumulation that the infiltrated fluid is seen to change place, in obedience to gravity, presence, &c. It has been supposed, but without any solid foundation, that this fluid is in a state of continual agitation in it, and that the diaphragm by its alternate rising and falling is the principal cause of this agitation; that it has currents which flow in various directions; that, for example, it is the secret way by which the drink passes to get from the stomach to the bladder, a supposition belied by all accurate observations; and that it is the path by which metastases travel, &c. However this may be, the fluid is again taken up by the vessels, so that the cellular tissue is intermediate between a perspiration and a resorption. The tonic contraction of the cellular tissue is the agent which impels its serosity into the vessels.

The cellular tissue is in fact the essential organ of absorption. It is it that forms the corpus mucosum of the skin, the spongy substance of the villosities of the mucous membranes, parts which absorb, and from the absorbed substances pass into the vessels. Before being introduced into the vessels, the substances absorbed by the cellular tissue, which may be called external or superficial, in opposition to all the rest, without doubt undergo changes or elaborations. In the same manner as the foreign matters, before entering into the vessels, must pass through the cellular tissue, the organ of absorption, so also those which issue from the vessels pass through the cellular tissue, the organ of secretion, before they are deposited upon the surfaces at which they are poured out.

The cellular tissue which envelopes each organ in particular, has been considered as forming for it an isolating atmosphere, which circumscribes its actions, whether healthy or morbid. Observation often contradicts this assertion, and when the fact is true, it is the particular texture of the organ, and in the variety of the agents that we must seek its explanation, and not in this pretended atmosphere.

The cellular tissue, which penetrates into the substance of the organs, connects all their parts.

As to the organic or parenchymal cellular tissue, it forms the base or essential element of each organ, and there presents remarkable varieties. In the most rational hypothesis respecting the seat of nutrition, it has been admitted that the nutritive matter is deposited externally of the vessels, in the cellular substance, which forms the base of the organs, to be assimilated to them, and that it is thus the essential organ of nutrition. Be this as it may, and whatever hypothetical uses may be attributed to the cellular tissue, it is without dispute one of the most important in the animal constitution.

150. The phenomena of the cellular tissue, whether in health, or in disease, are connected with those of the other parts. Thus, the organic lesions of the heart, and the derangements of the respiration and pulmonary perspiration, often determine in it an accumulation of serous fluid. The same thing takes place in the alterations of the different secretions, and especially of the cutaneous transpiration. Its inflammations commonly produce fever. The suppurative inflammation which is excited in it by setons and other means, often cause the inflammations of other organs to cease.

151. The cellular tissue is subject to various morbid alterations. When it is cut into and laid bare, it inflames, becomes covered with *fleshy* granulations, suppurates, and is at length covered over by a cicatrix or new skin, which will be elsewhere described, (Chap. III.)

When it is divided and placed in contact with itself, it adheres at first by means of a fluid poured out by the divided surfaces when the bleeding and pain have ceased. At a later period, this organizable substance becomes a highly vascular tissue. The lips of the wound can then no longer be separated without producing pain and renewing the flow of blood. This new tissue remains for a long time more compact, firmer and more vascular than the cellular tissue which it unites, and with which it is ultimately confounded. It is by a similar production that all the unions of divided parts are produced, with modifications relative to each tissue, and which will be examined in their own place.

It is in the same manner also that the adhesions take place between the contiguous surfaces of serous tegumentary membranes, and which will be described when we come to speak of these membranes. (Chap. II., III.)

The cellular tissue is susceptible of an extraordinary increase; it sometimes gives out a kind of vegetations or vascular exuberances, when it is denuded. The reproduction of this tissue is also, in general, so much the more easy, the more there remains of it in the part that has been injured. It would seem that this reproduction depends in a great measure upon the extension of the pre-existing cellular tissue.

Inflammation of the cellular tissue, or phlegmon, is characterized by various changes which that tissue undergoes. The first of these changes is a very decided increase of vascularity. The cellular tissue when inflamed becomes, moreover, sensible and painful. It entirely loses its permeability, and fluids cease to make their way through it; its consistence is augmented, and its tenacity diminishes; it tears or breaks under pressure, in place of elongating, as it previously did. This kind of fragility, which the cellular tissue acquires, accounts for certain phenomena; it explains why the ligature of a vessel often determines the section of the surrounding tissues; why, after peritonitis, it is sometimes so easy to separate the intestine from its peritoneal coat. Inflammation of the cellular tissue may terminate in an insensible manner, and then it gradually resumes all its properties. This is what takes place in the termination which is said to be by resolution. In other cases, the cellular tissue secretes a peculiar fluid, which bears the name of pus, and which will be elsewhere described; and this constitutes the termination by suppuration. This fluid commonly collects in a determinate point, which extends progressively to the circumference, so long as the secretion continues. This secretion belongs to the perspiratory kind; the pus is furnished directly by the blood, and even presents some resemblance to that fluid in its composition. However quick the progress of the disease may be, the walls of the abscess are lined by a membrane. This membrane is doubled, at the exterior, by a more or less thick layer of compact cellular tissue. This layer is less decided, and the membrane is nearly distinctly isolated, when the disease lasts for a certain time, the cellular tissue having resumed its properties around it. Abscesses are the seat of continual secretion and absorption, of which a proof is furnished by the entire absorption of the pus which they contain, and the effects which the presence of that fluid sometimes produces in the economy. The pus formed in the interior of abscesses generally ends with arriving at the external surface. The abscess empties itself, the walls contract, remain for some time indurated, and at length resume the characters of the cellular tissue. When the secretion and flowing of pus continue, the canal by which the abscess communicates externally, and which bears the name of *sinus* or *fistula*, becomes invested with a distinct membrane, presenting the characters of the mucous membranes, and whose history belongs to that of these membranes. After certain gangrenous inflammations, the cellular tissue becomes so contracted from the loss of substance which it has undergone, that the skin, muscles and aponeuroses are confounded together; but in this case, if the individual is young and robust, the cellular tissue may be reproduced and resume all its properties. Inflammation of the cellular tissue sometimes continues indefinitely, so that its substance remains hard and impermeable, which constitutes induration. This state exists in the callosities of ulcers and fistulæ, which are evidently the result of a chronic inflammation of the cellular tissue. The Barbadoes disease, one of the varieties of elephantiasis, in like manner, presents the characters of induration.

New born infants are subject to an induration of the cellular tissue, in which the inflammatory character does not present itself. This induration is observed beneath the skin, and sometimes in the intervals of the muscles. It is only, as M. Breschet's observations have apprised us, a secondary phenomenon of the persistence of the interauricular foramen of the heart, and of the defect or imperfection of respiration.

Air may insinuate itself into the cellular tissue, which constitutes emphysema. When the patient does not die in consequence of this accident, the diffused air escapes by the incisions which are made, or by the wounds which may happen to exist, or it combines with the fluids contained in the cellular tissue, and disappears by absorption. Leucophlegmasia, or anasarca consists of an accumulation of serous fluids in the cellular tissue. In ecchymosis, the cellular tissue contains blood diffused in its areolæ. All the organic fluids may be accidentally infiltrated into this tissue, in which they produce more or less violent inflammations, when they are of an excrementitious nature.

Solid foreign bodies introduced into the cellular tissue, do not in general remain long in the same place, but, like pus, are commonly impelled toward the surface, and if they are heavy, also to a certain degree obey the laws of gravity. It is evident, that it is not by passing through pretended cellules, that these bodies thus travel through the cellular tissue. The latter presents around them three distinct phenomena; it secretes pus at their surface, unites and resumes its softness and permeability behind them, and ulcerates before them. Here then we find united three of the kinds of inflammation admitted by John Hunter; the adhesive, the suppurative and the ulcerative inflammations. These phenomena together have received the name of eliminatory inflammation. It may happen that the foreign bodies abide in the cellular tissue, whether on account of their specific gravity being inconsiderable, or from the density of the surrounding tissue. A membrane then forms around them.

The cellular tissue, in some circumstances, contains living foreign bodies or worms. The *Cysticercus cellulosæ*, so named on account of its seat in the cellular tissue, and the *Filaria medinensis*, whose existence cannot be called in doubt, are met with in it; and in animals, larvæ of the *œstrus*.

The cellular tissue may undergo various transformations. The serous, fibrous, osseous and cartilaginous transformations, which are produced in the cellular tissue, will be described along with the natural tissues to which they belong.

The cysts, of which the cellular tissue is the seat, will also be examined, when we come to speak of the serous and tegumentary membranes, to which they have a great resemblance.

When an organ accidentally disappears, it is said to be transformed into cellular tissue. This is not perhaps perfectly correct; the cellular tissue in this case only takes the place of the wasted organ, which previously kept it at a distance.

The different degenerations may be regarded as belonging particularly to the cellular tissue. It, in fact, appears to form their base, for these degenerations are universally similar. However, as they are common to all the organs, I shall deliver their history after that of all the other tissues. The cellular tissue, wherever it is free in the intestines of the organs, is affected by these degenerations, as in the places where it forms part of the organs themselves.

SECTION SECOND.

OF THE ADIPOSE TISSUE.

152. The adipose tissue, so named on account of the fat *(adeps)* which it contains, results from the aggregation of microscopic vesicles, connected together by laminar cellular tissue, and serving as a reservoir for the fat. Two kinds of it are distinguished; one is the common adipose tissue, the other the adipose or medullary tissue of the bones.

ARTICLE FIRST.

OF THE COMMON ADIPOSE TISSUE.

153. It has been designated by the names of adipose cellular tissue, adipose membrane, tunica adiposa, tela adiposa, membrane of the fat, &c. It has also been named pannicula adiposa, on account of its forming a layer situated immediately beneath the skin.

154. This tissue was long confounded with the cellular tissue, which was said sometimes to contain serous fluid, sometimes fat, and in the latter case to form the adipose tissue. Malpighi was one of the first who raised doubts on this subject, and discovered that the fat is formed of grains appended to the blood-vessels. Swammerdam, in like manner, found it to be a fluid oil contained in membranules. Morgagni also discovered that the fat contains grains which he compared to those of the glands. Bergen was one of the first who distinguished two kinds of cellular tissues, one of which, named by him the *laminar*, corresponds to the adipose tissue. William Hunter gave the distinctive characters of this tissue, which were afterwards confirmed, and more or less accurately determined by Jansen, Wolff, M. Chaussier, Prochaska, Gordon, Mascagni, myself, &c. Haller denies the existence of this tissue, and admits only the areolæ of the cellular tissue, as constituent parts of the fat. His opinion has been adopted by Bichat, M. Meckel, &c.; but we shall see, as we proceed, that it has little foundation. The adipose tissue has been carefully described in various works, * and figured in a few. †

155. The adipose tissue presents different forms, according to the places in which it is examined. Under the skin it forms a

* M. Malpighi, *De omento, pinguedine, &c. in ejusd. oper. omn. et posth.* Bergen, *op. cit.* W. Hunter, *op. cit.* Wolff, *op. cit.* W. X. Jansen, *Pinguedinis animalis consideratio physiologica et pathologica.* Lugd. Bat. 1784.

† Mascagni, *Prodromo della grande anotomia.*

layer varying in thickness, and extended over the whole body. It represents rounded masses in the orbit, in the substance of the cheeks, in the interior of the pelvis, on the fore part of the pubes, around the kidneys, &c. These masses are pyriform and pedicellate, at the fore edge of the omentum, in the fatty appendages of the intestine, and at the level of the apertures which occur at the exterior of the peritoneum. In the omentum, the fat is disposed under the form of a network or of narrow bands which follow the course of the vessels.

156. Although the fat is not so generally distributed as the cellular tissue, it yet occurs in a great number of places.

The vertebral canal contains a small quantity of it externally of the dura mater. In the head it exists plentifully, especially in the face, in the parotideal cavities, the cheeks, &c. The neck presents more of it behind than before. In the thorax, the exterior and interior of that cavity presents a remarkable quantity of it, as well in the vicinity of the heart as between the pectoral muscles and around the mammæ. The fat of the abdomen is principally situated at the exterior of the kidneys, in the pelvis, in the substance of the mesentery, the omentum, and its appendages. In the extremities, the fat is more abundant opposite the joints, in the direction of the flexure, as well as in the places which are exposed to constant pressure, as the hips and the soles of the feet.

The adipose tissue possesses a different arrangement in each particular organ. That which lies under the skin always exists, unless in cases of extreme emaciation, and is prolonged into the areolæ of the dermis; we do not find any under the mucous membranes. The serous and synovial membranes are doubled, on the contrary, by this tissue, particularly in the substance of their folds; the adipose tissue which surrounds the muscles, in like manner, penetrates into the substance of those which are divided into distinct bundles, as the glutæus maximus, &c. In the lobulated glands, it is observed in the intervals of the lobes. The sheaths of the vessels generally contain very little of it. The great nerves, such as the ischiatic, contain small masses of it between their fibres. The fasciculated ligaments presents similar masses between their bundles. Lastly, in the bones, the fat is considered separately.

157. The fat is entirely wanting in certain parts, as under the skin of the skull, nose, ear, and chin, where the median line is entirely destitute of it. There is very little also between the skin and the platysma myoides. Scarcely any is to be seen opposite the insertion of the deltoid muscle, which always causes a depression at that part, even in the fattest subjects. This fluid is equally wanting around the long and slender tendons, and in the intervals of the muscles which perform great motions, as between the triceps and rectus femoris anticus, the biceps and brachialis anticus, the gemelli and soleus. The substance of the viscera is generally destitute of fat; there is none in the walls of the stomach or

uterus, in the spleen or liver, the palpebræ, the penis, the nymphæ, are equally destitute of any. The quantity of fat which exists in the body varies greatly; but there are parts which never contain any, even in the greatest obesity, and others in which the most complete wasting never makes it entirely disappear. In an adult man in ordinary condition, the fat forms about the twentieth part of the weight of the body.

158. The adipose tissue is generally of a yellowish-white colour, and of a soft consistence, varying, however, in the latter respect in the different regions of the body, and at different ages.

159. Whatever may be the external form of the adipose tissue, the masses which it represents divide into smaller masses, from the size of a pea to that of a hazle nut, smaller in the head, and larger around the kidneys. These masses are immersed in the cellular tissue. Their form varies. It is generally round, but in the median line elongated and ovoidal, one of the extremities being attached to the skin, the other to the aponeurosis. They may by dissection be reduced into lobules or grains, which on being examined by the microscope appear themselves composed of an infinite number of small vesicles having a diameter of $\frac{1}{800}$th or $\frac{1}{600}$th of an inch. The adipose tissue may therefore be considered as composed of agglomerated vesicles, united into grains, which are in their turn aggregated to form masses. There results from these arrangements that the structure of this tissue is not areolar, but rather resembles that of the fruits of the family of Hesperideæ, as the orange and citron, which in like manner contain membranous vesicles attached to dissepiments which separate them. The adipose vesicles, as well as the grains and masses which they form, are furnished with a small pedicel which is supplied to them by the vessels lodged in their intervals, and may be compared in this respect to grapes supported by their foot-stalk. These vesicles are so thin that it is impossible to distinguish their walls; but there are very certain proofs of their existence. In fact, if the fat were free, it would not form regular and distinct masses. Haller and several others have erroneously alleged this form to be inherent in fat, for that substance does not present globules, and of itself has no determinate figure. If some of these vesicles immersed in tepid water be placed under the microscope, no oil is seen at the surface; but on cutting them there immediately escape some drops which float upon the water. If it be added to these considerations that the fat being fluid in the living subject, as is proved by its flowing off when the tissues are divided, it ought necessarily to be infiltrated like the serous fluid, if not in the state of health, at least in that of disease. Now, this does not happen, and all that has been said of the infiltration of the fat for explaining the conformation of the pendulous breasts of certain tribes, the projecting hips of others, the dorsal protuberances of some animals, and the voluminous tail of others, presents nothing but an association of contradictory facts and absurd reasonings. Roose and Blumen-

bach have alleged in contradiction of the existence of the vesicles, the development of fat in parts where these vesicles do not exist, from which they conclude that the latter are not necessary to the production of this fluid. Fat is in fact produced in the cellular tissue, but it there forms vesicles, in place of being merely contained in open areolæ.

160. The cellular tissue which exists between the adipose vesicles is very delicate, as it is in general between the most attenuated parts of our organs. These vesicles scarcely seem to be attached to each other, and are separated without opposing any resistance. The cellular tissue becomes more distinct between the grains, and is very apparent between the adipose masses. These latter are even separated in some places by very tenacious fibrous laminæ, as is observed in the sole of the foot, and which are intended to give great elasticity to the feet. In other places the adipose masses are connected and supported by firm cellular laminæ, as in the head, the back, &c.; in others, by a loose tissue, as in the axilla, the groin, &c. To see distinctly the cellular tissue which connects the fatty lobes, it requires to be examined in bodies that have been affected with anasarca or emphysema. It will also be satisfactorily seen in this examination that the fat is not free in the areolæ of the cellular tissue; for however extensive, however deep these infiltrations may be, they may indeed separate, and as it were dissect the adipose grains, but the fat is never mingled with the infiltrated fluid.

The blood-vessels of the adipose tissue are easily injected. They are also distinctly seen on examining parts in which the blood, when it remains fluid, naturally accumulates after death. These vessels are more apparent in young subjects, the adipose lobules being more distinct in them. Their divisions and subdivisions go on until they arrive at the microscopic vesicles themselves. Malpighi imagined these vessels to be surmounted by a secreting apparatus, and a canal which terminated in the reservoir of the fat; but he afterwards himself discovered that this arrangement does not exist. The absorbent vessels of the vesicles are less known than the arteries and veins. Mascagni, it is true, says they are composed of an inner layer of lymphatic vessels, and an outer layer of blood-vessels; but he adduces no fact in support of this opinion. It is not known whether there be nerves in these vesicles.

When the fat does not exist, the vesicles are equally wanting; they disappear when that fluid ceases to exist in a part. Hunter, however, says, that they may be distinguished even when empty; but I do not believe this assertion to be correct; they become confounded, when they disappear, with the cellular tissue.

161. The fat of the human body, extracted from the adipose tissue which contains it, and purified by washing, melting, and filtration, exhibits the general properties of fixed oils. It is destitute of smell, and has a bland taste Its yellowish colour is owing to a colouring principle, which is soluble in water, and may be re-

moved by washing. It is lighter than water. Its degree of fusibility varies according to its composition; in general, it is fluid at the temperature of the body, and even at a lower, sometimes at one so low as 15° R. It is insoluble in water and acid, and but slightly so in cold alcohol. The acid which Crell has admitted in it is the result of distillation, an operation in which the fat in fact furnishes carbonic, acetic, and cebacic acids, as well as several others produced by the reaction of its elements. It is converted by the action of the energetic alkaline bases into mild principle, and into margaric and oleic acids. By its exposure to air and light it becomes rancid, giving out volatile acid, of a strong odour.

The elementary composition of some fats has been examined by MM. Berard and Th. de Saussure. It is a combination, in different proportions in different animals, of carbon, hydrogen, and oxygen. That of human fat has not been determined.

Previously to the labours of M. Chevreul, * the fats passed for immediate principles. He has shown that they are essentially formed of two organic matters; stearine, which is fusible at about 50°, and elaine, which remains fluid at zero. It is from the proportion of these parts that the degree of fusibility of each kind of fat results. These two immediate principles are separated from each other, on treating the fat with boiling alcohol. By cooling, the greater part of the stearine is precipitated along with a little elaine, the latter remaining in solution in the alcohol along with a little elaine. They may also be isolated by the absorption of unglued paper, which takes up the elaine, and leaves the stearine at its surface.

162. The fat of the adipose tissue is not the only fat matter that is met with in the animal organization, and in that of man in particular. A crystallizable fat matter occurs in the blood. Malpighi, Haller, and others, had thought that free fat circulated with the blood. This is a mistake, at least I have never seen it; but M. Chevreul has lately discovered in the blood a fat matter which exists in it in solution, through the intervention of the other ingredients of that humour. Butter is also a fat matter, possessed of colour and smell, which exists in solution in the milk. There is also in the nervous substance a crystallizable fat, similar to that of the blood. Lastly, in cases of disease, and in alterations produced in the dead body, there are observed several other fat matters.

163. The adipose tissue presents some differences in the animals. It exists in the greater number of them, being found in the articulated animals, the mollusca and the vertebrata. In the latter, the fat presents various degrees of consistence, coloration, &c. It is very fluid in fishes and the cetacea. The head of the *Physeter macrocephalus* contains a fluid oil, in which a concrete fat matter occurs. This is what is called spermaceti. The fat is soft in the

* *Annales de Chimie*, T. XCIV.—*Ann. de Chim. et de Phys.* T. II. and VII.

hog, in which it forms lard; firm in the ruminating animals, in which it is called suet or tallow, &c. The size of the adipose vesicles is not the same in all animals. According to Wolff's observations, they increase successively in the domestic fowl, the goose, man, the ox, and the hog. The fat also accumulates in different regions, in various animals, as on the back of the camel and dromedary, in the tail of certain races of sheep, &c. Even in the human species, the Bushman tribe is remarkable for the prominence of the hips in the females, caused by the accumulation of fat, of which a recent example was seen in Europe in the *Hottentot Venus.*

164. The different degrees of fatness determine great differences in the quantity of the fat. In obesity, it forms from the half to four-fifths of the whole weight of the body. On the other hand, in extreme emaciation, the fat exists only in some places. Women, in general, have more fat than men. Considerable differences exist in this respect at different ages. The fœtus is entirely destitute of fat until the middle of the fourth month. From that period until birth, the fat accumulates successively in the different parts. It at first exists only beneath the skin, and is there produced in isolated grains, which render its examination very difficult at this age. At birth, a large quantity is already found to exist under the integuments, and in the substance of the cheeks. The omentum also presents some isolated grains. The quantity of fat increases as the growth goes on, and it at length occupies the interstices of the muscles; but it is not until a very advanced period that it is produced around the viscera. The period at which the growth ends, is also the period of corpulence. Obesity is sometimes observed in children, but this is a much rarer occurrence. In old age, the quantity of fat diminishes, principally beneath the skin. That fluid then exists especially in the interior, as around the heart, in the medullary cavities of the bones, &c.

165. The properties and functions of the adipose tissue have relation only to the secretion of the fat. This secretion is not performed in glands or in particular conduits. Heister and Fanton were the first who raised doubts respecting the existence of these glands, of which many authors have spoken since Malpighi's error in respect to this subject. The secretion of the fat is a perspiratory secretion, and Riegel's attempt to revive the supposition of adipose conduits, at the same time that he proposed a hypothesis respecting the use of the suprarenal capsules, was without success. According to that author, the fat which surrounds the kidneys, and exist in their pelvis, is formed in these capsules,* whence it is transported in particular conduits, which, however, he says he was unable to inject. Does the fat result immediately from the organic action of the vessels which deposit in the adipose vesicles? Or, is it already formed in the circulating blood? Or, lastly, has it a

* *De usu glandularum superrenalium in anim; nec non de origine adipis disq. Anat. Philos. Hasniæ.* 1790.

more remote origin? Sir Everard Home fixes its origin in the intestine.* He thinks it is, like the chyle, a product of digestion, and supposes it to be absorbed by the large gut. This opinion rests, among other facts, upon the existence of fat or of the yelk in the intestine of the oviparous vertebrate animals in the fœtal or larval state, and upon some morbid phenomena which are not very conclusive.

166. The fat is continually taken up again by the absorbent vessels. The action of these vessels is demonstrated by its diminution of quantity in various circumstances. This action is in equilibrium with that of secretion, when the quantity of fat remains the same. The exhalation and absorption of the fat are sometimes very rapid, as various facts show. Children which have become emaciated after diseases, often resume their original state in a few days; and animals that are famished, as hogs, afterwards fatten very rapidly. Certain birds are said to get fat in wet weather, in less than twenty-four hours; and emaciation takes place with equal rapidity in many cases. The circumstances most favourable to the secretion of the fat, are the absolute rest of the animal and intellectual organs, and castration. These different causes are often united, when it is in view to fatten animals. They produce the same effect when they exist in man. Habitual bleedings, and mild and amylaceous food, are also considered as favouring the production of fat. There are, moreover, unknown circumstances which appear to act in the same manner, for cases of extraordinary fatness are observed, for which it is difficult to account. The causes which accelerate the resorption of the fat, are in general the opposite of those of which we have made mention above, and further, profuse secretions, organic diseases, and in particular diseases of the organs of the nutritive functions.

167. Many hypothetical uses have been attributed to the fat. Those which it really possesses are local and general. In fact, the fat, on the one hand, has uses which are purely mechanical, or result from its position, as that of moderating pressure, in the sole of the foot in standing, and in the hips in the sitting attitude, that of filling up vacuities in conjunction with the cellular tissue, and that of rendering the forms rounded in consequence. Accordingly these forms are more marked in women and children, which have in general a greater proportion of fat. The fat has been said to protect against cold, because it is a bad conductor of caloric; and the animals which inhabit cold climates are said to have a thick layer of it under their integuments. Admitting this to be the case, the surface of the skin at least would not be protected by the fat. It has been asserted, without reason, that it diminishes the nervous action and that of the muscles, in other words, sensibility and muscular energy. In this case the cause has been taken for the effect. Fourcroy, considering that this fluid contains an ex-

* Philosophical Transactions. 1813.

cess of hydrogen, thought it destined to render the nutritious substance more azotic, by depriving it of a part of its hydrogen. Several authors, and Bichat himself is much of the same opinion, have imagined that the fat might serve to oil the skin by a kind of transudation through its pores; but the sebaceous follicles are now too well known to permit us to adopt this idea. The general uses of the fat are connected with nutrition. The nutritive matter, before being assimilated, passes successively through various states; and the fat is one of the forms which it assumes. Further, this fluid may be considered as an alimentary substance kept in reserve, of which various examples are seen in animals. Insects, for example, are nourished on their fat before assuming their perfect state, and present the same phenomenon a short time previous to their death. This circumstance is still more distinctly seen in the hibernating animals which sleep during the winter, and live exclusively on their fat until the period of their revival, when they are very thin. The fœtuses of the ovipara are nourished by the fat, which forms a large proportion of the yelk.

168. The adipose tissue and the fat, besides the varieties of which we have spoken, present some morbid alterations.

When the adipose tissue is divided, little drops of oil escape from it, and if the lips of the wound are kept together, they soon unite; but the fat does not appear again in the place where the union is effected, unless when the new cellular tissue has ceased to be compact. The adipose tissue when laid bare becomes inflamed, and the fat is absorbed. It is then covered with a layer of organizeable matter, which becomes the basis of the cicatrix, or new skin, which forms over the fat.

This tissue and the fat which it contains, sometimes accumulate in very great quantities, as is seen in obesity or polysarcia. Individuals in this state have been found to weigh from five to six and even eight hundred pounds. When the obesity is local, or confined to a part of the body, it takes the name of lipoma.* This affection may have its seat almost anywhere; it is, however, more commonly observed beneath the integuments, and on the outside of the serous membranes. Tumours of this kind, situated beneath the skin, have been erroneously confounded with encysted tumours. Their form is roundish; and when very large, they raise and carry with them the skin, when they become pedicellate or pyriform. Tumours of this description have been seen, which weighed from forty to fifty pounds. At the outside of the serous membranes, their figure is commonly ovoidal. One of their extremities is attached to the membrane, the other approaches the skin. At the exterior of the peritonæum, this tumour constitutes the adipose hernia or liparocele. The lipoma has a structure similar to that of fat. According to Monro, the vesicles in it are of the same size

* See Ths. Ch. Bigot, *Dissert. sur les tumeurs graisseuses exterieures au peritoine*, &c. Paris, 1821.

as those in the fat, only they are more numerous. A cellular envelope, like that which surrounds the muscles, sometimes of a density approaching that of the fibrous membranes or cysts, commonly exists around the tumour. This membrane contains pretty large vessels. The lipomata, external to the peritonæum, sometimes present the appearance of the omentum when they are drawn out. In general, however, these tumours contain much fewer vessels than other tumours of the same size.

Authors have spoken of adipose transformations of the muscles. The following is what I have learned on this subject, from a certain number of observations. The muscles often become entirely white in palsies; their fibres diminish in size at the same time, and as this alteration is especially observed in old persons, in whom the fat is more abundant in the interior, and the rest of the part still further increases the quantity of that fluid, there results a fatty appearance of the muscles, which has been mistaken for a real transformation of them into fat. But in these muscles we find the fibrine which is proper to them, when they are submitted to the action of alcohol, to that of absorbent paper, when they are boiled in water, and when exposed to direct heat from fire. There is therefore only a discolouration of the muscles, and not a conversion of them into fat. M. Vauquelin and M. Chevreul, have obtained the same results in the analyses which they have made of these muscles. There is no adipose transformation in the bones either; only the marrow, which occupies their interior, may become very abundant. The liver is sometimes the seat of an adipose transformation, which has not been sufficiently examined.

The inflammations which supervene in regions in which the adipose tissue is very abundant, have a peculiar tendency to terminate in gangrene. This observation, which was long ago made with respect to very fat animals, such as hogs and sheep, when they experience punctures, applies to man also, in whom wounds and infiltrations, especially of urine or stercoraceous matter, in the adipose tissue, are followed by very extensive gangrenes. The very small proportion of living parts which the adipose tissue contains may account for these phenomena. Something similar is seen in hernia of the omentum. When large masses of omentum are left at the exterior, it then happens that this organ rots at its surface. There flows from it an abundant oil, and when once its bulk is considerably diminished by this, there only remains a red and very vascular fungus, formed by the cellular tissue existing among the fat, and by the development of vessels.

In a case of hepatitis, Dr. Traill of Liverpool, found in the serum of the blood extracted by bleeding a remarkable quantity of oil, being in the proportion of about two and a half to a hundred parts of serum. Cysts of the ovary also pretty frequently contain fat with hairs and sometimes teeth, but the alteration is then very complex, and this is not the place for describing it. Biliary calculi are sometimes formed of a fat matter named *cholesterine*. The matter of dejections also sometimes contains fat substances, whether mingled with its principles, or in isolated masses. Ambergrise is a fat matter, which appears to come from the intestine of the spermaceti whale. Certain cysts of the genital organs and some hydroceles, sometimes contain shining spangles, which are nothing else than cholesterine. This matter also occurs, but less frequently, in morbid tissues situated in other regions. The tumours called meliceris, steatoma and atheroma, and which are regarded as subcutaneous cysts (Chap. III.) contain a certain proportion of fat matter.

ARTICLE SECOND.

OF THE MEDULLARY TISSUE OR ADIPOSE TISSUE OF THE BONES.

169. The *Medullary Tissue* is a membranous, vascular, and vesicular tissue, contained in the cavities of the bones. It has received the names of *marrow*, medullary stem, *medulla* and *meditullium*, from a comparison with the pith of trees.

170. Duverney has made it the subject of several observations,* and detailed descriptions have been given of it by Grutzmacher† and Isenflamm.‡ All the anatomists who have written on the bones or adipose tissue have also spoken of the marrow. Havers in particular has given a very good description of it, and figured its vesicular texture.§ Albinus has given a very beautiful representation of it in his *Annotationes Academicæ*, only the vessels are there represented too large. Mascagni, in his *Prodromo*, has also given a good figure of the marrow.

171. The marrow occupies the great medullary cavity of the body of the long bones, the cellular cavities of the short bones, of the extremities of the long bones, and of the substance of the broad bones, and even the porosities of the compact substance of the bones. The sinuses and air-cells of the bones of the skull do not contain any.

172. The fat which occupies the medullary canal represents a cylinder moulded upon the long walls of that canal, and contained in a membrane which is named the internal or medullary periosteum. This membrane, the existence of which has been denied by some, while others have supposed it formed of two layers, has only a single lamina, easily perceivable by means of an experiment which consists of sawing a bone and bringing it near the fire or immersing it in an acid. The membrane crisps, separates from the

* *Memoires de l'Academie des Sciences*, 1700.

† *De Ossium Medulla.* Lips. 1758.

‡ Ueber das Knochenmark, in beitræge, &c. Von Isenflamm und Rosenmuller. B. II. Leipzig, 1803.

§ Clopton Havers. *Osteol. Nov.* Lond. 1691, and *Obs. nov. de ossibus.* Amstel. 1731.

bone, and forms a distinct canal, the tenuity of which is such that it is almost impossible to observe it without using this means. Its tissue can be compared to nothing but a spider's web. This membrane lines the internal canal of the bone, and seems to be continuous at its two extremities with the marrow which fills them. It sends prolongations outwards into the compact substance, and furnishes internally a multitude of similar prolongations, which in general resemble the filaments and prolongations of which the cellular membrane is composed. These prolongations are supported by the filaments and laminæ of the reticular substance in the place where that substance exists.

173. The composition of the medullary membrane is principally owing to the vessels which are ramified at the interior of the canal, and which are sustained by an extremely soft and scarcely visible cellular tissue. This membrane greatly resembles in this respect the pia mater or the omentum, and like these membranes seems to be formed only by the cellular tissue belonging to the sheath of the vessels. An artery and a vein penetrate into the medullary canal, and divide these immediately after their entrance into two branches, the ramifications of which extend to the two extremities of the bone, and communicate with the numerous and large vessels of these extremities. The lymphatic vessels have not yet been traced to the entrance of the medullary canal. Successful injections, on the other hand, disclose a multitude of coloured filaments in the canal of the long bones. The nerves of this canal, whose existence has been denied, are however not difficult to be traced. Soemmering, it is true, thinks that these nerves are destined for the artery only. These nerves have been particularly observed by Wrisberg and Klint. The medullary tissue is therefore essentially composed: 1st, of an arterial and venous network, and probably also of a network of lymphatic vessels; 2dly, of a nervous plexus, whether destined for the artery, or for the other parts at the same time; 3dly, of the cellular sheath proper to these parts, which furnishes fibres, forming by their aggregate and kind of imperfect fringed membrane. There must be added to this vesicles which are very apparent, but only in fresh subjects, and which become less perceptible in others, because the marrow very quickly becomes fluid. These vesicles are entirely similar to those of the general cellular tissue; they have the same size, and the same connexions with the blood-vessels to which they appear appended. Grutzmacher thinks that the texture of the marrow and that of the fat in general, is areolar like the common cellular tissue, and not vesicular. The cellular extremities of the long bones contain a great number of vessels; but their membrane is less distinct than that of the middle of these same bones. There appear to be vesicles in it similar to those of the medullary membrane. The porosities of the compact substance appear equally to contain vesicles.

174. The fat of the bones takes the names of marrow in the medullary canal, of medullary juice in the spongy substance, and of

oily juice in the compact substance. This fat is formed of the same principles as the common fat, only in different proportions, since it is more fluid. It is also of a more yellow colour.

175. The medullary membrane is possessed of sensibility. Duverney has very well described the experiment which is to be made for proving this property, which Bichat has perhaps somewhat exaggerated, but whose existence is unquestionable. In fact, if in amputations performed on the human species, the impression caused by the dividing of the bone is in most cases scarcely perceived, this depends solely upon the more intense pain resulting from the cutting of the skin, and which has preceded that arising from the membrane. But if in a living animal an interval be left between the cutting of the integuments and that of the marrow sufficient to allow the impression produced by the former to be dissipated, a stilet introduced into the medullary canal instantly produces a pain which the animal testifies in various ways. It will easily be seen that this sensibility resides in the membrane, and is foreign to the marrow itself. The nerves accompanying the principal medullary artery into the bone, if the latter be amputated above the entrance of that vessel, the remaining marrow no longer communicates with the nervous centre. It is to this circumstance that we must attribute the difference of sensibility observed by Bichat, between the centre and extremities of the medullary cavity, and also to the circumstance that the nervous filaments go on dividing towards the two extremities of that cavity. The medullary tissue is possessed of an obscure contractility similar to that of the cellular tissue. The arteries which ramify in this membrane, secrete and deposit the fat matter in it.

176. According to Bichat, the medullary membrane exists at a very early period, being formed before the canal; only it is filled with a cartilaginous substance, which afterwards gives place to the marrow, in proportion as ossification goes on. The most attentive observation does not discover in the cartilages, arteries or veins, or medullary membrane. At a later period, the cavity of the long bones is only a narrow canal which the artery fills. The latter retire to one side and is attached to the walls, when the canal begins to widen. A viscous or gelatinous substance is contained in the latter. Marrow is at length produced, but in small quantity. As age advances, the canal becomes wider, and the marrow more abundant. There is no appreciable difference, with reference to this tissue, between the sexes. This fluid, moreover, presents individual variations with respect to its quantity. When the degree of fatness of the individual is ordinary, the fat forms the greater part of the substance contained in the medullary canal. In eight parts of this substance I have found seven of fat; the rest is formed by the vessels, water and albumen. In thin subjects, on the contrary, the fat constitutes only a fourth, or a still smaller proportion of the fluid contained in the long bones. The rest has appeared to me to be water, or at least an evaporable substance, and

albumen, or a coagulable substance. Birds have air in place of marrow in the cavities of the long bones, as Camper first remarked.

177. The functions of the medullary tissue are to serve as an internal periosteum; and a reservoir of fat. It is upon it that the vessels ramify, which, on the one hand, proceed outwards to carry nutrition to the bone, and, on the other, direct themselves inwards to secrete the fat. The latter has the same general uses as in the other parts. Its local use is to fill up the vacuity which, without it, would exist in the bones. It has been supposed, and Haller and Blumenbach have adopted this opinion, that it renders the bones more flexible; but the bones of children, although destitute of fat, are less brittle than those of grown up persons, while the bones of old people, in which the fat is so abundant, are in general very fragile. Those who have advanced this opinion ground it upon the circumstance that combustion deprives the bony substance of all its solidity. It is evident, however, that it is not the oil alone which they lose in this case, but rather the animal matter which is expelled from them, on which the solidity depended. The same authors add that by boiling in oil, or in gelatine, the earthy residuum obtained by combustion, its solidity is restored in a certain degree; but these then form a peculiar compound, a kind of putty which has no resemblance to bone. Haller and several other physiologists have also thought that the marrow was subservient to the reproduction of the bones, and especially to the formation of callus. Observation, however, shows that a fracture heals with so much the more celerity, the younger the individual is. Now, the younger an individual is, the less marrow he has, or the less fat does his marrow contain. Duverney and others have thought the marrow necessary for the nutrition of the bones. To be convinced that this opinion is not admissible, it is sufficient to reflect that the marrow is wanting in various animals, as birds, that the horns of stags, for example, are destitute of it, that it does not exist in childhood, and that the bones are formed before the marrow. It has also been regarded as the reservoir of latent caloric and electricity. Nor does the marrow, as some have imagined, serve to lubricate the articular surfaces, for the synovia exists in many places where the marrow is not met with.

178. The marrow presents some morbid alterations.* In fractures, while the bone is consolidating, the fat disappears in the medullary canal; the cellular tissue of this canal becomes compact, as in other cases of solution of continuity, and at length ossifies. This latter fact, which Bichat first observed, has been confirmed anew by various observers. When the consolidation is perfect, the medullary membrane resumes its organic properties.

After amputations, the same phenomena are observed in the marrow as in the other wounds which interfere with the adipose tissue: the oily matter disappears, and a cellular and vascular layer

* See Moignon, *Tentamen de morbis ossium medullæ*, Paris et Lugd. Ann. iii.

forms at the truncated extremity of the bone, which ultimately closes. The marrow is destroyed in sequestra, and does not appear to form again after their removal or exit: at least it has not been seen to be reproduced in this case. Perhaps the state of the parts has not been examined at a sufficient distance of time after the issue of the disease.

The medullary membrane is susceptible of inflammation. It is probably to this inflammation and its consequences that internal necrosis are to be attributed. It is equally probable that osteocopic pains depend upon the inflammation. In rachitis there is observed a peculiar induration of the medullary membrane, which has not been described.

Of the affections peculiar to this membrane, spina ventosa is one of the most remarkable. According to my observations and those of several others, there are at least two, and even three distinct species of this disease. The great development of the bone depends upon the extraordinary growth of the altered medullary membrane, but sometimes the alteration of the marrow consists in a carcinomatous degeneration, a true soft cancer; sometimes the tumour is fibrous and cartilaginous; lastly, in some cases, and especially in children, the bone, enlarged in its middle, contains a very vascular red substance, the nature of which has not been well determined. This variety is especially observed in the bones of the metacarpus, metatarsus, fingers and toes. Spina ventosa particularly affects the long bones of the limbs. In the femur, it is generally the lower part of the bone that is diseased; in the humeris, it is the upper part. I have removed the upper third of the fibula of a young woman, in a case of spina ventosa which had increased the head of that bone to nearly the size of the patient's fist.* Tumours of this kind have been described by Vigarous, under the name of bony steatomata, and by Astley Cooper, under that of medullary exostoses.

CHAPTER II.

OF THE SEROUS MEMBRANES.

179. The Membranes *(Membranæ)* are soft, broad and thin parts, which line the cavities, envelope the organs, enter into the composition of a great number of the latter, and of themselves constitute some. They differ greatly from each other in their texture, composition, action, &c.

180. The serous membranes *(Membranæ serosæ, vel succin-*

* It is to be regretted that Mr. Beclard has not given the details of this very interesting operation: an attempt to remove the head of the fibula for a small osseous growth completely failed in the hands of a very expert surgeon, and the patient lost his life in the attempt. I do not think that the head of the fibula was removed by M. Beclard. R. K.

gentes,) so named because they contain numerous serous vessels in their substance, are bedewed with a fluid resembling the serum of the blood, and furnish coats to many organs, form a system of membranes closed on all sides, adhering by one of their surfaces to the surrounding parts, free and in contact with themselves at the other surface, serving to isolate certain parts and to facilitate motion, and resulting from a very simple modification of the cellular tissue.

181. Although long confounded with the parts to which they are attached, the serous membranes have been particularly distinguished from the other parts, and examined in their general relations, by Bonn,* Monro,† and especially Bichat.‡

182. The serous system comprehends membranes which, from their great similarity, form a very natural genus, in which however there are differences sufficient to authorize their separation into several groups. With reference to their situation and the greater or less unctuosity of the fluid by which they are moistened, they are distinguished into serous membranes properly so called, or serous membranes of the splanchnic cavities, and synovial membranes; and these latter are themselves distinguished into those of the articulations, those of the tendons, and those which are subcutaneous. We shall first give an account of the characters common to the whole genus, and then of those of the different species.

SECTION FIRST.

OF THE SEROUS MEMBRANES IN GENERAL.

183. All the serous membranes consist of bags closed on all sides. There is no other exception to this general disposition than the opening by which the peritoneum communicates with the genital organs in the female, these organs being themselves interrupted in their continuity between the ovary and the commencement of the oviduct or uterine tube. There results from the general conformation of the serous membranes, that the fluids which they contain are entirely isolated, and that the membranes are only permeable by the vessels which ramify in their substance, and not, like the cellular tissue, by areolæ communicating freely with each other. This conformation presents some varieties or secondary forms. Some of those membranes are as simple as possible, and present the appearance of a bag or bladder. These are called vesicular. Others form sheathing envelopes which surround certain parts, as tendons, ligaments, and blood-vessels; and as they are not perforated to allow these parts to pass out, but are reflected at their two extremities, and thus form a double sheath, they have for this reason obtained

* De *Continuationibus Membranarum*. Amst. Batav. 1763.

† A description of all the Bursæ Mucosæ, &c. Edin. 1788.

‡ *Traité des Membranes*, Paris, An. viii.

the name of vaginiform. This arrangement is one of the most common. Lastly, there are others more complicated still, which are the enveloping serous membranes, those which might with propriety be more peculiarly denominated *succingent* membranes. They surround the organs, excepting at a single point of their surface, around which they are reflected upon the walls of the cavity which contains them, and are thus divided into two portions, of which one forms an envelope to the organs, and takes the name of visceral lamina or coat, while the other which invests the walls, constitute the parietal lamina. The various forms which we have just examined are often united in the same membrane. In the enveloping serous membranes, such as those which occur around the heart, the lungs, and the testicles, there is always at the surface of the organ, a place which is destitute of serous envelope. It is at this place the vessels of the organ penetrate, or rather here that the organ is connected with the neighbouring parts. This free part of the organs which are invested with serous membranes, is sometimes broad, sometimes very narrow. In some cases, the viscus is separated from the walls which enclose it, and attached or suspended by a fold of the serous membrane which constitutes what is named a bridle, frenum, or membranous ligament. This disposition is not an exception to what we have above said: There is always a part of the organ which is not invested by the membrane in the whole extent of the adherence of the fold which the latter forms. Besides this kind of fold, the serous membranes present prolongations which float more or less in the interior of the cavity which they form, and which depend most commonly upon their visceral lamina, but which also sometimes belong to their other lamina. Examples of those prolongations are seen in the omentum and epiploic appendages, which come off from the peritonæum; the adipose folds observed in the pleura on the sides of the mediastinum, which belong to that membrane, and the synovial fringes, which belong to the articular capsules. These prolongations always contain in their substance cellular tissue which is generally adipose, and it is in them that the membrane is most vascular.

184. All the serous membranes present two surfaces, the one free, the other adherent. The latter is flocculent, and is attached to cellular tissue, ligaments, tendons, cartilages, &c. Its degree of adhesion to these different parts is various, being sometimes effected by a loose cellular tissue, while in other places, as upon the cartilages, the adhesion is intimate. There are numerous degrees between these two extremes, as may be observed when it is attached to ligaments, muscular fibres, tendons, &c. The free surface of the serous membranes is everywhere in contact with itself, these membranes representing the interior of a collapsed bladder. This surface at first sight appears perfectly smooth and polished; but when examined with the microscope, it presents obvious villosities; on which account the serous membranes have been named *simple*

villous membranes. This surface is constantly moistened by a fluid.

185. The serous membranes are in general of a whitish colour, which their transparence renders hardly perceptible, glistening on their free surface, very thin, and yet possessed of considerable firmness, and stronger than the cellular tissue would be were it reduced to the same state of tenuity. They are in general somewhat elastic.

186. At first sight they seem almost homogeneous; there is always, however, observed in various points of their extent, a fibrous appearance which is more or less marked. When they are torn asunder by stretching, they stretch at first, and then resolve themselves into small filaments interwoven together. Their nature appears greatly to resemble that of the cellular tissue, from which they differ only in being more condensed, and in forming the boundaries of a great cavity. Besides, there exists a kind of insensible gradation between the cellular tissue and the serous membranes, and the more simple of the latter bear a great resemblance to the former. The very loose cellular tissue which by insufflation may be formed into large ampullæ, such as that of the prepuce, that which occurs between the muscles that perform extensive motions, the subcutaneous synovial bursæ, in fact form a transition between the two kinds of tissue. Very numerous white vessels enter into the composition of these membranes. They are rendered very apparent by the injection of coloured liquids, and by inflammation which fills them with red blood, and in these cases their number appears very great. We must not, however, confound the vessels proper to the serous membrane with those which belong to the subjacent cellular tissue, and which might be thought to exist in the membrane itself, on account of its transparency. In the peritoneum, for example, inflammation must have long gone on before the blood arrives beyond the subserous cellular tissue; and, on examining the thing without much attention, one might be led to suppose that it was the peritoneum itself which the disease had rendered vascular. It is the same with injections, and it is only when they are very fine that they penetrate into the membrane itself. The nerves of the serous membranes have not been demonstrated.

187. The fluid which these membranes contains is not the same in all; however, it has a greater or less resemblance to the serum of the blood, or to blood deprived of colouring matter. It contains in general water, albumen, an incoagulable matter which may be regarded as a kind of gelatinous mucus, a fibrinous matter and soda. We shall see as we proceed the differences which this fluid presents in the different kinds of serous membranes.

188. The serous membranes, especially during life, are extensile and retractile in a high degree, as is seen in dropsies, and after the removal of these diseases; but their enlargement is not always merely a result of their extensibility; there is moreover a disappearance of their folds, which, by gradually developing themselves, allow the membrane to increase in extent. Another cause which

contributes to this augmentation of volume, is the sliding of which the membrane is susceptible, the kind of locomotion which it undergoes when it is distended only in one part of its extent, as is particularly seen in herniæ. Lastly, there appears in some cases to be a real augmentation of nutrition, which also contributes to the production of this phenomenon. This increase of substance, along with the other causes of distension, is manifest in gestation, for example. These phenomena are not equally marked in the different species of serous membranes. The peritoneum presents them in the highest degree; they are much less distinct in the synovial membranes, especially those of the joints, which depends on the one hand upon the circumstance that these membranes are less extensile, and also upon that of their having fewer folds, and on the other, and more especially, upon the circumstance that their connexions do not permit to be so easily displaced. When the distension ceases, the membranes gradually return to their original state; but if it has been carried so far as to produce separation there always remain traces of it.

189. The formative force, although considerably developed in the serous membranes, is yet less so in them than in the free cellular tissue. Mobility is very limited in them, existing only in the lesser degree which constitutes tonicity. But if irritation does not determine appreciable motions in them, it developes sensibility, in fact, these membranes become very sensible, and generally transmit painful sensations, in inflammation.

190. All the serous membranes are the seat of a continual deposition and resorption of the serous fluid in their cavity, or at their free and contiguous surface. The great extent of these membranes viewed as a whole, gives a great importance to this twofold function. The matter of this secretion is, like all the others, carried by the vessels into the substance of the membrane, and especially into the most vascular part, the fringed prolongations. It is not yet precisely known in what way the secreted matter issues from the vessels and passes into the cavity. All these membranes have been supposed to have secreting glands, whether in their vicinity, or in their substance itself, but these alleged glands have no existence. Transudations by means of inorganic pores have also been supposed; but although we do not exactly know the mode in which the perspiratory secretions takes place, we know that transudations take place only in the dead body, and that not until some time after death. The fluid is also continually absorbed by the membrane, in the substance of which it enters into the vessels. So long as the deposition and resorption are in exact equilibrium, the serous membranes are merely moistened at their surface. An increase of secretion, or a diminution of absorption, gives rise to an accumulation which is called dropsy.

The secreted fluid has local and general uses. Locally it serves to maintain the separation of the two contiguous laminæ of the serous membranes, and to facilitate the motions of the organs upon each other, and viewed in a general sense, it is probable that the nutritive matter, thus alternately deposited and taken up, undergoes a more perfect assimilation before being employed for the nutrition of the organs.

191. The action of the serous membranes, whether in health or more particularly in disease, is closely connected with the other organic actions. Thus, when they are diseased, the functions of the organs which they invest are more or less disturbed; this disturbance extends to a distance, and frequently to the whole organism. In like manner, the affections of the other organs, especially those of the tegumentary membranes, organs of circulation, and glands, often derange their functions. The affections of the organs which they invest, always alter them in a more or less sensible degree. On the one hand, the cavity which they form establishes a true separation between the parts over which their two opposite portions are spread out; and on the other hand, the continuity and extent of each of these membranes, easily give rise to very extensive affections.

192. The serous system is very soft at its commencement, which, however, is little known. In the embryo, the abdominal viscera seem only covered by a fluid and viscous varnish. The serous membranes are very thin in the fœtus, and, in general, less adherent, on account of the softness of the cellular tissue which connects them with the neighbouring parts, so that they are easily separated from these parts. However, on the articular cartilages and the tunica albuginea of the testicle, the adhesion is nearly as intimate as it is afterwards. It is entirely unknown whether these membranes, whose essential character is the interruption of continuity which they establish between the parts, are at first soft cellular tissue continuous and without internal cavity, as is affirmed by some anatomists, who admit that there exists at the commencement a general continuity among all the parts, among the bones, for example. The fluid of the serous membranes is at first very scanty. Some of these membranes, those of the splanchnic cavities, present remarkable differences of conformation in the fœtus. The serous membranes undergo various changes in old age.

193. The formation of an incidental serous tissue is often observed. Its reparation or reproduction takes place in wounds of the serous membranes, which unite when their edges are in immediate contact. Observation has shown that the opinion of the ancients, who believed wounds of this kind to be incapable of healing, is entirely without foundation. When there is loss of substance in these wounds, or when their edges are separated, the interval which they present is filled up by a new membrane, forming a true cicatrix. This new part appears to be somewhat thinner and more extensile than the surrounding membrane.

194. The fluid contained in the cavities of the serous membranes is capable of accumulating in it, whether by the absorption being diminished, or by the exhalation being increased. This accumulation gives rise to various dropsies. The fluid which form these

dropsies presents variable qualities, especially when there is inflammation. It contains sometimes more, sometimes less animal matter than in the state of health; and sometimes the proportion of this matter is the same as in that state. In general, the serosity of dropsies resembles the serum of the blood, only that it has a smaller proportion of albumen. There is a point of pathological anatomy to which sufficient attention has not yet been paid, which is, that dropsies which do not appear to depend upon an alteration of the serous membranes or of the organs of respiration and circulation, and for this reason have been regarded as general affections, are often preceded and accompanied by a flux of urine containing a large proportion of gelatine and albumen, an abstraction of animal matters which changes the composition of the blood, renders it more watery, and depends upon an alteration of the kidney and its function. This flux also sometimes accompanies dropsies with local affection of another viscus.*

195. Inflammation of the serous membranes, which is of very frequent occurrence, produces in these membranes alterations of tissue and alterations of secretion. The membrane becomes vascular, first in its external tissue, and at length in its substance; its vascular fringes and its villosities are more marked, and even become very prominent and very thick. If the inflammation continues a certain time, the membrane thickens a little and loses its transparency. Most commonly, however, the thickening which appears very great, is only so in appearance, and is foreign to the membrane itself. Besides the interstitial deposition which gives rise to this alteration, a secretion generally takes place in the cavity of the membrane. The secretion, however, is at first suspended to change its character afterwards. The fluid poured forth is generally a mere serosity, very abundant, but not otherwise altered; or a fluid of a whitish colour, milky or containing albuminous and fibrinous flakes. Sometimes, but rarely, the serosity is bloody. Lastly, the fluid is found to be pus, presenting all the properties of that which is produced in the cellular tissue. Besides these effects of inflammation, there are others also which are very remarkable.

196. The false membranes, *Pseudo-membranæ*, are not peculiar to the serous membranes, but are of very frequent occurrence in them. They consist in the concretion, under the form of a membrane, of the product of the secretion of the membrane inflamed to a certain degree. This product, like the organizable matter which determines the adhesion of the lips of the wounds, is at first poured out in separate drops upon the free surface of the membrane. These drops becoming numerous, and spreading out, meet each other, and form first a net-work, and then a continuous surface. In general, the same circumstances taking place on the opposite part of the membrane, and the latter commonly remaining

* See J. Blackall. Observations on Dropsies, &c. London, 1813.

in contact with the former, the false membrane determines the agglutination of the two parts formerly in contact. This is the first degree of adhesion, the *gelatinous* adhesion of some, the adhesive inflammation of others, which however I prefer calling agglutination. Sometimes the agglutinating matter forms but a thin layer, interposed between the two approximated surfaces; at other times it is so abundant as to fill and distend the serous cavity.

The organic adhesions of the serous membranes are a frequent result of the formation of false membranes. The organizable matter of the agglutination changes into cellular tissue, in which there form branched canals which gradually acquire the vascular structure, (Chap. IV.), and which ultimately communicate with the vessels of the inflamed membrane. Several of the first observers who saw the vessels of adhesions, took them for vascular villosities, prolonged from the old membrane into the substance of the new one. John Hunter and Sir Everard Home have observed the contrary, which I have myself repeatedly confirmed. On introducing a tube filled with mercury into any part of a recent adhesion at random, branched canals may be injected, the widest part of which or the trunk corresponds to the centre of the adhesion, while the branches running into two opposite directions, like those of the vena-portæ, direct themselves towards the serous surfaces without always reaching these surfaces, and without the latter furnishing very decided villosities. In the course of time, the disposition changes; the adhesion, after the canals have communicated with the old vessels, becomes more and more vascular in the neighbourhood of the membrane, and less so in its centre. The organic adhesions of the serous membranes have not always the same form. They commonly consist of a few bridles or cords, broader at the adherent extremities, and thinner at the centre, which is free. At other times, there is a vast number of filaments nearly resembling bridles. Lastly, in other cases, the adhesions are so numerous, that the two parts of the membrane are confounded together, and seem replaced by cellular tissue. The texture of adhesions, such as it is seen in the bridles, is that of the serous membranes; they form a kind of sheath smooth at its surface, and filled with cellular tissue containing some vessels. These adhesions are on the one hand so frequent, and on the other sometimes so regularly organized, that many of the older physicians took them for natural ligaments, and that, even among the moderns, Tioch found some in the pericardium, and Bichat others in the pleura, which seemed to them to belong to an original conformation.

The bridles which constitutes adhesions elongate more and more in proportion as they harden. It is even probable that their centre is at length entirely absorbed. What tends to confirm this opinion is, that on examining the walls of the abdomen shortly after wounds of that part, the intestine is generally found adhering to the place of the wound, while at a more advanced period, the adhesion is formed merely by a bridle which at length becomes itself very slender, and if the disposition of the parts is observed at the end of a very long period, no adhesion at all is seen. These different gradations were all met with in the body of an individual, who being affected with melancholy, had inflicted on himself at different times twelve or fifteen wounds with a knife, and whom I had occasion to dissect.

197. The serous membranes undergo various transformations, or, to speak more correctly, are the seat of various accidental productions. Fibrous, cartilaginous, fibro-cartilaginous and even bony plates, are sometimes observed in their substance, and in particular in the pleura, which sometimes forms a kind of scutum after chronic pleurisies. Most commonly, it is true, these plates are simply subjacent or superapplied to them.

Free concretions and others with stalks or pedicels have their seat in the interior of these membranes. They occur more particularly in the serous membranes of the joints, sometimes however in those of the tendons, and even in the splanchnic cavities. They are at first external to the membrane, then gradually push it before them, and project in its interior, where they present a broad and short base, and at a more advanced period a pedicel which gradually becomes longer and more slender, until at length the pedicel breaking, they become entirely free in the cavity of the membrane. Such is the true mechanism of the formation of these bodies, which were taken for true concretions, when they had not been observed at different stages of their development. The consistence of these bodies varies. They are sometimes very soft and as it were albuminous, but more commonly they are fibrous, cartilaginous, or bony.

The serous membranes participate in the degenerations common to all the tissues; they also appear to have some peculiar to themselves.

198. Vices of conformation are observed in some of these membranes, as in the arachnoid membrane of anencephalous fœtuses; in the peritoneum and tunica vaginalis, when the canal of communication between these two membranous sacs subsists after birth. A kind of supernumerary sacs has been met with in the peritoneum, of which Neubaur relates examples. The acquired vices of conformation are equally proper to a small number of these membranes, and belong to particular anatomy. Herniæ forms one of these defects.

199. The cysts may be described in speaking of the serous membranes. It is in fact to these organs that they bear the greatest resemblance. They represent in general, like the parts which the serous system comprehends, a membranous bag or cavity, closed on all hands, adhering at one side, free at the other, and in contact with a fluid which fills it. They are generally of a globular form. Their volume varies from that of a grain of millet seed to that of the distended abdomen. They are sometimes isolated and sometimes grouped several together, and communicating with each other. Their outer surface is floculent, cellular, sometimes furnished with laminæ or even with a fibrous layer. Sometimes this

surface is doubled by a natural membrane which they have carried with them in protruding at a surface. Their internal surface is smooth and polished. The thickness varies, and is not in general so great in the cysts of the organs as in those of the free cellular tissue; it also varies in the different parts of the same cyst. The consistence varies from that of a scarcely concrete fluid to that of the serous tissue, and even of the fibrous tissue. This is also the case with their adhesion, which is sometimes intimate, and sometimes seem to consist of a mere agglutination. There are no apparent vessels at their free surfaces. The fluid which they contain is equally variable. Sometimes there occurs in them a serosity which is limpid, or more or less thick, and as it were albuminous, and variously coloured; sometimes fat in the fluid state, or in spangles and forming cholesterine; in some cases, mucus or a viscous substance, which, in place of coagulating, is almost entirely evaporated by heat, and leaves very little residuum; at other times a mixture of mucus and albumen, or a blackish matter resembling chocolate, sometimes even pure blood; sometimes hydatic worms; sometimes crystallized saline substances. There has also been found in them a concrete substance resembling caoutchouc.

The cysts are in a state of repletion which may be compared to dropsy of the serous membranes. They are the seat of a continual secretion and absorption. They disappear in certain cases, persist in some, and continually enlarge in others.

Various hypothesis have been proposed for explaining the formation of cysts. Some consider them as membranes of new formation which are developed round a substance originally existing. Others again think that they exist before the matters which they contain, whether they are formed by the distended cellular tissue, or owe their origin to dilated lymphatic vessels. It is difficult to settle the question in a decisive manner, cases occurring which are favourable to both these opinions. Certain tissues which are ranked among the cysts are evidently pre-existent. To this class may be referred the subcutaneous wens, which are nothing else than sebaceous follicles greatly enlarged and not accidental bags, the cysts of the testicular cord of man, or of the lip of the vulva in women, which are remains of the tunica vaginalis, &c. On the other hand, certain cysts form consecutively. Such are those which succeed effusions of blood in the brain, those which are developed round a foreign body, &c. In other circumstances, it is very difficult to determine the mode and period of commencement of cysts. It is highly probable, however, that all the true cysts are membranes of new formation determined or not by an evident inflammation. Cysts are susceptible of all the affections of serous membranes: They are subject to all the varieties of inflammation, and to accidental productions, whether similar or morbid. They have been observed in all parts of the body, excepting perhaps the bones and cartilages.

With the cysts are commonly confounded the new cellular membranes which form envelopes to similar or morbid accidental productions and to foreign bodies. These envelopes are not like cysts or the serous membranes of inhalant and exhalant surfaces. They often surround cysts. Their consistence varies, and they are also always parts of new formation.

There exist between the cysts or serous vesicles connected with the cellular tissue by their outer surface, and the hydatic worms, insensible transitions between which it were very difficult to draw a very decided line of distinction. Thus the small serous vesicles which so frequently occur in the choroid plexus, those which are sometimes seen at the fringed extremity of the uterine tube, and those which I have repeatedly seen in vegetations of the nasal and uterine mucous membranes, evidently appear to belong to the cysts. The hydatic or botryoid mole seems to me to belong to them also, and yet a very able naturalist refers them to the genus acephalocystus.* The three species of simple acephalocysti themselves, whose animal nature is still doubtful, also in a certain degree resemble cysts. I have once extracted from beneath the skin of the neck, and several times from beneath the skin of the mamma, acephalocysts of these species, single, not encysted, and not adherent, indeed, but as it were glued to the cellular tissue. Most commonly, it is true, one or other of the three species of simple acephalocysts, occur associated in great numbers and free in a distinct cyst.

A modern physician† has attributed to the formation, development, and transformations of the hydatids or hydate form, cysts of which we have just been speaking, the origin of tubercles, of all the kinds of tumours, and even of foreign bodies suspended or free in the serous and synovial cavities.

Having now given the general history of the serous system, we shall next describe successively the different species which it comprehends.

SECTION SECOND.

ARTICLE FIRST.

OF THE SUBCUTANEOUS SYNOVIAL BURSÆ.

200. The Subcutaneous Synovial, or Mucilaginous Bursæ, *Bursæ mucosæ subcutaneæ*, had not been described by anatomists, although some pathologists, and especially Gooch, Camper, and recently M. Asselin, had spoken of their dropsy, in doing which Camper took occasion to say a word respecting their healthy state,

* See H. Cloquet. *Faune des Medecins*, T. I. Paris, 1822.
† See J. Baron. An Inquiry, &c. on Tuberculous Diseases, London, 1817.

when I examined them and described them in my lectures. I have also spoken of them in the additions to Bichat's General Anatomy, and in the *Dictionnaire de Medicinè*.

201. The Synovial Bursæ, of which we find as it were the rudiment in the loose and very extensive cellular tissue which exists between all the parts intended for performing extensive motions, are met with under the skin, in all places where that membrane covers parts which exercise great and frequent motions; as between the skin and the fibula, between the olecranon and the skin, upon the trochanter and acromion, before the thyroid cartilage; sometimes behind the angle of the jaw; always between the skin and the projecting side of the articulations of the metacarpus and metatarsus with the fingers and toes, and of those of the first with the second phalanges. All these latter bursæ are commonly confounded with those of the neighbouring tendons.

To see these membranes distinctly, they must be filled with air. It is then found that they form a roundish multilocular cavity, (that is, divided by imperfect septa,) closed on all sides, the air which is blown into them remaining enclosed, and not making its way into the surrounding cellular tissue. The walls of the cavity which they form are very thin, and possessed of little strength.

Their texture is very simple, like that of the serous membranes in general, and seems to differ from that of the cellular tissue only in being more condensed. There are very few vessels in the substance of these membranes. Their free and contiguous surface is moistened by an unctuous or mucilaginous fluid, which exists in too small quantities to be capable of being properly examined.

These membranes and the unctuous fluid which they contain, evidently have for local use to facilitate the motion of the bones under the skin.

These bursæ are developed at a very early period. They exist at birth, and are then very easily perceived, on account of the rather abundant fluid by which they are moistened.

Their development increases in proportion as the parts which they cover are exercised. That of the acromion, for example, becomes more apparent in individuals who carry burdens on the shoulder, and that of the knee is larger in persons who habitually kneel.

202. They form accidentally in cases where the skin happens to be much rubbed. Mr. Brodie speaks of a hump, on which one was developed in consequence of the continual rubbing which the skin experienced on that part. The same thing is observed in club-feet, at the place where the skin rubs against the projecting side of the tarsus; as well as after amputation of the thigh, between the end of the bone and the cicatrix.

Dropsy of the subcutaneous synovial bursæ constitutes hygroma, an affection long known, which is particularly observed at the knee, before the patella of persons who often rest upon this part, as priests, devotees, the washer women of certain countries, and female servants who kneel in washing, chimney sweeps and others, and which is also sometimes, but less frequently, observed in the other membranes of this kind. The hygroma may acquire a great size. It sometimes very rapidly disappears without assignable cause, or after medicinal applications. I have sometimes punctured it, and drawn a vicous serosity from it. A stimulant injection, made after puncture, often causes adhesion of the walls and obliteration of the cavity.

The subcutaneous synovial bursæ are susceptible of inflammation and suppuration, and may form extensive abscesses, whether after long continued pressure, or after being injected.

ARTICLE SECOND.

ON THE SYNOVIAL MEMBRANES OF THE TENDONS.

203. The Synovial Membranes of the Tendons, *Membranæ mucosæ tendinum*, are serous membranes moistened by an unctuous fluid, annexed to the tendons, in those places where they rub against the neighbouring parts.

They have received the rather inappropriate names of mucous, mucilaginous, unguinous, synovial bursæ, vesiculæ, capsules or sheaths. They have been long known. Vesalius and A. Spigel speak of some of them. Albinus has accurately described a certain number of them. Janckius was the first who gave a general description of them. He was acquainted with sixty pairs. Camper first gave a figure of one of these membranes. It is to the celebrated Fourcroy* that anatomy is most indebted in this matter, as well as to Monro.† Koch‡ has very accurately described these membranes, not only in man, but in various animals. Gerlach || was the first who described and gave good figures of those which occur in the neck and on the head. Rosenmuller § has published an enlarged edition of Monro's work, and Mascagni has given a good figure of one of these membranes in his *Prodromo*.

204. The number of these membranes is great, but variable, there are now known about a hundred pairs. Like all the serous membranes, they form membranous cavities without apertures, but two kinds are distinguished with respect to their form. Some of them are rounded vesicules, attached on the one hand to the tendon, and on the other to the part on which they slide. These are named vesicular, others are vaginal, surround the tendon in a cir-

* *Hist. de l'Acad. Roy. des Sciences.* Paris, 1785—1788.

† A Description, &c. with Tables.

‡ Ch. M. Koch. *De Bursis Tendin. Mucos.* Lips. 1789

|| F. E. Gerlach. *De Bursis Tendinum mucosis in capite et collo reperiundis, cum tabul. Æneis.* Viteberg. 1793.

§ *Icones et Descrip. Bursar. mucosar. corporis hum. Ed. J. Ch. Rosenmuller.* Lipsiæ, 1799.

cular manner, and line on the other side a canal in which they are contained, these two isolated portions joining each other at the extremities, so as to be separated by an interval which constitutes the cavity of the membrane. Among these latter there are some which are simple at one of their extremities, and at the other present a kind of digitations which correspond to an equal number of tendinous portions or of different tendons, these tendons being at first united and afterwards separating from each other. This is what is observed at the wrist, under the annular ligaments which occur there.

205. The very loose and membraniform cellular tissue which is observed between the muscles that perform frequent and extensive motions, as under the latissimus dorsi, the rectus femoris anticus, the muscles of the calf, &c., constitutes, in some measure, the rudiment of the membrane of which we speak. Synovial membranes occur around the tendons, in the places where the latter rub upon the bones, slide at their surface or upon other parts, or where they are reflected and change their direction. Sometimes these membranes exist between two tendons which move upon each other. The glutæus maximus, at the place where it slides upon the trochanter, the obliquus oculi superior, at the place where it is reflected in its pulley, the lateral peronæi, where they change their direction to gain the sole of the foot, &c. are furnished with synovial membranes. In general, these membranes are in connexion with bones or fibrous rings. They are especially very common around the joints, because it is there that the tendons are peculiarly situated, as may be seen at the knee, the elbow, and the wrist. The two kinds of which we have spoken occur in these places. Some of these capsules are confounded with the subcutaneous bursæ, or with the synovial bursæ of the joints. That of the triceps, for example, is not always isolated, and often appears a continuation of the synovial capsule of the knee.

206. The adherent surface of these membranes, besides being attached to the tendon and the part on which it rubs, is in connexion, in the interval between them, with the cellular and adipose tissues. It often adheres to fibrous tissue, as to the tendinous sheaths, or to fibro-cartilaginous tissue, as in the places where the tendons slide upon the bones, and opposite which the periosteum has a cartilaginous appearance. Their interior presents a cavity which is commonly simple, but sometimes compound, being traversed by septa formed of a kind of fibrous prolongations. Fringed prolongations occur in some of them, as in that situated behind the calcaneum. There also occur in them cellular or adipose pellets, but only in those which have the vesicular form, the vaginal kind not having any. These prolongations have been likened to excretory ducts. Rosenmuller describes follicles in these membranes. I have not seen any, however. Villosities are met with in them, which pour out the synovia.

207. The synovial membranes of the tendons are whitish, semi-

transparent, thin and soft, especially the vaginiform, which are furnished with ligamentous sheaths at the exterior. The vesicular bursæ are thicker, and in some parts present a fibrous appearance. The texture of these membranes is the same as that of the other serous membranes, their tissue has a great resemblance to the cellular. The fibres, fringes, and adipose pellets, common to the whole serous system, occur in them also. Serous vessels, which become visible in inflammation, and some blood-vessels, which are especially apparent in the fringes, enter into the composition of these membranes, the lymphatics and nerves of which are entirely unknown. The fluid which they contain is viscous, more abundant than that of the subcutaneous mucus bursæ, of a yellowish colour, sometimes reddish. This fluid has an oily appearance, is in part coagulable, and contains albumen and mucus. It is more viscous in the mucous bursæ which are of greatest extent. M. Koch has found some difference in this fluid when examined in different animals, as in the ox, the horse, and the hog.

208. The properties of the tendinous capsules present nothing peculiar. Their functions are those of secreting and containing a mucilaginous fluid, which facilitates sliding by diminishing the loss of motions that results from friction.

Little is known of the development of these membranes. According to some, they are numerous in young subjects, and are in part confounded in old persons in consequence of their enlarging and meeting each other. M. Seiler asserts, on the contrary, that they diminish in extent and partly disappear in old age.

209. They present some alterations.* Dropsy of them is not of rare occurrence, especially in those which are near the skin, in which case the disease is liable to be confounded with hygroma. The name of *ganglion* is particularly applied to the small circumscribed tumours which result from it, and which are also frequently cysts. Tumours of this kind are especially met with in the ham, at the wrist, on the foot, &c. They contain a serous fluid, which is albuminous, of a yellowish or reddish colour, in colour and consistence bearing a considerable resemblance to jelly or to gooseberry syrup. The resorption of this fluid is performed slowly. It is favoured by pressing the tumours containing it, by which it is disseminated in the cellular tissue. These tumours sometimes occur much larger. Large collections of purulent serosity which have been observed under the broad muscles of the back, the deltoid muscle, &c. and which has been confounded with the common abscesses of the cellular tissue, have their seat in membranes of this kind, or in membranes similar to them.

The inflammation of the membranes of which we speak is very severe. It is observed in one of the varieties of the panaris. There result adhesions, or, in other cases, the formation of an abscess

* Monro. *Op. cit.* Koch. *De Morbis Bursarum tendinum Mucosarum*, Lips. 1790.

which opens at the surface of the body, and, in either case, the motions of the part are lost. When the adhesion is filamentous, it is sometimes at length broken up. Chronic inflammation produces nearly the same results, it may also induce ulceration.

Solid cartilaginous bodies have been found by Monro, and afterwards by many observers, in the interior of these membranes. There often occur in them, and in very great number, small bodies nearly of the form and size of grape stones or seeds of pears or apples, which have been supposed to be animated, and which it has been proposed to name *Acephalocystis plana*. They have been most commonly formed under the anterior annular ligament of the wrist, and sometimes in other membranes of the tendons, as those of the glutæus maximus, flexor longus pollicis, &c. Incision gives issue to them, but there commonly results a very severe inflammation, and in the most fortunate cases, an intimate adhesion, which, at the wrist, for example, confounds all the flexor tendons into a single parcel, and render the fingers immoveable. In general, inflammation of the tendinous synovial membranes deserves to fix the attention of pathologists, as is also the case with most of their morbid alterations, which have often been confounded under the name of white swellings, with the diseases of the joints, in the neighbourhood of which they are situated.

ARTICLE THIRD.

OF THE SYNOVIAL CAPSULES OF THE JOINTS.

210. Under the name of Articular Synovial Capsules, *Capsulæ Synoviales*, are designated the serous membranes of the diarthrodial articulations. Most of them belong to bones, although some belong to cartilages, as is the case with respect to the larynx. These membranes, like the preceding, are moistened by a fluid at their interior, and in the same manner facilitate the sliding of the parts which they cover.

They were long confounded with the capsular ligaments of the joints. Nesbitt, Bonn, and W. Hunter, had observed that they form a membrane distinct from the articular ligaments and cartilages. Monro first remarked their resemblance to the other synovial and serous membranes. Bichat drew the attention of anatomists more to these organs, and gave a more complete general description of them. Monro and Mascagni have given figures of them.

211. The number of these membranes is very great, there being nearly as many of them as there are joints. The number is not precisely equal to that of the articulations, because, on the one hand, certain of these membranes are common to several articulations, as is observed in the carpus, and, on the other hand, because

there are articulations which contain several. They occur no where but in the articulations.

212. The following varieties are observed in the configuration of these membranes. 1st, There are some which represent rounded and simple bags, like the vesicular membranes of the tendons. This is what is seen in the articulations of the phalanges with each other, and with the metacarpus and metatarsus. There is in these parts no kind of complication, and by insufflation there is only obtained a small round ampulla. 2dly, In some articulations, the cavity of the membrane seems traversed by a ligament or tendon, around which the membrane is reflected upon itself, forming a sheath which is continuous at its two extremities with the common envelope which the synovial membrane furnished to the joint. This synovial membrane is then vaginiform. This arrangement is met with in the hip and shoulder joints, &c. 3dly, A greater complication is observed in other joints. In that of the knee, for example, there occur a common envelope, sheaths for the tendon of the poplitæus muscle and the adipose membrane; and, moreover, folds pass round the semi-lunar and crucial ligaments, which raise the membrane and project in the joint. The following order might therefore be established in the complication of the synovial membranes: 1st, A simple ampulla. 2dly, An ampulla raised by adipose projections. 3dly, The latter disposition joined to the presence of sheaths. 4thly, Besides the presence of sheaths, folds formed by parts which sink into the joint, and are invested by the membrane. All these forms, however varied, are ultimately referable to the vesicular form.

213. The outer surface of the synovial membranes is more or less intimately connected with the neighbouring parts. At the two extremities of the kind of sac which they represent, all adhere intimately to the articular surfaces of the bones, or rather to the cartilages by which their surfaces are covered. Their connexion with these cartilages is so intimate that the latter might be thought to be bare; however, Nesbitt, Bonn, and W. Hunter, long ago announced the existence of a prolongation of the articular synovial membranes over the cartilages. In inflammation of these membranes, their redness, which at length becomes sensible, extends over the circumference of the cartilage, and is gradually fainter as we proceed towards its centre, the membrane becoming more and more identified with the cartilage. The centre itself at length becomes penetrated by vessels, but the cartilage is coloured only at its surface, and preserves in its substance the white colour peculiar to it. The bridles which sometimes form in the synovial membranes arise indifferently from all points of their extent; and it is observed, when they are connected with the cartilage, that their base adheres less intimately to it, and that in that place the membrane becomes apparent, as it is naturally at the circumference of the articular surfaces. In this manner the synovial membrane is

apparent upon the very centre of the cartilage. The fungous degeneration which is peculiar to the synovial membrane is also observed upon the cartilage. Lastly, the continuity of the membrane is demonstrated by direct inspection. On cutting a cartilage obliquely, and then turning the slice back so as to break it across, the latter still holds by the synovial membrane, which covers it as well as the rest of the cartilage. When a bone is sawed, and the cartilage afterwards broken from its extremities. the connexion is still kept up in the two portions by the synovial membrane, which extends from the one to the others.

In the rest of their extent, that is to say, at the edge of the articulation, the synovial membranes are attached to the articular membranes in an equally intimate manner, as is seen at the capsule of the shoulder joint. The adhesion is especially intimate at the middle, and becomes looser towards the extremities. In the interval between the ligaments, these membranes are attached to the cellular and adipose tissues. These tissues form very distinct pellets, as well as near the place where the synovial membrane leaves the ligaments to be reflected over the bones.

The inner surface is smooth, polished, in contact with itself, lubrified by the synovia, and furnished with villosities and fringed prolongations.

214. The synovial membranes are thin, soft, semitransparent, whitish, extensile in a certain degree, although less so than the serous membranes of the viscera, and retractile, as is shown by their dropsy and their returning upon themselves after the evacuation of the fluid which then accumulates in them. Their rupture in luxations depends less upon their defect of extensibility, than upon the strictness of their connexions and the less extent of their folds.

215. These membranes are furnished with adipose pellets, placed at their exterior or in their substance itself, and improperly designated by the name of *Synovial Glands of Havers*. These rounded masses, which were first noticed by Vesalius and Etienne, and have been described by Cowper and especially by Cl. Havers,* were considered by all physiologists down to Monro, as the secreting organs of the synovia.† Their size varies according to the quantity of fat which they contain. They always contain more or less of that fluid, and are almost entirely formed of adipose tissue. The fringes exist at the interior of the membrane, at the place where these bodies exist at the exterior. The points at which these different objects are met with are those in which the membrane presents the greatest quantity of vessels. The fringes contain in their substance cellular tissue, fat, and blood vessels. The other parts of the synovial membranes receive only serous vessels. The lymphatics are apparent only in some of these membranes. It were useless to recur anew to Mascagni's hypothesis, which that author

* *De Ossibus*, *Sermo* iv. Cap. i.

† See Pitschel. *De Axungia Articulor.* Lips. 1740. Haase, *De Unguine Articulari, ejusque vitiis.* Lips. 1774.

applies to all the transparent membranes. No nerves have been observed in the synovial capsules.

216. The fluid secreted by these membranes, or the *synovia*, so named by Paracelsus on account of its resemblance to the white of an egg, is the result of a perspiratory secretion, although many other ideas have been entertained respecting the mechanism of its formation. This fluid is not, as was long supposed, the product of a mixture of serous fluid with the fat; the medullary matter of the bones does not transude to form it, as we have seen; nor does the synovia contain oil in its natural state. The alleged glands of Havers cannot, from what we have said, perform the office which that author ascribed to them, and the fringes by which they are surmounted are not, as he imagined, excretory ducts. Nothing of a glandular nature, in fact, is observed in the synovial bodies, there being no granulations or excretory ducts in them; yet the idea of this glandular structure has recently been revived.* The fat itself which they contain is not essential to their structure, and besides, as there is no oil in the synovia, it is not the transudation of the former of these fluids, when it exists, that gives rise to the other. Rosenmuller asserts that there are secretory follicles in these adiposed bodies. I have not seen these follicles, nor am I aware that any person has confirmed their existence. The secretion of the synovia is therefore neither glandular nor follicular; nor is it a mere result of transudation, but a true perspiratory formation. The whole extent of the synovial membranes is its seat, but especially the portion of these membranes which surmounts the fringes, on account of the greater number of vessels which it contains. The synovia is in part taken up again by absorption, and the circumstance of its quantity being always nearly the same supposes an equilibrium between the latter and the secreting power.

This fluid, which was known to the Greeks, who gave it the name of μυξω των αρθρων, and was long designated by the names of *axungia* and *unguen*, is ropy, viscous, salt to the taste, and of a specific gravity of 105. Its chemical composition has been examined, as well in animals as in man, but more particularly in the ox, by Margueron, Fourcroy, J. Davy, Hildebrandt, Orfila, and several others. There have been found in it water, albumen, mucus or incoagulable matter, considered by some as mucilaginous gelatine, filandrous matter, which some consider as fibrine, others as albumen in a particular state, soda, muriate of soda, phosphate of lime and an animal matter which is said to be uric acid. The uses of the synovia are to diminish friction, and thus to facilitate the motion of the parts upon each other.

217. The synovial capsules of the joints present some pathological alterations.† They unite again when they have been divid-

* See Heyligers; *Dissertatio Physiol. Anat. de Fabricâ articul.* 1803.

† See Reimarus, *de Tumore Ligament*, &c. Leyd. 1557. *Wynpersse, de Ancylo si*, Leyd. 1783.—*Ejusd. de Ancyl. Pathol.* Leyd. 1783.—Brodie on Diseases of the Joints.

ed, but the mode of union is little known, there being no accurate facts recorded in the history of wounds of the joints and luxations relative to it. New synovial membranes are sometimes formed, as is observed in false joints, after unreduced luxations; in this case, which has been described by Dr. Thomson, and which I myself have observed, the remains of the old capsule and the cellular tissue together form a new membrane pretty similar to the first. After fractures that have not united, there in like manner exists, in the supernumerary articulations which succeed, a closed membrane, smooth internally, and containing a fluid more or less resembling synovia.

Dropsy of the joints constitutes hydrarthrosis. The synovia is commonly altered in various ways in this affection.

218. Inflammation produces the same alterations of tissue and functions in these membranes as in the serous membranes in general. They become a little thickened, acquire a red colour over a greater or less extent, assume a covering of albuminous grains, and sometimes contract adhesions. This inflammation may terminate by resolution, and then leaves a stiffness depending upon the thickening of all the neighbouring parts. The membrane itself also remains in general thicker. Effusions, whether of pure synovia, or of milky serum, or serum containing albuminous flakes, or even of true pus, may result from this inflammation. The adhesions which supervene constitute one of the species of anchylosis. There are several varieties of this disease, as is well known; all of them depend upon the alteration of the synovial membrane, and sometimes of parts external to it. Thus in the false anchylosis, there appear to be a thickening and induration of all the soft parts which surround the joints. Another kind, to which the epithet *false* might be applied, were it worthy of being retained, is characterized by adhesions of the synovial membrane. The articulation then becomes an amphiarthrosis, and the diarthrodial surfaces are united by synovial strings or laminæ. These strings are sometimes so numerous as to represent a kind of cellulosity. The motions are more or less restricted, according to their number, length, and extensibility. The thickening and induration of the soft parts combine with this alteration, after which the parts never completely resume their motions. In the true anchylosis, not only are adhesions established between the articular surfaces, but these surfaces unite and become confounded together. A perfect continuity takes place between the bones, the compact and cartilaginous laminæ of which ultimately disappear, so that the spongy tissue of the one is continued into that of the other. It is with the synovial membrane that this change commences which we have found it necessary to mention here for that reason. Ulceration is not so common a termination of inflammation of the synovial membranes.

219. In white swellings, among which are included alterations of very diversified kinds, as inflammation, dropsy, diseases of the cartilages, &c. there sometimes occurs an alteration peculiar to the serous membranes. It is a state in which these membranes are

converted into a fungous substance from which vegetations sprout up until they reach the skin, and even protrude externally. Reimarus, Brambilla and Brodie have described these carcinomatous fungi.

220. Foreign bodies sometimes form in the joints. The knee-joint is the most frequent seat of these formations. The volume of these bodies varies, as well as their number and consistence, as we have already said when treating of the serous system in general. They form externally of the synovial membrane, and appear to be the result of a particular alteration of the nutrition. They gradually make their way to the inner side of the membrane, and at length become entirely detached from it according to the mechanism described above. Their presence, which is accompanied by severe pains when they get between the articular surfaces, scarcely produces any inconvenience when they are lodged in places possessed of mobility, or where the articulation is loose. Depressions varying in depth are sometimes ultimately produced by the pressure which they exercise upon the cartilages, and as these depressions correspond in their form to that of the bodies which are lodged in them, this circumstance has caused them to be attributed to pieces of cartilage that have been separated by external violence; but to be convinced of the inaccuracy of this opinion it is sufficient to consider that these depressions do not exist in the greater number of cases in which foreign bodies occur, that they in no degree resemble the surfaces of a fracture, and that the bodies are much thicker than the articular cartilage.

ARTICLE IV.

OF THE SPLANCHNIC SEROUS MEMBRANES.

221. The serous membranes properly so called, which have also been named transparent membranes, are those which line the splanchnic cavities, and which furnish more or less complete coats to the viscera situated in these cavities.

222. These membranes, like all the other serous membranes, were long confounded, whether in the healthy or in the diseased state, with the organs which they envelope, and the parts to which they furnish a covering, and were described along with them. Each of these membranes, however, had been correctly described, in the former state, independently of the parts which they cover; and some anatomists, as Monro, had even pointed out their general similarity. With reference to pathology, Sauvages and Pinel established an order of inflammation for those of the transparent membranes; but they concluded with inflammation of the stomach, intestine, bladder, and omentum, as forming so many genera. Various observations of pathological anatomy, and especially those of J. E. Walter respecting peritonitis, had shown that this membrane,

like the other serous membranes, might be affected in its whole extent, and independently of the subjacent parts. Lastly, Dr. Carmichael Smith had marked with accuracy the identity of the inflammation of all the transparent membranes, when Bichat published his complete and accurate description of the serous membranes, and particularly of the arachnoid. Since then various descriptions have been given of several of these membranes, but little has been added to Bichat's statements.* Their pathological history has received more additions.

223. The serous membranes of which we here speak are situated in the cavities of the trunk, which they line. They there invest the most important organs, those which are most essential to life. These membranes are distinct and separate from each other. Their number is not great; they are, 1st, The peritoneum in the abdomen, where it invests more or less completely most of the organs of digestion, which are contained in that cavity, and in a much smaller degree the genital and urinary organs; 2dly and 3dly, The two pleuræ; and 4thly, The pericardium, in the thorax, where each of these membranes is confined to a single organ and to the walls of its cavity; 5thly, The arachnoid membrane, within the cranium and in the spinal canal; 6thly and 7thly, In man only the tunica vaginalis of the testicles.

The whole extent of these membranes is very great, and much surpasses that of the skin. The peritoneum is the largest, its extent being at least equal to that of all the others together.

224. The general description of the serous membranes has already in a great measure made known the species of which we here speak, and which may be considered as the type of the genus. Their form is the same as that of all the serous membranes, that of a bladder without aperture, and having the walls in contact. They invest on the one hand the inner surface of the walls of the cavity in which they are contained, and on the other furnish external coats or envelopes to the organs. The pleuræ, the pericardium, and the tunica vaginalis have a rather simple conformation, their visceral and parietal parts being continued all around from the point at which the organ which they invest is connected by vascular prolongations to the walls of the cavity which contains it. Their disposition is somewhat more complex in the arachnoid membrane and peritoneum, although it continues essentially the same. In the former, the complication depends upon the great number of vessels and nerves that terminate in the brain and issue from it. Now, over each of these parts the arachnoid membrane forms a sheath which is continuous at one of its extremities with the visceral lamina of the membrane, and at the other with its parietal lamina, an arrangement which was pointed out and figured by Bonn, to which Bichat more particularly directed his attention, and from

* See Langenbeck, *Commentarium de Structura Peritonæci, &c., cum tabulis*, Gotting. 1817.—*L. Rolando. Osservazioni sul peritoneo et sulla pleura, in Mem. della real Accad. delle scienze.* T. XXIV, Turin, 1820.

which there results, on the one hand, that the membraneous cavity is not open, and, on the other, that the two points of the membrane are continuous with each other. The complexity of the peritoneum depends upon the great number of parts to which it furnishes coats, and upon the different disposition of these parts, of which some are very near the posterior wall of the abdomen, from which they receive their vessels, and are merely covered by the peritoneum, while the others are distant, sometimes greatly so, from the posterior wall, and are suspended by membranous bridles which contain the vessels within them. Its complexity also depends upon vascular prolongations projecting beyond the viscera, and to which the serous membrane furnishes floating or omental envelopes. This membrane further presents the peculiarity of being the only serous membrane that has an aperture. This aperture occurs at the extremity of the uterine tube. Further details respecting the conformation of the serous membranes belong to the particular anatomy of these membranes, and especially to that of the peritoneum and arachnoid membrane.

225. Of the two surfaces of these membranes, one is always free in the sound state, the other generally adherent. The free surface is shining, moist, and appears smooth, although it is furnished with minute villosities which become visible when it is viewed under water, and which, under inflammation, become very apparent. It is to the serous membranes which envelope and line them, that the organs and walls of the splanchnic cavities owe their shining appearance. Wherever they are destitute of them, they present a different aspect. This free surface, which is everywhere in contact with itself, together with the serous fluid by which it is moistened, establish a true separation between parts that are extremely near each other, and, in particular, facilitate the motions of these parts in a singular degree.

226. The other surface of the serous membranes is almost everywhere adherent to the viscera or the walls of the cavities. There are only a few points of the visceral lamina of the arachnoid membrane that are free at both their surfaces, and in every other place the external surface of the serous membranes is adherent. This adhesion takes place on the one hand with the walls of the cavities, and on the other with the surface of the viscera. It varies greatly in degree. In general, wherever the serous membranes are connected with a ligamentous tissue, such as the dura mater, the pericardium, the aponeuroses of the walls of the abdomen, the tunica albuginea of the testicle, &c. this adhesion is intimate. On muscular and other parts, as the heart, the lungs, the stomach, intestine, &c. it is still considerable. It is much less perfect in some places, as wherever the membrane passes from an organ to the walls of the cavity, or the reverse; wherever it forms bridles and floating prolongations which contain vessels; in the places where the subserous cellular tissue contains fat, and in general wherever it is loose.

227. These differences are of sufficient importance to arrest our attention here: there result from them, for example, that when the uterus, bladder, stomach or intestine increase in size, the ambient peritoneal bridles and folds, are stretched out and applied close to the organs; and that, when the organs resume their original size, the membrane separates from them. This is owing to the looseness of the subserous cellular tissue towards the adherent edge of their folds. When a hernia takes place in the groin and enlarges, it is for the greater part through the displacement and sliding of the serous membrane, favoured by the laxity of the adhesions, that the sac enlarges. When, on the contrary, an umbilical hernia increases in size, it is by distension and attenuation that the sac enlarges, the peritoneum adhering closely around the umbilicus. Bichat has perhaps a little exaggerated the influence which the looseness of the adhesions of the serous membranes may have upon the isolation of their diseases, and of those of the subjacent parts.

228. The physical properties of these membranes are those which we have exposed when speaking of the serous system in general. They are thin, but the tenuity is not the same in all, in all parts of the same membrane, or in all individuals. They are soft and semi-transparent; their extensibility is greater than that of the synovial membranes; their tenacity is also considerable, and superior to that of the cellular tissue, and they possess some degree of elasticity. When these membranes are distended beyond a certain degree, they fret or lacerate; the lacerations occupy the free surface, the rest of the membrane offering a greater resistance to force, or yielding more to distension.

229. They all consist of a single lamina, which is denser and closer on the free surface, and of looser texture on the other, where it becomes floculent, and is confounded with the common cellular tissue. Until the period when Douglas gave a correct description of the peritoneum, that membrane and those of the same kind were considered as consisting of two laminæ, and containing the viscera in the separation of their laminæ. This erroneous opinion he refuted, and it was in vain tried to be re-established by Vacca and others. The alleged outer lamina is nothing else than the subserous cellular tissue so well described by Douglas. They consist essentially of a layer of cellular tissue extremely condensed, and becoming more and more distinct from the cellular tissue, from the adhering surface, where it is continuous with that tissue, to the free surface, where it differs greatly from it. Fibres or small interlaced fasciculi are not so distinctly seen in it as in the synovial membranes. The floating appendages of these membranes also contain free cellular tissue, and frequently adipose tissue. They are much more vascular than the other serous or synovial membranes. They contain an immense quantity of white or serous vessels, which become apparent by injection, congestion and inflammation, and some very small red vessels which belong to their

external surface, and especially to the subserous cellular substance, as may be demonstrated by detaching the membrane, which is found white in the places where it was supposed to contain numerous red vessels, which however were only seen through it. The red vessels are particularly abundant in the floating or omental folds. Nerves have been followed until near these membranes, but they have not been traced into their substance itself.

230. When dried these membranes become transparent; assume a slight yellow tint, and become, at the same time, elastic and firm. On immersing them in water, they resume their properties. Maceration renders them, at first, soft, opaque, thick, then pulpy, and at length, but not until after a very long period, dissolves them. In dead bodies beginning to alter, these membranes on the one hand allow fluids to transude, and on the other, become impregnated with them; whence the various colours which they acquire. By exposure to the fire, and by immersion in boiling water, they harden. Continued boiling converts them into gelatine and a little albumen? These various characters indicate their approximation to the cellular and ligamentary tissues.

231. The power of formation is less developed in them than in the free cellular tissue. Irritation produces no perceptible motion in them, but it alters their secretion and texture, and gives rise to inflammation. They are not possessed of sensibility excepting when in this state, when they generally become the seat of intense pain.

232. In the state of life and health, they are moistened at their free surface by the serous fluid which they continually deposit and take up again. This secretion has been attributed to the action of certain glands which have been supposed to be lodged in their tissue. Ruysch has proved that these alleged glands have no existence. Hunter imagined that this secretion took place by a transudation, similar to that in the dead body, through the areolae, interstices, or inorganic porosities of the tissue of the vessels. Although the true organic mode, according to which the perspiratory and other secretions are performed, is not well known, it may at least be affirmed that it differs from transudation, which takes place only in the dead body. The serous fluid, in the state of health, exists in so small quantity as scarcely to be perceptible, and cannot be collected without difficulty. Hewson collected in small quantity the fluid which moistens the serous membranes, in animals instantaneously killed, and found it, on exposing it to the air and allowing it to rest, to coagulate like the coagulable lymph of the blood. He did not succeed, however, in collecting the serosity of the cellular membrane, under the same circumstances. Bostock found in the healthy serosity of the splanchnic cavities, water, albumen in smaller proportion than in the serum, incoagulable matter and salts. Schwilgue found in it albumen, an extractive matter and a fat matter. From the examination which I have made of the serosity of the splanchnic cavities, it seems to me that the in-

coagulable matter is gelatiniform mucus similar to that which occurs in the coagulated albumen of the serum of the blood. The coagulability of the healthy serosity, which before Hewson had been observed by Lower, Lancisi and Kaau, has been on the other hand denied by Sarcone, Cotunnio and Geromini.* For my own part I consider the serosity always coagulable in the healthy state.

233. Of all the serous membranes, those of which we here speak have their functions and morbid actions more intimately connected with the organic phenomena. In this, however, they differ among themselves: thus, the membrane of the testicle and that of the abdomen differ greatly in this respect.

234. What has been said respecting the morbid alterations of the whole nervous system also, applies more particularly to them. They are subject, more than the others, to certain defects of original conformation, such as the unnatural apertures that are observed in some cases of monstrosity, and of which they may all present examples, as well as the prolongations or appendages which envelope congenital herniae and other displacements of the viscera.

235. The accidental herniae are also accompanied with an almost constant alteration of form in the serous membranes of the viscera, consisting of the production of a hernial sac which envelopes the displaced parts. This sac is formed by the serous membrane which invests the walls, and which the viscera, as they become displaced, push before them.

236. Dropsy, inflammation and its effects, false membranes, adhesions, and accidental productions, whether similar or morbid, are more common in the serous membranes of the viscera than in the other kinds, and more common in certain of them than in others.

237. Although the splanchnic serous membranes form a pretty natural group, they yet present differences which belong to particular anatomy; and, moreover, the arachnoid membrane differs greatly from the others. It has indeed the same conformation as the other serous membranes, but its consistence is very soft, its tenuity extreme, and its texture impossible to determine; it appears to be homogeneous; and no vessels have been discovered in it, even in the diseased state. Most of the morbid phenomena that are attributed to it take place in the adjacent cellular tissue of the pia mater. In short it seems to constitute a genus of itself.

CHAPTER III.

OF THE TEGUMENTARY MEMBRANES.

238. The Tegumentary Membranes are those which invest the parts naturally exposed to the contact of foreign substances, whe-

* Sagg o sulla Genesi, e cura dell' idrope. Cremona, 1816.

ther at the interior or at the exterior of the body. They are also called compound villous or follicular membranes, on account of the numerous parts which enter into their composition, and in particular on account of the follicles which they contain. Next to the cellular tissue, of which they are a more or less complicated modification, they constitute the tissue or organ most extensively diffused in the animal kingdom. They are the first parts of the embryo that present themselves under a distinct form; it is upon them and by them that all the rest of the body is formed; in health and during life, they are the organs of the most essential functions; it is in them and by them that all extrinsic absorption and secretion are performed; it is upon them that all foreign substances make impression; they are often altered in diseases; lastly, it is upon them that most therapeutic agents are applied. Their study is therefore of great importance to the physician.

239. Galen* had observed that besides the external skin which is the common tegument of all the parts, there is a thin and membraniform skin which covers the internal parts.† Several anatomists had pointed out the continuation of the skin into some of the natural cavities, and the resemblance of the mucus to the epidermis.‡ Bonn|| had described in detail the continuation of the skin into the internal membrane in all the apertures and cavities. The zootomists and naturalists had also observed it, as well as the similarity which exists between these two parts of the same membrane in the interval of which all the rest of the body is placed. Bichat has particularly insisted upon this continuity. M. J. B. Wilbrand§ has recently made a detailed exposition of the cutaneous or tegumentary system in all its divisions. M. Hebreard¶ has described the transformation of the skin into mucous membrane, and *vice versa*.

240. The tegumentary membranes have in their whole extent common characters, which it is necessary first to expose; but according to differences in their situation, their texture, and their functions, they are distinguished into two parts, which it will be necessary to describe separately afterwards; these two parts are the mucous membrane and the skin.

SECTION FIRST.

OF THE TEGUMENTARY MEMBRANES IN GENERAL.

241. The Teguments, whatever may be their extent and their apparent multiplicity, form one and the same membrane, every-

* On the Therapeutic Method, L. xiv. chap. 2.

† Casserius. *Pentaesthesion, hoc est, de quinque sensibus liber.*

‡ Glisson, *De Gula.*

|| *De Continuationibus Membranarum.*

§ *Das hautsystem in allen seinen verzweigungen, anatomisch, physiol. und pathol. dargestellt.* Giessen, 1813.

¶ *Memoire sur l'analogie qui existe entre les systemes muqueux et dermoïde; Mem. de la Soc. Med. d'Emulation.* Vol. viii. p. 153.

where continuous with itself, from the external skin to the bottom of the last ramifications of the excretory duct of the most deeply seated gland. This membrane has consequently an immense breadth. Its situation is everywhere external or superficial, in this sense that it is everywhere in contact with substances foreign to the organization; but a part only is apparent at the exterior and envelopes all the body, while the other concealed part invests at the interior the alimentary canal, which passes through the trunk in the direction of its length, from the mouth to the anus. The figure of the tegumentary membrane may thus be conceived as that of an envelope and of a canal which passes through it, united by continuity at the two extremities; or as that of two canals, the one wider and the other more narrow, the latter encased in the former, both continuous with each other at the two ends, and in the interval of which all the rest of the body is lodged. Were we to employ a trivial comparison, the one which would answer best for representing this disposition would be that of a muff, having in fact two surfaces separated by a more or less thick layer of intermediate substances.

242. Besides the skin and the mucous membrane of the alimentary canal, which are continuous with each other at the two orifices of that canal, and are everywhere continuous with themselves, and which constitute the two principal parts of the tegumentary membrane, this membrane has a great number of appendages or prolongations more or less extended and branched out into the substance of the body. Such are; 1st, The genital and urinary membranes, which are prolonged into all the cavities of the organs of generation, and urinary depuration; 2dly, The pulmonary membrane, which lines all the divisions of the bronchi; 3dly, The membranes which line the excretory ducts of the glands, whether they end at the mucous membrane, or, like those of the mammary gland, terminate at the skin; 4thly, those of the nasal cavities, their sinuses, the posterior nasal fossæ, the auditory canals, the tympanum, the mastoidal sinus, and the surface of the eye.

Of these prolongations, which are all mucous, excepting that of the external auditory canal, which is cutaneous, the greater part end at the mucous membrane, and are appendages or prolongations of it. The external skin, on the contrary, is much less complicated by appendages of this kind.

243. The tegumentary membrane presents in its vast extent differences or varieties of appearance, texture and function, which might excite doubts as to its unity and continuity.

The skin and the mucous membrane, compared with each other, seem very different at first sight; but in the animal series the difference gradually disappears in the most simple animals. In the higher animals which inhabit the water, it is still in general not very distinct. In the human fœtus, the difference, although real, is at first far from decided; and even in the adult the skin is seen to become readily transformed into mucous membrane, and the latter into skin. When, for example, a part of the surface of the body is long removed from the action of the atmosphere, as has been observed in contractions in which the leg has been strongly bent and applied against the thigh, and as is often seen in the folds of the skin in very fat children, the epidermis softens and disappears, and the skin at length secretes mucus. On the other hand, in prolapsus of the uterus the mucous membrane of the vagina, and in natural or accidental prolapsus of the anus, that of the intestine, are seen to become thicker, to harden and to assume the appearance of skin. Lastly, in the state of health, the skin is seen in many parts to change, but gradually and in an insensible manner, into mucous membrane. This is what takes place in the lips of the vulva, in the prepuce, the anus, the nipple, and the nostrils. It is only in the palpebræ and lips that the line of demarcation appears somewhat distinct. There is therefore no real interruption, but on the contrary a real identity and continuity, between the two principal parts of the tegumentary membrane.

244. The different parts of these two principal portions of the tegument also present considerable differences. Those which are observed to exist between the skin of the back and that of the eyelids, between the skin of the head and that of the pulp of the fingers, for example, are pretty remarkable, but they are neither absolute nor decided. This is also the case with respect to the mucous membrane, and the interruption which have been supposed to be observed in it are only apparent interruptions, as will presently be seen (Section II.) The differences which are observed between the different parts of the mucous membrane, although more distinct than those which occur in the skin, are yet not real. In general, the change of appearance and texture is gradual, as is seen in the excretory ducts, where the membrane becomes progressively thinner, and so to speak, undergoes a degraded action, but in an insensible manner. If the membrane of the frontal sinuses and that of the stomach be compared together, there will certainly be found very great differences between them, as well as between those of the tongue and uterus; but these differences are in some measure connected by intermediate gradations. We only observe somewhat decided differences in parts very near each other, but whose functions are very different, as between the œsophagus and stomach, or between the vagina and uterus; but even here, as everywhere else, we have only varieties which very easily reduce themselves to one and the same type of organic texture.

245. The teguments have a free surface and an adherent surface. The free surface is turned outwards for the skin, and inwards for the mucous membrane. The reverse is the case with the other surface, which corresponds to the mass of the body, and generally to the cellular tissue. This tissue (139) there forms a more or less dense and more or less thick layer. In other places the teguments are applied upon ligamentous tissue or elastic fibrous tissue; and in a pretty large portion of their extent they are furnished with or applied upon muscular fibres.

246. The tegumentary canal, besides the great appendages and the excretory ducts of the glands, of which mention has been made (242), is provided with a prodigious multitude of other more simple and much smaller depressions, which have been named follicles, locules, lacunæ, crypts, simple glands, &c. These follicles,* which were first described in certain parts of the integuments by various anatomists, and afterwards in all the parts by Malpighi, Boerhaave, Kaau, and many others, in fact exist in all or nearly all the parts of these membranes. The follicles are round or nearly so, graniform, of a variable and in general very small size. They are in part situated in the substance of the membrane, and form a greater or less protuberance under its adherent substance. They have in general the form of a small ampulla, of which the more or less elongated neck opens at the free surface of the membrane. They are formed by this membrane folded upon itself, and constituting a depression or a small cul-de-sac. It is to their presence that are owing the porosities which are perceived on the surface of the skin, on the nose especially, as well the granulations which in many places raise up the mucous membrane. The cavity of these follicles is extremely small in proportion to the thickness of their walls. They are formed by the whole membranes, whether it retain its thickness, or the latter be increased or diminished. They are surrounded by a very great number of vascular ramuscules. Most of these small ampullæ are simple, separate, and more or less distant from each other; but in certain parts of the skin, and especially of the mucous membranes, there occur follicles variously grouped and compounded. Besides the follicles, of which we have been speaking, the tegumentary membranes, and especially the inner, present many depressions, the orifice of which is as wide as the bottom, and which are named alveolar; and both also present a great number of small funnel-shaped depressions. The follicles differ moreover from each other in the nature of the fluid which they secrete and which they contain. Those of the skin are called sebaceous, and those of the internal tegument mucous, on account of the fluid which they furnish; those of the mucous membranes in the vicinity of the skin are of an intermediate nature.

247. The teguments have a foliated texture. They are, in a great part of their extent, evidently formed of two layers, the dermis and epidermis. In many places there is also distinguished a somewhat compound layer between these two principal layers; and, in a great number of parts, there are moreover appendages or productions which project at the free surface of the membrane.

248. The dermis, whatever may be the differences which it presents in the two teguments and in their divisions, is always the

* See M. Malpighi, *Epistola de Structurâ Glandularum*, &c. *in Op. Posth. Opusculum anatomicum, de fabricâ glandularum. continens binas epistolas.*—H. Boerhaave et F. Ruyschii, &c. in *op. omn. Ruyschii.*—A. Kaau, *Perspiratio dicta Hippocrati*, &c., cap. xi. xii. et xiii.

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deepest and thickest part, that which forms the basis of them, and at the surface of which the others are placed. It is formed of a layer of fibrous cellular tissue, more or less compacted, having the appearance of being felted, and leaving interstices through which various other parts pass.

249. Blood-vessels, lymphatics and nerves, varying in their number, are distributed and ramify in the substance of the dermis, and especially at its outer surface, where they form inequalities, which are named papillæ, villosities, or vascular buds, and which will be more exactly defined and described, when we come to treat particularly of the two teguments.

250. The surface of the dermis is covered by a layer, which is more or less distinct according to the different parts of the teguments, and which is called the *Corpus mucosum* or *reticulare*. It consists of cellular tissue, in a semifluid state, or scarcely organized, in which terminate or from which arise the most minute divisions of the white vessels. This layer, which is considerably compounded, is the seat of the colouring, as well as of the horny incrustations with which the integuments are furnished in some parts. This layer is less distinct in the mucous membranes than in the skin.

251. The Epidermis is the least essential of the tegumentary membranes, that which forms their free surface. It is an albuminous layer excreted at the surface of the corpus mucosum. In many parts of the mucous membranes the epidermis is not distinct, and seems to be substituted by mucus. The epidermis has a great resemblance to mucus in respect to its chemical nature.

252. Several parts of the tegumentary membranes are provided with projecting appendages at their free surface. These appendages are, for the skin, the nails, and hairs; and, for the mucous membrane, the teeth.

253. The teguments are almost entirely resolved into gelatine by decoction. The very diversified colouring of the integuments depends in part upon that of the blood, and in part upon a colouring matter secreted from the blood in the corpus mucosum. Their density, which varies greatly, is nearly intermediate between that of the cellular, ligamentous, and elastic tissues. Their elasticity is considerable. They also possess a slow extensibility and retractibility to a very great extent. Their power of formation is highly developed. The irritability which they possess, although much inferior to that of the muscles, is yet great. They are the essential organ of sensibility.

254. The organic action, or the function of the tegumentary membrane is very important, very complex, and different in the different portions of that membrane. As a tegument, or envelope, internal as well as external, of the mass of the body, it constitutes a barrier which has to be traversed from without inwards by all the foreign substances which enter into the body to form part of it, and from within outwards by all those which, after having formed part of it, become foreign to it. These substances, and all the

others which are in contact with the tegument, determine impressions upon it. Thus, this membrane is a more or less efficacious organ of protection or defence against the action of external bodies. It is the organ of the absorptions and of all the extrinsic secretions, in other words, of all those whose matter is carried out or deposited at the surface. It is the organ of all the external sensations and of the feelings of want and of appetite. Lastly, by means of its appendages, it is even sometimes an organ of offence or aggression. But, according to the varieties of its texture, the functions of this membrane vary in the different regions. Thus, the mucous membrane is much better disposed for secretion and absorption than the skin, and the latter is better accommodated to the sensations and to the defence of the body than the former. Some parts are especially disposed for sensation, and even for particular kinds of sensation, others for absorption, others for excretion, others for generation, others for respiration, &c.

255. The immense extent of the tegumentary membrane, and the number and importance of the functions of which it is the seat and instrument, render its consideration highly important, whether in health or in disease. There exists the most intimate connexion between the different parts of which it is composed, a connexion which, in certain respects, was perceived by the most ancient observers,* who knew that the abundance of the mucous secretion is generally in the inverse ratio of cutaneous secretion. Observation has shown that the healthy state of the skin coincides with a healthy state of the mucous membrane, and that, for example, persons who have the skin very white, and of a fine and delicate texture, are very liable to diseases of the skin and mucous membrane, and especially to fluxes of these two membranes. It has also shown, that each part of the skin sympathises with the whole mucous membrane, and especially with certain parts of it. In like manner, there exists the most intimate relation between the teguments and the mass of the body, and *vice versa;* a relation which is daily rendered obvious by observation, is continually put in play by morbid causes, and of which the medical practitioner avails himself in the cure of diseases.

256. The embryo, we have already said, is entirely formed upon these membranes. The vitellar, or intestinal membrane, is the first part that makes its appearance in the egg. It is by its prolongation towards the stomach, and towards the anus, that the intestine is formed. The next part that appears is the allantoid, or vesical membrane, by the extension of which the urinary passages and genital organs are formed. The external skin then forms. From being at first widely open at the forepart of the trunk, it afterwards closes in the median line of the abdomen, and at length around the umbilicus. In the two sexes there is a considerable difference of conformation in the genito-urinary portion of the in-

* Ἡ δέρματος ἀραιότης ἡ κοιλίης πυκνότης. ΙΠΠΟΚΡΑΤΟΥΣ, τῶν ἐπιδημ. Βιβλ. ϛ.

teguments, and a difference of development in that of the excretory ducts of the mamma There is moreover a difference of thickness and colouring in the external skin. These differences are very decided in the different races of the human species, and are even considerable in individuals.

257. The morbid alterations are very numerous in the different parts of the tegumentary membrane. The accidental production of the cutaneous and mucous membranes are pretty frequent. Reproduction of the teguments, or cicatrices, are also of frequent occurrence. Vices of conformation, alterations of texture and functions, accidental productions, similar or not to the sound tissues, transformations of tissue, &c. are also frequently observed in the teguments; but their description will come with more propriety after that of the membranes themselves, which is also to be remarked of their alterations in the dead body.

258. The accidental teguments, on the contrary, require to be described here, because, on the one hand, their production presents much similarity in the two kinds of tegument, and on the other hand, because, in the production of an external cicatrix, the new tissue resembles, during a period of its production, the mucous membrane, and at a more advanced period, the skin; and, lastly, because in some cases the texture and appearance of the skin occur in one part, and that of the mucous membrane in another part of the same production; as, for example, in the membranes of fistulæ.

Whenever, in consequence of a mechanical lesion, or from the effect of cauterization, gangrene, or ulceration, there has been destruction of the teguments and even of the subjacent parts, to a greater or less depth, there is produced a new tegument, similar, or at least very much resembling that which has been destroyed, and always the same in its whole extent, whatever be the diversity of the parts laid bare and which are to be covered by it. After the first phenomena, which vary according to the diversity of the destructive causes, there presents itself a series of secondary phenomena always the same. These are, 1st, The production of a plastic layer like that of agglutinations; 2d, The formation of granulations, and the secretion of pus; 3dly, The cessation of this secretion and the formation of the cicatrix. The phenomena of cicatrization commence with the deposition of a plastic layer similar to that which constitutes the false membranes. This layer, which is at first inorganic and is presently organized, becomes covered with small conical granulations of a red colour, and then constitutes the membrane of the fleshy granulations. This membrane is cellular, vascular, highly contractile, possessed of sensibility, absorbing, secretes pus, is very readily destroyed by ulceration, and is quickly reproduced. This membrane continually contracts its dimensions; the secretion of pus gradually diminishes and at length entirely ceases; and it is then covered with a distinct epidermis, or with mucus, according to the place, and constitutes a new tegument having a great resemblance to the old one, and sometimes entirely similar to it. The new membrane, however, besides exhibiting some slight anatomical differences, is much more liable to ulceration than the original teguments.

259. In abscesses, and especially in chronic abscesses, there forms a membrane which circumscribes the pus and which bears a great resemblance to the mucous membrane. It acquires a still greater resemblance when the abscess is open and remains the source of a fistulous ulcer. This is also the case with ulcers of this kind which are kept up by a necrosis or by the presence of a foreign body, as well as with the true fistulæ or accidental canals which arise from a natural mucous cavity. In all cases, the canal is invested in its whole extent by a soft, spongy, in short mucous membrane, as was first discovered by Hunter in fistulæ at the anus. At its orifice in the skin, if it be at this surface that it opens, the mucous canal of the fistula is furnished, to a certain depth, with a distinct epidermis which is continuous with that of the skin.

SECOND SECTION.

OF THE MUCOUS MEMBRANE.

260. The internal tegumentary membrane, or the mucous membrane, received the latter name from the nasal fossæ, (μύξαι, *nostrils*), on account of the mucus (μύξαι, pituita, *rheum*,) which it furnishes. It constitutes a moist tegument which covers all the cavities which communicate externally, and which all receive or reject foreign substances. From being at first considered in each hollow organ as its peculiar internal membrane, and from having no other name, it was afterwards called villous or spongy, pulpy, porous, and villoso papillar in the alimentary canal, and pituitary or mucous in the nose and gullet. Anatomists soon perceived follicles nearly in its whole extent, which made them give it the generic name of glandular, and remark the resemblance which the nasal and intestinal mucus bears to the unctuous humour of the trachea and bronchi, and even the analogy existing between the mucus and epidermis. Henceforth the identity of the different parts of the membrane became known. The pathologists, and especially M. Pinel, had already remarked it in giving the history of catarrhs. However, no general and satisfactory description of this membrane had been given before Bichat's time.* Since then anatomists and pathologists have been pretty generally agreed to adopt his ideas on the subject, excepting Gordon, who found too essential differences between the various mucous membranes to include them within a common description.

261. The mucous membrane forms an internal integument to

* *Traité des Membranes*, Paris, Ann. viii.

all the cavities that open externally. Its most important part forms a covering to the whole alimentary canal, from the mouth to the anus. The rest of this membrane constitutes prolongations or appendages prolonged into a cul-de-sac, and more or less deeply extended and ramified in the mass of the body, and ending with open mouth at the external or the internal skin. It thus forms an immense internal integument of greater extent than the skin.

262. The mucous membrane, like the skin, presents an adherent surface and a free surface. The adherent or external surface is in general invested with a layer of fibrous cellular tissue of a peculiar nature, to which Ruysch and many other anatomists have given the name of nervous membrane, which Albinus and Haller have demonstrated to be cellular tissue, and which Bichat has named submucous cellular tissue. This tissue, which is close, fibrous, and white, never contains fat, and rarely infiltrated serosity. It is traversed by a great number of minute divisions of vessels and nerves. Several anatomists have likened it to the dermis of the skin. Be this as it may, it is to it that the hollow organs in a great measure owe their solidity. The mucous membrane is further doubled in the whole extent of its principal canal, and in several of its divisions, by a muscular plane, forming a kind of internal cutaneous muscle. In some places, it is an elastic tissue that backs the mucous membranes, as is seen in the trachea and in the excretory ducts. Besides these, a true ligamentous tissue, such as the periosteum of the nasal fossæ, sinuses, palate, and alveolæ, lies upon the membrane and constitutes it a fibro-mucous membrane

263. The free surface of the mucous membrane presents valvulæ, folds, and rugæ, formed by the whole thickness of the membrane doubled back upon itself. The valvulæ are formed by the folded mucous membrane, by the submucous tissue, and by muscular fibres contained in the fold. This is what takes place at the pylorus, the entrance of the small intestine into the large intestine, the velum of the palate, the orifice of the larynx, &c. The folds contain in their substance nothing but submucous tissue, but they are constant like the valvulæ and are never obliterated. Such are the numerous replications of the small intestine, which are named valvulæ conniventes. The rugæ, on the contrary, are accidental or momentary replications, in which the mucous membrane is in reserve for future dilatations of the organs, or which depend upon the circumstance, that the organ having been dilated and having returned upon itself, the mucous membrane is in excess over the muscular membrane. Of this kind are the longitudinal rugæ of the œsophagus and trachea, the irregular rugæ of the stomach when it is contracted, the regular rugæ of the vagina and the neck of the uterus, &c.

264. The free surface of the mucous membrane also presents depressions of various kinds, and papillar and villous prominences. But these various objects, although very generally distributed in the membrane, do not yet exist, or, at least, are not by any means

qually apparent, in all parts of its extent. There occur at the urface of the membrane infundibuliform, cellular or alveolar depressions. They exist at the maximum of their development in the econd stomach of the ruminantia, which, for this reason, is called the oney comb bag. They also exist, but of much smaller size and microscopic, in a great part of the alimentary passages, and especially in he œsophagus, the stomach, and the large intestine of man, where hey have been perceived and pointed out by Fordyce and Hewon, and described and figured by Sir Everard Home.

265. The follicles or crypts,* differ from these alveolar depresions only in having a narrower orifice, a more or less prolonged eck, and an inflated fundus lodged in the submucous tissue, in hich they form projections. They are formed by the membrane lded upon itself, and strengthened at the exterior by dense cellur tissue furnished with numerous small vessels. They are very enerally distributed, although their number varies in the differnt parts. They are in general very small, but their size also varies reatly. Some are simple and distinct; others open into a comon canal of which they are as it were branches; others end in a ommon and dilated orifice called a lacuna, of which kind is the ble at the base of the tongue, the lacunæ of the urethra, rectum, c.; others are aggregated or agminated, as the caruncula lachryalis, the arytenoid gland, the agminated glands of the ileum, &c.; stly, others are compound and furnished with multiple lacunæ or mified ducts, and greatly resemble glands, of which kind are the nsils, the molar glands, the prostrate gland, Cowper's glands, &c.

266. The small eminences called papillæ and villosities, which are rceived at the free surface of the mucous membrane, appear to ve for their object the enlargement of the surface, like the deessions of which we have just been speaking, and with which ey are in inverse numerical relation; but, in the one as in the her of these dispositions, the texture and functions of the memane are greatly modified. These eminences, which are called losities, in consequence of the comparison made by Fallopius of e internal membrane of the intestines to velvet, and papillæ, on count of the resemblance which they are supposed to bear to a tton or nipple, do not differ essentially among themselves: they all more or less minute prominences of the membrane, most them hardly visible to the naked eye.

The largest among these eminences are called papillæ. Such those which fill the cavity of the teeth, and which are commonnamed their pulp. Of this kind also are those smaller eminences ich cover the surface of the tongue in its two anterior thirds, and se still smaller ones which are perceived on the glans of the is and clitoris, &c. These eminences belong to the corium of mucous membrane, which is in these places provided with a

* Peyer, *De Glandulis Intestinalium*, Amstel. 1681. J. C. Brunner, *De Glandulis deni*, Francof. 1715.

very large quantity of nervous filaments, and of ramuscules of blood vessels, among which the small veins present an erectile disposition. In the parts furnished with papillæ, the mucous membrane is provided with a distinct epidermis, which is named epithelium for the very reason of its covering the papillæ.

267. The villosities whose existence is very general, but which are no where more numerous, larger, or more apparent than the pyloric half of the stomach, in the small intestine, and especially in the commencement of that intestine, are eminences still finer than the papillæ.

These villosities, which may with propriety be called the *radicles of animals*, are small foliaceous prolongations of the internal membrane of the digestive passages, whose form and length vary in the different parts of that canal, and which may in general be compared to the transverse folds or valvulæ conniventes of the intestines, with a difference of size only. The villosities,* which were first perceived by Falopius and Azelli, and have been described and figured by Helvetius, Lieberkühn, Hedwig, Rudolphi, Meckel, Buerger, and several other anatomists, exist especially in the small intestine, being shorter and less numerous in the stomach and large intestine. To see them well, one must take a part of the intestine not yet altered by putrefaction, open it with precaution, moisten it with a few drops of water until the surface be entirely covered by it, and examine it with a lens having a magnifying power of about forty diameters.

268. I also employ with much advantage, for this purpose, and others of a like nature, a small apparatus consisting of a sphere of clear glass of small diameter, open in a fourth of its surface, of an operculum or cover a little larger than the opening, and a thin layer of wax laid over the operculum. The part which is to be observed is fixed upon the wax with small pins. It is then immersed in water, as well as the open sphere, which is filled with that fluid, and which is then placed on the cover. The apparatus is lifted out of the water, and we have thus the object to be examined covered with a small mass of lenticular water which augments its diameter.

269. When examined by either of these methods, the villosities do not appear conical, or cylindrical, or canaliform, or enlarged at the summit, as several authors have described them; but rather under the form of minute laminæ, whose number is so great that they present the image of an abundant and dense turf. These laminæ, which are differently folded, and consequently present themselves under different aspects, appear of various forms. Their form, besides, is not everywhere the same; those of the pyloric half of the stomach and duodenum, are broader than long, and

* See, among others, Helvetius, *Mem. de l'Acad. des, Sc.* &c. Paris, 1721. J. N. Lieberkühn, *De fabr. et act. Villos. Intest. hom.* Lugd. Bat. 1744, 4to. R. A. Hedwig, *Disquis. Ampull. Lieberkühnii Physico-micros.* Lips. 1797, 4to. C. A. Rudolphi, in *Reil's Archiv. der Physiol.* iv. *et Anat.-physiol. Abhandl.* Berlin, 1802. J. F. Meckel, in *Deutsches Archiv. fur die Physiol.* iii. H. Buerger, *Examen Microsc. Villos. Intestin. cum iconibus.* Halæ, 1819, 8vo.

constitute a small laminæ; those of the jejunum, which are long and narrow, better deserve the name of villosities, and towards the end of the ileum they become laminar again, as well as in the colon, where they scarcely project. The villosities are semi-transparent, their surface is smooth, and there are not perceived, either at their surface the apertures which have been admitted in them without their number having ever been agreed upon, or in their substance the cellular ampulla, or the vascular texture which have been described as belonging to it. There are only perceived in their gelatiniform substance microscopic globules disposed in linear series, and at their base twigs of blood vessels and lymphatics of excessive minuteness.

270. The texture and anatomical composition of the mucous membrane presents numerous varieties or differences in the different places where they are observed. The foliated disposition cannot be demonstrated in all the parts of the membrane, and, on the other hand, distinctly exists in certain points.

In the greater part of its extent, the membrane consists entirely of a spongy tissue, more or less soft, and whose thickness varies greatly. It is to be remarked, on this subject, that in the fœtus, and in the lower animals of the series, the external skin itself presents this character of simplicity. The thickness presents a successive diminution from the gums, the palate, the nasal fossæ, the stomach, the small intestines, the large intestine, the gall bladder and the urinary bladder, to the sinuses and the divisions of the excretory ducts, in which its thinness becomes extreme. It is in this essential part of the membrane and at its surface, that the last divisions of the vessels ramify, and it is from its surface that the villosities rise.

271. Few traces occur in it of a distinct layer of corpus mucosum, unless we consider as such the layer of coagulable fluid which separates the papillæ of the tongue from the epidermis, or the gelatiniform surface of the villosities, or admit as proofs of its existence the ephelides or variously coloured spots which sometimes occur in the teguments of the glans and vulva, as well as the imperfect accidental horny productions which are still more frequently observed in the same parts under the form of vegetations, and which are named poireaux.

The existence of the epidermis is much more evident, although not in the whole extent of the mucous membrane.

272. The epidermis or epithelium is very apparent at the orifices of the mucous cavities. It is less so in the deep parts of these cavities, and at length ceases to be apparent. It may be questioned whether it exists there: Haller and others have thought that it does, and that the membraniform accidental secretions are a proof of its existence. All pathologists now know that such excretions are commonly results of the plastic inflammation or inflammatory crusts, and sometimes of escharæ. The same conclusion has been drawn from the fact of preternatural anuses with reversion of the intestine, in which the epidermis becomes very apparent. But

this only proves that the free surface of the mucous membrane is covered by a substance which has a great similarity to epidermis, and is readily transformed into it. On referring to observation, and making use of dissection, decoction, or putrefaction, for separating the epithelium, we find it very distinct as far down as the œsophagus, and ending abruptly at the union of that canal with the stomach; and in like manner we find it very distinct in the vagina, and suddenly ceasing on the lips of the orifice of the uterus. These interruptions, which have long been observed, have been erroneously adduced by some modern writers as proofs of the interruption of the mucous membrane itself. In other parts, as the nassal fossæ and the lower extremity of the alimentary canal, the diminution of appearance of the epithelium is gradual and insensible, so as to render it impossible to point out its limits. In the places where it is distinct, it becomes thinner as it sinks in the follicles, and disappears in them. In the places which are destitute of a distinct epithelium, the free surface of the membrane is covered with a mucous varnish, which, since the time of Vesalius, and even of Rhazes, has been compared to the covering or enamel of vessels, and of which the resemblance to the epidermis, at least in respect to functions, was remarked by Glisson.

273. The cellular tissue which forms the corium of the mucous membrane, has more regularly an areolar disposition, like the tissue of the cutaneous dermis; it being rather spongy or fungous. The blood vessels and lymphatics are abundant in it. Its nerves come in general from the great lymphatic nerve and the pneumo-gastric. At all the natural apertures, the mucous membrane has nerves coming from the spinal marrow.

274. The colour of the mucous membrane varies from white to red, and, besides the intermediate shades, it also presents some other varieties of colouring. This colour is, for the greater part at least, owing to the blood which circulates in its substance, for asphyxia and syncope instantly colour brown the part of this membrane which are visible by their situation, or deprive it entirely of colour. Its consistence is in general soft and spongy. Its thickness varies greatly, and its tenacity is moderate. The mucous membrane readily alters by putrefaction, and the submucous tissue still more readily, for it is then very easily detached. It is not known if it can be converted into leather by the action of tannin.

275. It has a very highly developed power of formation. When it has been destroyed, it is readily reproduced, and with all the characters of the natural tissue. It is somewhat irritable, and possesses tonic contractility in a more decided degree than the cellular tissue. Its sensibility is obscure and vague in the greater part of its extent, even when inflamed it does not in general give rise to acute pains. It is very sensible at the natural orifices, and at the entrance of the alimentary and perspiratory passages it is the seat of a particular sensibility.

276. Its organic actions or functions are the following:

1st, Absorption, which is very active and general, and of which the villosities are the most active, but not the sole agents.

2dly, Secretion, which is perspiratory and follicular, and of which the products, although they differ considerably in the different parts, are generally known by the name of mucosities.

3dly, Motions of tonic contraction, augmented in many places by the action of the elastic tissue, and even by the action of the muscular fibres by which this membrane is in many parts surrounded.

4thly, Sensations, more or less distinct or obscure, general or particular, and feelings of want or appetites.

277. The mucosities or mucous humours which occur at the surface of the internal tegument are, for the most and principal part, composed of mucus. Animal mucus,* which is very similar to vegetable mucilage, but contains azote, which the other does not, is one of the immediate principles of animals. It occurs, both in the internal membrane in the product of the mucous secretion, and in the external in the epidermis, the hairs and the horny parts, of which it constitutes a large part. In the fluid and pure state, it is white, viscous, transparent, inodorous, and insipid. It contains nine-tenths of its weight of water. It is insoluble in alcohol, soluble in acids, not coagulable like albumen, and not capable of congealing like gelatine. It is precipitated by acetate of lead. In the dry state, it is semitransparent, brittle, insoluble in water, and difficultly soluble in acids.

M. Berzelius has found the mucosity identical in the nostrils and trachea, and having the following composition: water, 933.9; mucous matter, 53.3; hydrochlorate of potash and soda, 5.6; lactate of soda and animal matter, 3.0; soda, 0.9; phosphate of soda, albumen and animal matter, 3.3.

In the analyses of the other mucosities given by that chemist, and in those of MM. Fourcroy and Vauquelin, there exist considerable differences, which depend some upon the parts in which the mucosity was obtained, and in which it had undergone various mixtures, others upon the difference of individuals affected by various diseases. In fact, while the mucus may be identical, the mucosity is not always so, nor in all parts the same. In general it coagulates milk.

278. The functions of the mucous membrane are in a very intimate connexion with all the other parts. In the state of health, the nervous action, the circulation, the functions of the skin, &c. have a manifest influence upon the functions of the mucous membrane and *vice versa*. In the state of disease, the mucous membrane produces sympathetic effects, which are extremely remarkable, and also experiences similar effects through the action of other parts upon it.

* See Fourcroy and Vauquelin. *Annales du Mus. d'Hist. Nat.* vol. xii. Bostock. Medico-chir. Trans. vol. iv. Berzelius. Ibid. vol. iii.

279. The origin of the mucous membrane, from the first existence of the egg, and its development in the embryo, have been already pointed out, (256). There remains for us to make known the manner in which the villosities form. It is to M. Fr. Meckel that we are indebted for the knowledge of this point of the embryology. The villosities form at a very early period. At the commencement of the third month, they are perceived under the form of very close longitudinal folds. These folds afterwards present on their free edge serrated incisions, which gradually increase in depth; and toward the end of the fourth month, the folds are replaced by the multitude of small eminences which constitute the villosities. They are at first pretty large and distinct up to the seventh month. At the commencement, they are as numerous in the large as in the small intestine, although they are shorter in the former. Those of the large intestine afterwards become less numerous up to the period of birth. It is to be remarked, that in reptiles the villosities are replaced by small longitudinal folds.

280. The differences of the mucous membrane dependent upon sex, races and individuals, do not belong to general description, excepting however the difference of conformation of the genital and urinary parts in the two sexes. The mucous membrane of the digestive canal is thicker in the human species than in the carnivorous mammifera, but thinner than in the herbivorous. On the contrary, the peritoneal coat of the intestine is thinner in the herbivora and thicker in the carnivora than in man.

281. The teeth, as has already been said, are appendages of the mucous membrane of the mouth, which is prolonged into the alveolæ as far as the dentary papilla or pulp. These appendages may be compared to the hairs and horny appendages of the external skin.

282. The mucous membrane is subject to extremely numerous and highly diversified morbid alterations. It participates in the original and acquired vices of conformation of the organs of which it forms part, as well as in their displacements. It also of itself, especially in the æsophagus, the intestine and the bladder, experiences displacements of greater or less extent, through the lacerated submucous tissue. This constitutes false diverticula. The mucous membrane also presents other prolongations depending upon its elongation and the looseness of the submucous tissue. Of this kind are certain prolongations of the folds or valvulæ conniventes and the uvula, prolapsus of the anus and vagina, &c. Certain polypi also appear to be nothing but a vegetation or hypertrophy of the membrane and submucous tissue; but most commonly there is the production of an accidental tissue. Swellings of the palpebræ, amygdalæ and uvula are to be regarded as a hypertrophy of this membrane.

283. The mucous membrane is very subject to a serous and mucous flux, which constitutes the phlegmorrhagiæ and the blennorrhœæ without inflammation. The subcutaneous tissue itself

is subject, although this is a rare occurrence, to an œdema or serous infiltration This membrane is frequently the seat of hæmorrhages or bloody fluxes. The submucous tissue is also sometimes ecchymosed. It is also certain that it is sometimes the seat of gaseous fluxes.

284. Inflammation is of very frequent occurrence in the mucous membrane, and exhibits itself there in all its forms. Its anatomical characters are an increase of the redness, which sometimes passes into brown ; a degree of thickening, generally rather small, but variable, and proportional to the duration of the disease; a more or less marked softening, and sometimes an enormous augmentation of the villosities. The most common result of this inflammation is an increase of quantity and a change of the qualities of the mucus. Frequently this catarrhal inflammation degenerates into phlegmorrhœa or blennorhœa. Suppurative inflammation also pretty frequently takes place in it : the membrane without being ulcerated secretes mucus and pus, and even pure pus alone. Abscesses also sometimes occur in the submucous cellular tissue. Adhesive or plastic inflammation is less frequent in it. It is however frequently observed in the respiratory passages, where it constitutes croup, and pretty often in alimentary passages, the intestines, the bladder, the ureter, and even sometimes in the eyes. The organizable matter is commonly excreted in flakes or membranes, sufficiently large and consistent to have been sometimes taken for the inner membrane of the stomach or bladder, &c. ; or the patient dies before the matter is organized. At other times, on the contrary, the new membrane becomes organized, and unites with the surface of the old membrane ; or it contracts adhesions with itself, and thus forms mucous bridles, which traverse in greater or less number, and contract in a greater or less degree the cavity which they occupy.

285. The inflammation of the mucous membrane is not always erythematous and uniformly extended at its surface. It has sometimes the form of isolated red patches, and more commonly that of a tubercular exanthema, whether the small elevations be discrete or confluent. This is well known to occur sometimes, but not always, on the mucous membrane of the digestive and respiratory passages of individuals who have died of small-pox, and it has even been considered as an internal variola.* This elevated internal exanthema, which appears to consist of an inflammation confined to the follicles, has been particularly observed by M. Bretonneau, in an epidemic enteritis, of which it is to be regretted that he has not yet published a description.

286. Gangrene sometimes takes place, and ulceration frequently, in the mucous membrane, especially after the exanthema of which we have just been speaking. After either of these causes of de-

* See Wrisberg, in *Sylloge Comment.* p. 52. G. Blane, in Trans. for the Improvem. of Med. and Chir. Knowl. vol. iii. p. 423—428.

struction, if the individual survive, a new membrane rapidly forms in the destroyed places, and with all the characters of the old membrane. It has already been said that the membrane of abscesses, especially that of chronic abscesses, as in particular that of fistulæ of the parts about the anus, is, as well as that of fleshy granulations, a mucous membrane, like that of fistulæ. The serous and synovial membranes which suppurate assume the same character. When, on the contrary, a mucous membrane is closed, and becomes the seat of a dropsy, the membrane assumes the appearance of the serous membranes. This is what is seen to happen to the uterine tube, the maxillary sinuses, and, in a less degree, to the gall-bladder and the duct of the submaxillary gland. Certain cysts also belong, by their texture and the humour which they contain, to the mucous membrane. Such in particular are the atheromata. But, as will be seen a little farther on, the atheromata are frequently follicles of the skin, and there is then only a slight transformation.

287. The mucous membrane is subject to various kinds of accidental productions, whether healthy or morbid. Sometimes the reversed natural mucous membrane of the vagina, that of the prepuce in cases of phymosis, and frequently that of fistulæ, and especially in the lung, become more or less completely cartilaginous, and sometimes even osseous, whether by transformation, or by new production, serous cysts have sometimes been observed both in its substance and beneath it. Accidental hairs also occur at the surface of this membrane; there also occur imperfect horny productions upon it. Adipose tumours, although rare in the submucous tissue, have yet sometimes been observed in it. Erectile productions are observed in this tissue, frequently around the anus, and sometimes in the other parts of the intestinal canal. Lastly, morbid productions are frequently observed in it.

288. The alterations which the mucous membrane undergoes after death have already been in part described (274.) This membrane becomes coloured sometime after death, by the penetration of the humours which cover it. Thus it is yellowish in the intestine opposite the feces; it presents livid marks which correspond to the largest submucous veins; it becomes greenish in the gall-bladder, &c.

In certain kinds of death, it is in some internal parts the seat of bloody or sero-sanguinolent congestions. In death by apoplexy, hydrothorax, and especially strangulation, in short, in cases where the respiration is impeded before death, it frequently happens that the congestion, after having at first been confined to the submucous veins, and then to the vessels of the membrane itself, at length produces hæmorrhage in the stomach and intestine, as Boerhaave and Morgagni had announced, as Mr. Yelloly* has observed, and as I myself have several times seen after this kind of death, both in man and in animals. This congestion is easily distinguished

* Medico-Chirurgical Transactions, vol. iv. p. 371.

from inflammation, by the absence of all morbid, mucous, purulent, or plastic product at the surface of the membrane, by the other cadaveric phenomena dependent on the stoppage of the blood in the right side of the heart, and especially by the state of the skin, which also, like the mucous membrane, presents lividities, and sometimes ecchymoses.

THIRD SECTION.

OF THE SKIN.

289. The skin, *pellis*, *cutis*, *corium*, δέρμα, constitutes the external tegument. It is a compound membrane, furnished with various appendages, which envelopes and protects the body, and which performs several other important functions.

290. Galen has given some observations respecting the structure, and especially the functions of the skin. The anonymous author of the Anatomical Introduction, and afterwards Avicenna, are the first who spoke of the panniculus carnosus. Vesalius and Columbus still thought that the skin is perforated at the natural apertures; but Casserius, as has already been seen, had observed that it is continued into the nostrils and mouth. We also owe to him a figure of the epidermis separated from the dermis. J. Fabricius has described with much detail and accuracy the appendages or the various dependencies of the skin of animals. Since then the observations of anatomists respecting this organ have been greatly multiplied.*

ARTICLE FIRST.

OF THE SKIN IN GENERAL.

291. This membrane, which is extended over the whole surface of the body, of which it determines the figure in many of the inferior animals, and of which, on the contrary, it receives the form in man and the other vertebrate animals, is in fact moulded upon the subjacent organs, and allows their more decided prominences to be seen. It is everywhere continuous with itself, there being only seen in various places in the median line an apparent inter-

* M. Malpighi, *De Lingua, exercit. epist.* De Externo Tactu *Organo epist. in op. omn.* t. ii. J. M. Hoffman, de *Cuticula et Cute*, Altæ. 1685. Littre, *Obs. sur les differentes parties de la peau*, &c. *Acad. Roy. des Science*, 1702, F. de *Riet, de Organo Tactus*. Ludg. Bat. 1743. J. Fantoni, de *Corporis integumentis*, &c. Turin, 1746. Lecat. *Traite des sens.* Cruickshank, Experiments on the Insensible Perspiration, &c. London, 1795. C. F. Wolff, *De Cute in Nov. Comm. Petrop.* vol. viii. G. A. Gautier *Recherches sur l'Organe Cutane*, Paris, 1811. Dutrochet, *Obs. sur la Struct de la Peau*, *Journ. compl.* vol. v. J. F. *Schroter, dans Menschlich gefühl*, &c. Leipzig. 1814. Lawrence, in Ree's Cyclopædia; Seiler, in *Anat-physiol. Realworterbuch.*

ruption which is named the raphe, and which indicates that there were originally two separate halves. This raphe is very distinct in the places where the union of the two halves is latest effected, and where it is most common to find abnormal division; for example, in the upper lip, the perinæum, and below the umbilicus. The skin seems perforated, but is not so in reality, at the orifices of the digestive canal and those of the respiratory, urinary, and genital passages, where it is reflected and continued, with a change of character, into the internal skin. This is also the case at the external auditory canal, into which it sends a cutaneous prolongation, and at the eyes and excretory ducts of the mammæ, into which it sends prolongations of a mucous nature.

292. The skin presents two surfaces. The free surface, which is external and in contact with the atmosphere, presents various objects to be considered. There are seen in it wrinkles or folds of greater or less depth, some of which depend upon the cutaneous muscles, situated on the head, the neck, and around the anus, the contraction of which the skin is unable to follow. It is the same with the wrinkles of the scrotum, which are produced by the contraction of the subjacent tissue. Other wrinkles correspond to the articulations, and depend upon their motions. Of this kind are the wrinkles of the hands, feet, &c. Others again depend upon emaciation and muscular atrophy, when these phenomena manifest themselves rapidly and at an age when the skin has lost its contractility. The surface of the skin, moreover, presents small wrinkles peculiar to the epidermis, in the palms and soles. These are prominent lines, separated by other depressed lines, running in various and winding directions, and which are formed by rows of papillæ. On the back of the hand and on the forehead they are of a polygonal form; on the cheeks and thorax they are only dots and rudiments of stars, &c. There are also seen at the surface of the skin small rounded apertures, very generally distributed, and which especially abound on the face. They are the orifices of sebaceous follicles. Other apertures of still smaller size and microscopic also occur, or apparent porosities of the epidermis, but which are infundibuliform depressions terminating in a cul-de-sac. In general, this surface is pretty smooth. It is in a small degree moistened and covered by the transpired humour and the sebaceous matter.

293. The deep or adherent surface of the skin is in general connected with the subjacent parts by a loose cellular tissue, which allows the skin to slide upon the parts which it covers, and *vice versa*. In some places, subcutaneous bursæ mucosæ interrupt the continuity of the cellular tissue and greatly augment the mobility of the skin and of the parts which are beneath it. In other places, on the contrary, the cellular tissue is dense and firm, and is little different in appearance from the skin. Such is its disposition on the cranium, the back of the neck, and the abdomen. In other places, again, it is by means of fibrous or ligamentous tissue that

the skin adheres to the subjacent parts, as around the wrist and ankle-joint, on the palm of the hand, the sole of the foot, and especially the heel. The adhesion is produced in some places by means of a reddish, semimuscular cellular tissue, if we may call it so, of which kind is the dartos, on the scrotum and lips of the vulva. Lastly, in some places the skin is attached to muscles, as the cutaneous muscles of the cranium, the face, the neck and the hand. The panniculus carnosus of the mammiferous animals, which is much more developed than that of man, excepting on the face, is of like nature with the cutaneous muscles of the latter. The anatomists of the middle ages disputed much respecting its existence in man. It is evident, however, that it does exist, although it is of small extent. In many places, the subcutaneous cellular tissue is mixed with adipose tissue, and these two tissues penetrate together into the substance of the skin. The subcutaneous cellular tissue is traversed by large veins, by numerous arteries and lymphatic vessels, and by nerves.

294. The cutaneous or sebaceous follicles* bear the greatest resemblance to the mucous follicles.

They exist in the whole extent of the skin, at least they are admitted so to exist, excepting in the palms and soles. Their existence is admitted there because the sebaceous humour covers the whole extent of the skin; because by an attentive dissection, and the assistance of the lens, they are perceived in places where they are of an excessive tenuity; and lastly, because certain morbid alterations render them evident in places where they are not otherwise perceived. They abound especially wherever there are hairs, in the neighbourhood of orifices, and in the groin and axilla. They are situated in the substance of the skin or beneath it. They are best seen in cutting the skin obliquely. Their orifice constitutes pretty distinct porosities at the surface. They are of the size of a millet seed and even less. Their size varies: those of the nose are pretty large, those of the cheeks much smaller, they have the form of a small bottle. They are in general simple and separate from each other. Those of the nose, however, are very close; some are even aggregated or compound. They consist of a small ampulla formed by the skin, rendered thin and reflected upon itself, and there furnished with a great number of vascular ramuscules. They contain an oleo-albuminous matter, which differs a little in the different regions of the body.

295. The texture and anatomical composition of the skin are points of minute anatomy, which have much exercised the patience of observers, and respecting which they differ greatly. From the earliest period it was known that the skin is composed of two layers, one deep and thick, the other thin and superficial. Malpighi having observed in the tongue of the ox, that the papillæ of the

* J. Ch. Th. Reuss. *præside* Autenrieth, *De Glandulis sebaceis dissert.* &c. Tubingæ, 1807.

dermis were separated from the epidermis by a mucous or glutinous layer, which like a net-work filled up the intervals, transported this layer by analogy to the human skin. Ruysch afterwards figured this net-work. Since this period anatomists have been singularly divided respecting the existence of the membrane in question; some denying it altogether, and admitting only the dermis and epidermis in the constitution of the skin, others admitting its existence only in the coloured races; others again, improving upon Malpighi, and admitting several layers in the mucous membrane of the skin, corresponding in a manner to the anatomical elements in that membrane, or the functions which it performs.

296. The blood-vessels, lymphatics and nerves of the skin penetrate into it through the areolæ of the dermis, after dividing into minute branches. Supported by a delicate cellular tissue which surrounds them, they thus arrive at its external surface, where there exist myriads of them, which, by their ultimate divisions constitute the papillæ and vascular net-work. With respect to the disposition of these parts, and particularly the vessels, it has been pretty generally admitted, that they are foreign to the dermis, and that they only pass through it to form a vascular net-work above it. M. Chaussier, on the contrary, admits that all the anatomical elements of the skin are united in the dermis itself. Gordon even goes so far as to assert, that the injected dermis is equally vascular in all parts, at its lower surface as well as at its upper. It would be incorrect to say, that the vessels are foreign to the dermis, and that they only form a superjacent * layer; but it would not be less, so to say, that they are as much divided and as numerous, at the inferior surface of the dermis, as at its external surface. The vessels divide and ramify in the dermis in proportion as they penetrate into its substance, and their last divisions, which are prodigiously multiplied, are distributed in the external surface of this membrane, and in the eminences which cover it, in consequence of which these parts are much more vascular than the deeper surface. The nerves are precisely the same in this respect.

297. The *Dermis, Corium*, or *Cutis vera*, is a fibro-cellular membrane, which forms the deeper and principal lamina of the skin, and of itself constitutes almost its whole thickness. Its internal surface, which is also the internal surface of the skin, generally presents alveolar apertures of a conical form, directed obliquely in the substance of the membrane. These areolæ, which are very large in the dermis of the hand, the sole of the foot, the back, the abdomen, and the limbs, are narrower in the neck, the chest, and especially the face, are scarcely visible on the back of the hand

* In the original author, the word subjacent is used, which is probably an error of the press, for no author, so far as I know, has said that the vascular layer of the dermis was only subjacent; the criticism, may, after all, be considered unimportant; the dermis, very obviously, is not equally vascular throughout.

and foot, the forehead, the scrotum and the lips of the vulva. The edges of these areolæ are continuous, the first and largest, with the subcutaneous fibrous tissue; the second, with the more or less dense cellular tissue; the last, or smallest, with the very loose tissue that exists in the regions in which it is observed. The areola itself is filled by an adipose cellular tissue, and traversed by the vessels and nerves of the skin. The bottom of these alveolar cavities is perforated by very small apertures, which correspond to the external surface of the skin. This surface, which is in general smooth, presents, in various places, small papillar eminences, which are much more distinct upon the denuded dermis, than when seen through the epidermis.

298. The papillar body and vascular net-work of the skin, which have been improperly described as distinct layers of that membrane, belong to the outer surface of the dermis, the papillæ,* which were discovered by Malpighi, admitted, figured, and described afterwards by Ruysch, Albinus, and many other anatomists, and of late years by Gautier, under the name of granulations, and called in doubt by Cheselden and several others, are very small prominences on the surface of the dermis, generally of a conical form, distinctly visible in the tongue, disposed in double lines, and very perceptible in the palm of the hands, the sole of the feet, and especially in the pulp of the fingers; still distinct, but irregularly distributed, in the glans, nipple, and labia; but so small and indistinct in the rest of the skin that they are rather admitted to exist there by analogy than actually observed, and are in a manner blended in the surface of the dermis into a vascular and nervous net-work. These papillæ, in the places where they are very distinct, evidently consist of a projection of the dermis, which is very soft, highly vascular, penetrated by numerous nervous filaments, destitute of neurilemma, and of vascular ramuscules, having there an erectile disposition which will be described in Chapter IV. In the places where the papillæ are less distinct, although the composition and texture of the surface of the dermis may be essentially the same, there are fewer nerves, and the vessels, which are very numerous, form a net-work. The blood constantly penetrates, but in variable quantity, into the vessels of the surface of the dermis. In ecchymoses of the skin, it goes farther, and is infiltrated into the corpus mucosum. Delicate and penetrating injections, after filling the papillar and vascular bodies of the skin, also sometimes spread out beyond them.†

299. The texture of the dermis is that of an areolar web more or less condensed. The fibre which forms it is peculiar to itself. It was considered by the older anatomists as intermediate between the muscular fibre and the aponeurotic tissue. Some have pronounced

* Hintze *de Papillis cutis tactui inservientibus*. Lugd. Bat. 1747. Albinus, *Acad. Annot.* Lib. III. cap. ix. et xii.

† See Prochaska. *Disquisitio anat. phys. organismi*, &c. Viennæ, 1812, 4to.

it purely cellular, others ligamentous. M. Osiander* has recently maintained that it is distinctly muscular at the inner surface of the skin. He made his observations on the skin of the abdomen of women who died in child-birth. The tissues which it most resembles in its general characters, are the cellular tissue and the fibrous tissue.

300. The dermis is white. Its outer surface has more or less of a reddish tint, according to the quantity of blood retained in its minute vessels. Its thickness is not the same in all parts, but varies from a line and a half to the fourth of a line. In the trunk, it is generally thicker at the posterior than at the anterior part, and in the limbs, at the outer part than at the inner. The dermis is in particular very thin in the palpebræ, the mammæ, and the organs of copulation; very thick, on the contrary, in the palm of the hand, and especially in the sole of the foot. It has a kind of semi-transparence which allows the colour of the subcutaneous veins to be seen through the skin. It possesses a power of cohesion which adapts it for making very strong ligatures in the mechanical arts. In the arts of the tanner, currier, &c., it is submitted to various operations which prevent it from putrefying, and increase its density or flexibility, &c. It naturally contains a great quantity of moisture, the removal of which renders it yellow and elastic. By boiling, it is reduced to glue or gelatin. Besides its extensibility and retractility, which are very great and remain after death, it possesses during life a very evident power of tonic contraction, although in a much smaller degree than the muscles. It is this contraction which roughens the skin in cold weather. It is at its outer surface that the sense of touch resides. The dermis forms the support of the rest of the skin, and it is at its surface that the corpus mucosum exists.

301. The *Corpus mucosum* of Malpighi,† *corpus reticulare* or *rete glutinosum Malpighianum*, is a very thin layer of half fluid cellular tissue, which invests the papillar surface of the dermis, separates it from the epidermis, adheres intimately to both, and is the part which gives the skin its colour. This portion of the skin, first pointed out by Malpighi, accurately observed by Meckel and Albinus, and admitted by most anatomists, at least in the negro; although denied by several of them, and in particular by Bichat, Chaussier, Gordon and Rudolphi, cannot in truth be isolated by dissection, but may be perceived under various circumstances. Whenever the epidermis separates from the dermis, whether during life, or in the dead body, there is distinguished on one or other, and sometimes on both of these membranes, a mucous layer which covers the papillar eminences and fills up their intervals. This intermediate membrane is in particular very distinct in the

* *Commentationes Gottingenses Recentiores.* Vol. iv. 1820.

† See Meckel, *Recherches anatomiques sur la Nature de l'Epiderme et du Reseau qu'on appella Malpighien. Mem. de l'Acad. roy. des sciences de Berlin,* 1753. Albinus, *Academ. Annot.* Lib. i. cap. i—v.

negro, as well as in the black spots which sometimes occur in white people, and even on a bit of white skin which exists in the Hunterian collection. This layer, which is extremely thin at the summits of the papillæ, and less so in their intervals, has the appearance of a net-work, but is not perforated. Those who have admitted only two membranes of the skin, have considered it as the deep part of the epidermis. This mucous body, respecting the nature of which it is difficult to form a very correct idea, appears to consist of a plastic fluid or a half-organized cellular tissue. The blood or injections do not disclose vessels in it. Fluids however penetrate it, but they seem to be imbibed by it, or to be contained in particular interstices. No nerves have been seen in it either, and it is without due foundation that Dr. Gall has compared it to the cineritious substance of the brain. This membrane forms a humid varnish which invests the papillar and vascular surface of the dermis. The substances which enter into the economy, or issue from it by the skin, pass through it. It is the seat of the colour, and that of the horny, scaly, and other similar productions, that naturally exist in the skin of animals and in that of man, as well as of those which are accidentally developed there. This membrane, which is so thin, and whose existence has even been doubted, appears, in some animals, and even in man, at least in some parts of the body, and in certain cases, to be formed of several superimposed layers.

302. An anonymous author first pointed out this circumstance. Cruickshank observed it in a negro who had died of small-pox, and Bayham in the injected skin of a white, in another case of disease. Gautier demonstrated it in the skin of a negro by various methods, and M. Dutrochet in the skin of animals. These observations are sufficiently numerous to render it necessary to examine before rejecting them. 1st, There is upon the papillar surface of the dermis a very thin, colourless, and transparent layer, which is especially distinguished beneath the coloured scales and horns of animals, in the negro, and even in the white, but under the nails only; 2dly, A coloured layer, very distinct in negroes, in whites spotted with coloured marks, and much less so in the places where the skin is white:—it is frequently united with the next layer; 3dly, A superficial colourless layer, more or less soft or encrusted with horny or calcareous matter: it is distinct in many animals, and is so in a small degree in the negro, but in the white can only be seen at the nails, the hairs, and in accidental horny productions. This layer is immediately covered by the epidermis.

303. The pigment of the skin* has its principal seat in the corpus mucosum, and especially in its middle layer, but the outer surface of the dermis, and especially the inner surface of the epidermis, also possess it in a small degree. The anatomists who preceded

* B.S. Albinus, *De sede et causâ coloris Aethiopum et ceter. homin.* &c. Lugd. Bat. 1737; et *Annot.* Lib. i. cap. ii. Meckel, *Loc. cit.* S. T. Soemmering, *ueber die korperliche verschiedenheit des negers vom europäer.*

Malpighi, and some of those who have succeeded him, place its seat in these two membranes, especially in the latter. The colouring matter exists in the men of all races, excepting albinos; but it is only in negroes that it can be seen very distinct from the rest of the skin. Malpighi only announced that the colour of the skin has its principal seat in the rete mucosum. Littre tried, but in vain, to obtain the colouring matter separate, by submitting the skin of the negro to maceration, in order to swell, the corpus mucosum, and thus separate the epidermis from the dermis. However, although the corpus mucosum is very soft, and capable of becoming fluid, considerable portions of it in a coloured state may be separated from the skin of the scrotum of the negro, under the form of a continuous membrane, independent of, and separated from, the epidermis. But more commonly, and I have several times repeated the experiment, maceration separates from the dermis, which remains possessed of very little colour, the epidermis and corpus mucosum adhering together and coloured; and it is only with difficulty that the corpus mucosum can afterwards be separated under the form of a membrane. If the maceration be prolonged in a small quantity of water, and the experiment be made with the skin of the scrotum, a part which is very deeply coloured, the corpus mucosum, in becoming resolved into a kind of mucosity, tinges the water and at length allows to fall to the bottom of the vessel, an impalpable powder of a brown colour. Gautier has assigned as the special seat of the colouring matter, the middle layer of the corpus mucosum, which he describes under the name of *gemmules*, as an undulated layer which covers with each of its contours singly, the double furrowed lines of the dermis, on the palms and soles. It would rather seem that the pigment results from coloured globules disseminated in the corpus mucosum.

Not only is the corpus mucosum more coloured, but it is also thicker in the negro race, than in the other races, and in the latter its thickness is in the ratio of its colouring. Accordingly, it is so thin in white people that its existence in them has been doubted. It is still thinner and so fluid in albinos, that the action of the sun very readily blisters their skin, while in negroes epispastics do not produce that effect without great difficulty.

The colouring matter of the skin is very similar to that of the blood. It appears to be secreted from that humour, and to pass from the vessels of the surface of the dermis into the corpus mucosum, where it exists in a kind of imbibition; various morbid phenomena countenance the belief that it is there continually renewed by continual deposition and resorption. Beddoes and Fourcroy have found that the skin of the negro, on being immersed in water impregnated with vapour of chlorine, becomes white, and in a very few days resumes its dark colour in all its original intensity. The chemical observations of Davy, Coli, and others, have demonstrated what Blumenbach had long ago advanced, that the pigment of the skin is principally formed of carbon.

The use of the pigment, in the coloured races, appears to be to protect the skin from the rubefacient effect of the sun's rays, which is commonly called sun-burning.*

304. The *Epidermis*, *Scarf-skin*, or *cuticle*,† is a distinct, although thin, layer of the skin, which forms a kind of dry and defensive varnish at its surface. The free or external surface of this membrane, which is at the same time the external surface of the skin, presents, as has been already seen in § 292, small wrinkles and eminences, variously disposed, and visible to the naked eye. Further, if this surface be examined with a magnifying instrument, and even with a simple lens, the places of the epidermis comprised between the small wrinkles, and which, to the naked eye, seemed perfectly smooth, there appear very uneven and rugged, and present small depressions, which have so much the more the appearance of pores that the sweat is seen to exude from them.

The under surface of the epidermis is adherent, and cannot be separated from the rest of the skin by dissection; but putrefaction, maceration, the action of heat, whether dry or moist; epispastics, and various diseases effect this separation. When it is determined by incipient putrefaction—a process preferable to any other for the purpose, there is perceived, on raising the epidermis with caution, a multitude of very delicate, transparent, and colourless filaments, which break, after being elongated to a certain degree. These filaments, which have been accurately described and figured by William Hunter, who considered them as the vessels of the sweat, had previously been remarked by Kaau, who was of the same opinion. Bichat and M. Chaussier also consider them as exhalent and absorbent vessels. On the other hand, Cruickshanks thinks that they are not vessels, but excessively delicate prolongations of the epidermis, which line the minute pores of the dermis. Seller seems to adopt this hypothesis, and according to him they are rudiments of sebaceous follicles and of bulbs of hairs. However, it is not certain that their prolongations exist when the epidermis adheres to the dermis, and they might be considered as mucous threads formed by the substance intermediate between the dermis and epidermis, rendered fluid and viscous by incipient decomposition.

The epidermis penetrates into the sebaceous follicles, where it is attenuated. It also penetrates, exhibiting the same circumstance, into the openings of the bulbs of the hair.

305. It has been said that the epidermis is composed of im-

* See Philosophical Transactions for 1821. I. On the Black Rete Mucosum, &c. by Sir E. Home.

† H. Fabricio, *De totius animalis integumentis, ac primò de cuticulâ, et iis quæ supra cuticulam sunt, in Oper. omn.* Ludwig, *De cuticula*, Lipsie, 1739. Meckel, *loc. cit.* and *Nouvelles observations sur l'epiderme*, Mem. de l'Acad. Roy. des sc. de Berlin, 1757. Monro, senior, *De cuticula humana*, oratio, in his Works, Edinb. 1781. J. Th. Klinkosch and Hermann, *de vera natura cuticulæ, ejusque regeneratione*, Prague, 1775. B. Mojon, *Sull, epidermide*, &c. Genua. 1815.

bricated scales; but the appearance which has led to this assertion is fallacious; it consists of a plain and continuous membrane. Nunberger has admitted that it is provided with vessels, and that it is nourished by intus-susception. Mojon, as well as Klinkosch, suppose it possessed of fibres, laminæ, vessels, and all the properties of organization and life. Mascagni considers it as being entirely formed of absorbent vessels. Fontana had imagined that he saw contorted vessels in it, but Humboldt found that these alleged vessels are merely folds. The most attentive observation and the most delicate anatomical operations, discover nothing in the epidermis but a homogeneous layer, the adherent surface of which is insensibly blended with the corpus mucosum, and which is destitute of cellular tissue, vessels and nerves.

306. The thickness of the epidermis is very inconsiderable, scarcely equalling the fifth or sixth part of that of the skin. On the palms and soles it is thicker than anywhere else. In these places, especially in persons who work at mechanical occupations or who walk much, it appears formed of several layers. M. Heusinger* considers this part of the epidermis as a variety of the horny tissue, and has described it under the name of callous tissue. The epidermis is less elastic than the corium, very flexible, and easily torn. It is transparent, and of a colour slightly tinged with grey. In the coloured races, it partakes of the colour of the skin; but is less dark than the corpus mucosum. The transparence of the epidermis is not the same throughout; when held between one and the light, it exhibits more transparent points, which have been taken for porosities.

307. It is well known that Leuwenhoeck thought he perceived them, and that he has figured them. Many anatomists after this admitted them upon physiological considerations. But neither the observations of M. Humboldt, made with magnifying instruments of much higher power than those of Leuwenhoeck; nor those of Seiler, made upon the epidermis, detached with a razor, from the body of an animal in a state of perspiration; nor my own, which were made by charging a shred of epidermis with a column of mercury of about the weight of one atmosphere, have discovered these porosities. Further, observation apprises us that the epidermis prevents or greatly moderates evaporation in the dead body, and that the parts of the skin from which it is removed dry up, as well as the subjacent parts, with great readiness. However, the epidermis gives passage to the matter which the skin absorbs during life, and certainly those which it excretes. But, what is more surprising still, is that in the observations above-mentioned, there could not even be perceived the apertures of the epidermis which give passage to the hairs, those which correspond to the sebaceous follicles, or even those which were made with a fine needle. It is well known that the same circumstance takes place with respect to elastic gums.

* System der histologia, von Heusinger, Eisenach, 1822, 4to.

Filtering paper, in like manner, exhibits no pores under the microscope when it is moistened, but they are easily seen in it when dry.

308. As the cutaneous absorption and perspiration cannot depend upon the physical properties of the epidermis, it has been attempted to find their explanation in its chemical properties. The epidermis when dried diminishes in bulk, becomes firmer and more elastic, and assumes a somewhat yellowish tint. When macerated in cold water, on the contrary, it swells a little, and becomes soft, less elastic, whiter and more opaque. This substance, however, imbibes very slowly; it requires a pretty long immersion of the hands and feet in water, before the epidermis has absorbed enough of fluid to become white and opaque, and yet the epidermis of these regions appears to imbibe more easily than that of the other parts of the body. It is to this difficult permeability of the epidermis that we must attribute the difficulty with which the fluid of the ampullæ escapes during life, and the slowness with which the skin dries in the dead body, even in the driest atmospheres, provided the epidermis remains untouched. It resists putrefaction long, and has been found untouched in graves at the end of more than fifty years. Boiling water renders the epidermis white and opaque, and deprives it of elasticity much quicker than cold water. Continued boiling removes from it a little gelatin, which appears to be furnished by its adherent surface. The residuum does not differ perceptibly from the epidermis in its entire state. When exposed to the heat of the fire it burns like a plate of horn, and emits a similar smell. The pure fixed alkalies dissolve it completely into a saponaceous substance. Nitric acid almost immediately renders it yellow, thickens and softens it, renders it opaque in about a quarter of an hour, and in twenty-four hours reduces it to a yellowish pulp. If ammonia be applied upon the epidermis after being rendered yellow by nitric acid, it assumes a deep orange colour. Now, Hatchett has shown that the same effects are produced in coagulated albumen. The epidermis appears to consist of a layer of albuminous mucous, coagulated and dried.

309. The epidermis is possessed of neither irritability nor sensibility, but of all the parts of the body it is that which is endowed with the most active power of formation. It results from the concretion of a fluid exuded at the surface of the skin, continually renewed, and never absorbed again, but worn down at the external surface in proportion as it is produced at the internal.

310. Numerous opinions have been entertained respecting the formation of the epidermis. The oldest is that which considers it as produced by the desiccation of a fluid supplied by the surface of the dermis. Others, with Leuwenhoeck, have seen in it only the expansion of the vessels of the skin. Others, as Ruysch, have regarded it as originating from the expansion and desiccation of the papillæ. Heister attributed its formation to these two causes united; Morgagni, to the callification or hardening of the surface of the skin by the pressure of the water of the amnios at first, and

afterwards by that of the atmosphere; and Garangeot, to the hardening of the rete mucosum. All these opinions, and especially the first and the last, contain some truth. It in fact results from an exudation or excretion of the dermis. It is the indurated surface of the corpus mucosum, so that from the dermis to the free surface of the epidermis, there is a successive degradation of organization and vitality, which reduces the epidermis to a kind of varnish, participating of organization and life only in its origin, which renders it well adapted for resisting the action of external bodies, and for protecting the vessels, nerves, and other parts of the skin.

311. The skin, formed by the dermis, the vessels and nerves which are distributed in its substance, and especially at its outer surface, the epidermis of which we have just been speaking, and the intervening rete mucosum, thus presenting a diminution of organization and vitality from the dermis to the epidermis, partakes of the physical, chemical, and vital properties of these different parts. This is equally the case with its functions or organic actions.

312. The skin, on account of the dry and not readily permeable epidermis which forms part of it, is not so well adapted as the mucous membrane for absorption and secretion.

The skin, being furnished with its epidermis, in the entire state, the cutaneous absorption or cuticular absorption, as it is also called, is in fact still a subject of doubt and discussion with physiologists. To decide this question between Seguin, Currie, Klapp, Rousseau, Dangerfield, Chapman, Gordon, Magendie, &c. whose observations and experiments tend to invalidate the idea of cutaneous absorption, and Keil, Haller, Perceval, Home, Cruickshank, Watson, Ford, Abernethy, Bichat, Duncan, Kellie, Brandner, Stuart, Sewal, &c. and especially Young, whose experiments and observations are favourable to it; it is necessary to make abstraction of cases in which absorption may have taken place by respiration as well as by the skin, and they are numerous; as well as of those in which the epidermis may have been softened, altered or injured by continued applications at its surface, or by repeated rubbings; in which circumstances absorption is no longer cuticular, but rather of the same kind as that which is performed by the mucous membrane, or by inoculation, the matter of which is carried through a cut in the epidermis into the corpus mucosum as far as the dermis, both which parts are eminently absorbent. This done, there remains a small number of facts which show that certain substances are sometimes absorbed by the skin through the epidermis, in its entire state, but that this membrane is really an obstacle, and very frequently an efficacious one, to the absorbent erection of the external tegument.

313. The skin is also an organ of secretion and excretion. Two kinds of well known external secretion are performed in the membrane, the cutaneous perspiration and the sebaceous follicular se-

cretion. The perspiration is sometimes insensible and in the state of vapour, and sometimes fluid and perceptible. In the latter case it is called sweat. This secretion goes on without intermission, and is probably essentially the same in both cases; but in the first it is imperceptible on account of its vaporization. The secretion takes place in the skin, but by what vessels it is performed we are ignorant, and the passages by which it makes its way through the corpus mucosum and epidermis are entirely unknown. It may, however, be admitted with some probability, that the perspiratory excretion is performed in the bottom of the microscopic depressions of the epidermis, in which place it is the least dry. The quantity of this matter secreted is very great, but difficult to be estimated. Sanctorius, whose experiments are so celebrated, found that he lost five-eighths of the general mass of his food by the pulmonary and cutaneous perspiration. Of those who have repeated his experiments, Lavoisier and Seguin have made the following distinction. They found that the cutaneous perspiration is to the pulmonary perspiration, on an average, as eleven to seven. Cruickshank attempted to determine its nature, and found that it possesses all the properties of water containing carbonic acid and an animal matter on which its smell depends.

When the perspired matter collects under the form of sweat, it makes its appearance at the surface of the skin in drops, on which Leuwhenhoeck has made some interesting observations. Human sweat in the healthy state is always acid, possesses a saline taste, and emits an odour. It is formed, according to M. Thenard, of much water, a small quantity of acetic acid, hydrochlorate of soda, and perhaps potash, very little earthy phosphate, an atom of oxide of iron, and an inappreciable quantity of animal matter. Berzelius considers it as water holding in solution hydrochlorates of potash and soda, lactic acid, lactate of soda, and a little animal matter.

The cutaneous perspiration, whether sensible or insensible, is to be considered as one of the most important secretions of the organic structure. Moreover, it is a powerful means of refrigeration and of resistance against a too elevated external temperature. This function presents numerous varieties, depending upon age, sex, individuals, external circumstances, the state of the other functions, the action of substances taken within the body or applied to its surface, diseases, &c. It also exercises a powerful influence upon the other functions.

314. It has been admitted that gaseous absorptions and secretions are performed by the skin, similar to those of the lungs, and constituting a kind of cutaneous respiration. Thus Spallanzani has seen the skin absorb oxygen in the mollusca, Edwards in reptiles, and Irvine in man himself. But objections and experiments may be opposed to these assertions. We may even oppose the experiments of Priestley to those of Cruickshank, Dr. Mackenzie and Mr. Ellis, who seem favourable to a cutaneous excretion of

carbon which would combine with the oxygen of the atmosphere to form carbonic acid. It is at least certain that, if in man whose epidermis is dry, and whose pulmonary expiration is of great extent, the air exercises a vivifying action upon the blood which circulates in the skin, this action is by no means capable of supplying that of the lungs.

315. The skin excretes an oily matter,* which Cruickshank succeeded in obtaining under the form of dark-coloured drops at the surface of a knitted woollen under-vest which he had worn night and day during a month, in the warmest time of summer. This matter rubbed on paper exhibits the same appearance as fat. It burns with a white flame, and leaves a carbonaceous residuum. It is uncertain if this oil, which has been said to be subcutaneous fat transuding through the skin, is furnished by the same passages as the preceding or the following.

316. The cutaneous follicles secrete a sebaceous matter. This matter is thick, not glutinous, and without fibrous appearance when hardened. On being suspended in water by trituration, it forms a kind of emulsion, but does not dissolve in it. It does not melt in the fire, and when burnt leaves much charcoal. It contains, especially the cerumen, a proportion of oil which may be separated from it by absorbent paper. This matter forms in the sebaceous follicles, whence it may be made to issue by pressure in the form of small worms, and from which it exudes of itself to anoint the skin in the neighbourhood, and to defend it especially from the action of water and excrementitious humours.

It is of these three matters together that the cutaneous excretion consists, an excretion which is very abundant, and of which a portion is continually converted into vapour, while the more fixed parts cover the skin, and are afterwards detached from it under the form of dandriff. To these excretions ought to be added that of the epidermis, which while it is continually worn at its outer surface, is incessantly reproduced at the other.

317. The skin is an organ of sensation. It is, still more than the other tegumentary membrane, the organ of the general and passive touch which enables us to perceive the presence of bodies, their temperature, &c. Further, and especially in certain places, abundantly supplied with nerves and vessels, and well fitted for adapting themselves to the form of bodies, it is an organ of special or active touch, or of palpation. Both modifications of touch are so much the more active the more developed and less covered the papillæ are.

318. Lastly, The skin is a defensive organ, of little efficacy in man, but of much in certain animals, in which the corpus mucosum is the seat of calcareous and horny incrustations. It is evident that this organ, whose functions are so numerous, and whose texture is so complicated, cannot have one of its parts, or one of its

* Ludwig and Grutzmacher, *De Humore Cutem inungente.* Lipsiæ, 1748.

functions highly developed, excepting at the expense of the other. Accordingly, the thicker and more defensive the corpus mucosum and epidermis are, the blunter is the touch.

319. The embryo, towards the middle of the second month, has as yet no distinct skin. About this period, according to Autenrieth, the epidermis begins to appear. Until the middle of the fifth month the epidermis remains thin, colourless, and transparent. It then becomes of a rosy tint, and continues so until about the eight month. At this period it becomes paler, excepting in the folds. About the middle of the fifth month of gestation, the sebaceous follicles begin to make their appearance, first in the head, then in the other parts of the body. At the seventh month, the sebaceous covering of the skin begins to appear. At birth the skin is covered with it, and is of a pale rose colour. After birth, the skin presently acquires the colour peculiar to the race, and increases in thickness and strength until adult age. In old age, it dries, becomes wrinkled, and gradually loses its colour.

The skin is thinner, more delicate and softer in the female sex, but these characters sometimes disappear after the age of fecundity.

320. The differences which the skin presents in the different races have already been pointed out, (§§ 112–116.) The individuals of the coloured races, and even negroes themselves, are nearly of the same colour as whites at birth. The colour begins to show itself the moment the child respires, but more especially towards the third day after birth, around the nails, the nipples, the eyes, the anus, and the organs of generation. By the seventh day the colouring has become general, the palmar and plantar regions alone remaining whitish. During the first year the colour is but light, it afterwards increases, and continues through the greater part of life to diminish in old age. The smell of the skin varies in the different races, like its colour. Besides the national varieties, there occur very numerous variations in individuals.

321. The morbid alterations of the skin are extremely numerous. We have already spoke of the cicatrices or accidental reproduction of that membrane, (§ 258.) The new tissue is similar to the old, but is not identical with it. The dermis is denser in it, less areolar, more compact, less vascular, and less papillar than that of the skin. The epidermis distinctly exists in it, although this has recently been denied. The corpus mucosum also exists, as well as its coloured layer, and Camper was deceived when he asserted that the cicatrices of negroes are white, the shade being in them merely a little different. These sometimes form horny productions on the cicatrices. These accidental teguments are very susceptible of ulceration.

There also sometimes occurs accidental skin in cysts of the ovaries. These are probably imperfect fœtal productions, whether engendered or enveloped in the fœtal state, by the individual which contains them.

322. The skin sometimes presents original vices of conformation. These may be either vices of defect, constituting divisions or denudations in the fœtus, or of excess, and then there are folds or bags of greater or less extent. It also presents acquired vices of conformation. Its distension, when carried to a great length, as in gestation for example, separates and tears asunder the fibres of the dermis, and produces marks which are at first brown after child birth, and afterwards become and continue whiter than the rest of the skin and shining. More moderate and more prolonged distension causes the skin to lose its elasticity or retractile power, and when it has cessed leaves wrinkles more or less distinct.

323. The skin is the frequent seat of congestions, fluxion, acute, and chronic inflammations, whose very diversified effects, whether upon the texture of the membrane, or upon its colour, or upon the products of secretion, have given rise to the establishment of half a hundred genera, and double that number of species of diseases of the skin, consisting of pimples, scales, eruptions, ampullæ, pustules, vesicles, tubercles, spots, &c. respecting which may be consulted with advantage the works of Plenck, M. Alibert, Willan, and Bateman.

324. The retention of the sebaceous matter and its accumulation in the follicles, give rise to the formation of tumours, which are named *tannes* when they are small, and which when large are confounded with encysted tumours under the names of *wens*, *miliceris*, *atheromata*, and *steatomata*. When the tumour is small, and the orifice of the follicle is not obliterated, the sebaceous matter may be pressed out under the form of a worm, a circumstance which has led inattentive observers, fond of the marvellous, into error. When, on the contrary, the tumour has become enlarged and bulky, and its orifice is not apparent, it greatly resembles a cyst; but on dissecting it carefully, traces are found of the orifice at the point where it is attached to the skin, and if the skin and the tumour are cut at this point, the epidermis is easily followed in its reflection from the surface of the former into the cavity of the latter. The contained matter, whether it have the appearance of honey, pap, or suet, still sufficiently resembles the matter of the sebaceous follicles not to be mistaken for any thing else.

325. Various accidental productions, whether of the same nature, or morbid, are observed in the skin. This membrane is sometimes raised by a greater or less, and sometimes immense number of tumours of very different sizes, formed by the accidental production of a white fibrous tissue, much more compact than the cellular tissue, and weaker than the ligamentous tissue. The same tissue also occurs pretty frequently in polypi, and especially in submucous tumours of the vagina and vulva.

326. The colour of the skin presents various alterations, the most singular of which is that exhibited by Albinos. In them the skin is of a dull or reddish white, very different from the white of Europeans; the hairs are transparent and whitish, or rather co-

lourless; the eye has the iris of a pale rose colour, and the aperture of the pupil red, which depends upon the absence of the pigment of the choroid membrane and of the uvea. The functions of the skin, and especially of the eyes, are greatly weakened by this alteration, which has been attributed to the absence of the corpus mucosum, and which at least very certainly depends upon that of the colouring matter of the skin and its dependencies. This state has erroneously been regarded as an effect of leprosy or cachexy, or as a diseased condition. This opinion, the principal supporters of which were Blumenbach and Winterbottom, has been sufficiently refuted by the observations of Jefferson, who says expressly that all the individuals of this kind whom he has seen were well formed, strong, and active. This alteration occurs in all the races of men, in all the parts of the globe, and in a very great number of animals. It commences immediately after birth, persists through life, and is transmitted by generation. The union of an Albino and a coloured individual commonly gives rise to coloured individuals, and sometimes to Albinos. These Albinos do not form a distinct race of men, but occur sporadically, as it were, or as accidental varieties.

The *nœvi* and marks of the skin consist, sometimes of a coloured patch of the corpus mucosum, which is then sensibly thicker in that part than elsewhere; at other times of an erectile disposition of the vessels of the skin, which will be elsewhere described, (Chap. IV.)

The colouring of the skin is also subject to accidental alterations. Thus we see individuals of the white race become brown or entirely black in parts of greater or less extent. Whites and blacks are also seen to become albinos in parts of the skin of variable extent.

Melanosis, which generally coincides with the discolouring of the skin, and which is so frequently observed in white-haired persons, probably depends upon an aberration of the pigment of the skin.

There are sometimes seen in the corpus mucosum horny productions which become more or less prominent at the surface of the skin. These productions being similar in nature to the nails, will be described along with them.

ARTICLE II.

OF THE PARTS DEPENDENT UPON THE SKIN.

327. The nails and hairs are the only parts connected with the skin in the human species; but in animals there occurs a great variety of these appendages. These parts have been considered erroneously as appendages of the epidermis alone, for they are connected with the whole skin.

I. OF THE NAILS.*

328. The *nails (ungues)* are horny scales or plates which are attached to the skin of the last phalanx of the fingers and toes on the upper side only.

These parts are distinguished in the nails; the root, the body, and the free extremity.

The root or adherent extremity is the fifth or sixth part of the length of the nail. It is the thinnest part. It is received into a groove of the skin, and is of a white colour. The body or middle part is intermediate in thickness as well as position. Its external free surface, which is smooth, and presents longitudinal furrows more or less distinct, is convex in both directions, and especially in the transverse. The opposite surface adheres intimately to the skin. The posterior part of the body of the nail, in a smaller extent, and which diminishes from the first towards the fifth finger or toe, is white. This semilunar part has received the name of *lunule.* The other part appears reddish, on account of its transparency, which allows the colour of the skin to be seen through it. The free extremity of the nail is its thickest part. It is prolonged beyond the finger; and tends, although in a slight degree, to curve downwards so as to form a kind of hook.

329. The connexion of the nail with the dermis and epidermis takes place in the following manner. The dermis is thick, red and very papillar beneath the body of the nail, excepting under the lunule, the papillæ are disposed in linear series, like very small and close longitudinal furrows, the corresponding surface of the nail is soft, pulpy, and furnished with longitudinal grooves which receive the prominent lines of the dermis and adhere very intimately to them. However, their separation is produced in the dead body by the same causes which detach the epidermis and corpus mucosum from the dermis. The adherent extremity of the nail, which is very soft and thin, is received into the bottom of a fold of the dermis, destitute of epidermis. Under the nails of the last toes, which are small and irregularly developed, the papillæ of the dermis are irregularly disposed, and not in linear series. The adherent surface of the nail presents the same irregular disposition for receiving the papillæ.

330. The epidermis, on arriving at the root of the nail, is reflected with the dermis until near the bottom of the groove. There, the dermis passes under the nail. The epidermis, on the contrary, is reflected over its root, and is prolonged upon its upper surface, which it thus covers with a very thin superficial laminæ, which is confounded with it. At the free extremity of the nail, the epider-

* Frankenau, *de Unguibus*, Jenæ, 1796.—Ludwig, *De Ortu et Structurâ Unguium.* Lipsiæ, 1748.—B. S. Albinus, *in Annot. Acad.* Lib. ii. cap. xiv. *de Ungue Humano, ejusque reticulo*, &c. and cap. xv. *de Natura unguis*—Bose, *de Unguibus Humanis*, Lips. 1773.—Haase, *de Nutritione Unguium*, Lips. 1774.

mis of the end of the nail is reflected under its inferior surface, and unites with the free parts of this surface. On the sides, there exists posteriorly a disposition similar to that which is observed at the root, and anteriorly to what exists at the free extremity.

The nails have no other connexions than those which have been described above. It is from not having correctly examined them, that some anatomists have admitted a connexion between them and the periosteum and tendons.

331. It has been admitted by some with Blancardi, that the nails are formed of agglutinated hairs. Others are of opinion that the nails result from the superposition of horny scales or laminæ, the outermost of which has the whole length of the nail, while the others successively diminish in length, which produces a successive increase of thickness in the nail from the root to the free extremity. These opinions however are rather modes of accounting for the formation of the nails, than results of observation, which in fact discovers nothing in the nails but a horny substance, hard and dry at the exterior, and mucous at the interior. Neither vessels nor nerves have been found in the nails. They consist of a thick and horny layer of the corpus mucosum of the skin.

332. The nails are transparent, flexible and elastic, they tear transversely notwithstanding their fibrous appearance in the opposite direction. Their chemical properties are those of coagulated albumen. They appear to contain also a little phosphate of lime. They have the greatest resemblance to horn, and are utterly destitute of irritability and sensibility. The power of formation, or the continual growth by a kind of vegetation, is the only organic and vital phenomenon which is observed in them; and even this phenomenon is foreign to them. The materials of their formation are continually secreted and execreted by the dermis. This matter applied to the adherent extremity and surface of the nail, like that of the secretion of the silk-worm becoming concrete in proportion as it is excreted, and being continually added to that which has preceded it, pushes it before it, and thus elongates the nail by juxtaposition and not by intus-susception. It is therefore a true excretion, the materials of which once deposited, are never absorbed again. The nails, arm, support and protect the extremities of the fingers and toes.

333. The nails begin to appear about the middle of the fœtal life, and at birth are still very imperfect. In the coloured races, the colour is subjacent to the nail. In many animals, on the contrary, the coloured layer of the corpus mucosum is confounded with the horny layer in the composition of the claws and analogous parts. The parts which most resemble the human nails are the claws of the carnivora, &c., which surround the dorsal surface and sides of the last phalanx, and curve towards the plantar surface; and the hoofs of the ruminantia, &c., which envelope the whole extremity of the last phalanx. The nails of the human feet sometimes acquire a great development, and assume a curved direction, which makes them look like claws.

334. The alterations * which are attributed to the nails are, in reality, entirely foreign to them, and depend solely upon the skin by which they are furnished. This is also the case with accidental horny productions. It is in the subjacent tissue that their origin is to be looked for.

When a nail is pulled out by violence, or detached by disease from the subjacent skin, it slowly grows again, and differs more or less from the original nail, according as the affection of the skin has continued more or less when it sprouts again.

Horny laminæ, more or less similar to the nails, form upon cicatrices, the ends of the toes, and other places exposed to reiterated pressure or friction, of this kind are callosities, lacunæ, &c. Ichthyosis, whether simple or in plates, differs from these only in being of greater extent and in its cause being unknown.

Corns also consist of accidental horny productions of a rounded form, small, and very hard, and which by the compression transmitted by them, irritate, inflame, and sometimes perforate the skin, and even alter the subjacent bones or articulations.

Horns, or conical horny productions, more or less elongated, have been frequently observed, from the earliest periods, upon all parts of the skin. Sometimes only one of these excrescences exists on an individual, and is developed either upon a cicatrix, or in a sebaceous follicle, or upon some point of the skin, previously altered, or sometimes without any thing particular being observed in the skin previously to the production of the horny substance. At other times, productions of this kind exists in almost all parts of the skin, constituting a kind of ichthyosis.

The warts that form on the skin and the poireaux of the mucous membrane, may be compared to accidental horny productions, and regarded as imperfect horny tissue, both kinds participating of the horny and membranous tissues.

The nails soften, carnify, become imperfect horny tissue, vegetate irregularly, present excrescences, become dry, brittle, &c. in certain general or local affections of the skin, as well as from the habitual contact of alkalies, acids, &c. as happens in some trades. They always participate also in the healthy or diseased state of the skin, of which they are productions. When the nail enters the flesh, it only forms a mechanical cause of inflammation of the skin.

II. OF THE HAIRS.†

335. The hairs *(Pili, Crines,)* are horny filaments, generally

* Plenck, *de Morbis Unguium, in doctrinâ de Morbis Cutaneis.*

† P. Chirac. Letter to M. Regis, on the Structure of the Hair, Montpellier, 1688. Malpighi, *De Pilis Observationes in Op. Posth.*—Withoff, *Anatome Pili Humani.* Duisb. 1750, and in *Comm. Soc. Scient.* Gotting. 1753.—J. H. Kniphof. *De Pilorum Usu.* Erf. 1754.—Duverney, *Œuvres Anatom.* Paris, 1761.—Albinus, *Acad. Annot.* lib. iv. cap. ix.—J. P. Pfaff. *De Variet. Pilor. Natural. et Præternat.* Halæ, 1796.—Car. Asm. Rudolphi, *Diss. de Pilorum Structura.* Gryphiswald, 1806.—Gautier *L. cit.*—Heusinger, *L. cit.* &c.

slender and elongated, which, in greater or less number, cover nearly all the parts of the skin, excepting the palms and soles.

Each hair consists of a bulb and a stem, and each of these parts has a somewhat complicated texture, which is especially distinct in the largest hairs.

336. The bulb or follicle of the hairs, which Malpighi compared to the vessels in which gardeners plant flowers, and which has been well described by Chirac, is situated in the substance of the dermis or beneath it. It has an ovoidal form. By one of its extremities, which penetrates obliquely through the skin, it communicates with the surface of that membrane; and by the other, which is deep-seated, and furnished with some filaments, inserted like roots, it is immersed in the subcutaneous cellular tissue. It is formed externally of a closed, white, coriaceous capsular membrane, which is continued at its superficial extremity with the dermis. Internally of this membrane is another thinner membrane, which is soft, and of a reddish tint, or variously coloured, and which seems to be the continuation of the corpus mucosum. The cavity of this membranous follicle is in a great measure filled with a conical papilla, adhering by its base to the bottom of the cavity, and free at its summit, which rises towards the orifice of the follicle.

Blood-vessels arrive in the papilla, according to Gautier, by the neck of the bulb, creeping between these two membranous layers, and according to my own observations by the bottom. I have also followed by dissection nervous filaments into the root of the follicle, which I therefore consider as formed of vessels, nerves, and cellular tissue.

The bulbs of the hairs therefore seem to consist of a small part of the skin, sunk, depressed, or folded upon itself, surmounted by a papilla, and furnished with vessels and nerves which are of great size when compared with the smallness of the space to which they are distributed.

Lastly, there occur in the substance of the neck of this piliferous bulb several small sebaceous follicles circularly arranged.

337. The shaft of the hair is inserted by one of its extremities into the piliferous bulb, and is free in the rest of its extent. Its form is conical, the free extremity being a little smaller than the rest. It varies greatly in length, as well as in thickness. The base is hollow, lodged in the bulb, where it embraces the papilla, and the summit is often split. Whatever be the colour of the hair, its root is always white and transparent. The part contained within the bulb is also always softer than the rest, and its lowest portion, which covers the papilla, is entirely fluid. The surface of the hair has been said to be scaly or covered with microscopic asperities, free in the direction of the summit, and adhering on the side next the root; but I have never been able to perceive them.

338. The connexion of the hair with the skin takes place in the following manner: It is attached by its base, which is hollow, to the surface of the papilla; moreover, the epidermis, after intro-

ducing itself from the surface of the skin into the entrance of the bulb, is reflected upon the base of the hair, and unites and is confounded with its surface. Accordingly the hair holds very firmly to the skin, and cannot be detached from it without painfully pulling it. The separation of the hairs in the dead body is effected by the same causes as those which detach the epidermis and nails from the skin.

339. The shaft of the hair consists of a horny, transparent sheath, nearly colourless, and an internal coloured substance, which has been more generally described as being formed of a certain number of filaments, from five to ten, moistened with a colouring substance. Others have represented it as a spongy substance, like that with which the shaft of the feathers is filled ; while others have asserted that the internal filaments are vascular. It has also been alleged that the hairs consist of a homogeneous horny filament, which is not probable. Mascagni says they are entirely formed of absorbent vessels. It appears on the contrary that, like the epidermis and horny matter, the hairs are entirely destitute of vessels and nerves, and that they merely consist of a prolongation of two layers of the corpus mucosum, the coloured layer and the horny layer, to which the epidermis also unites itself.

340. The colour of the hairs is generally conformable to that of the skin and eyes. In individuals who have coloured or white spots upon the skin, the hairs are coloured in the former, and white or colourless in the latter. They are very strong, and support considerable weights without breaking. They are easily split or torn in the longitudinal direction. They are highly hygroscopic, being enlarged and elongated by humidity, and shortened by dryness. Saussure was the first who took advantage of this circumstance for hygrometical purposes. They are idio-electric. They depolarize light, and, according to Dr. Brewster, possess perfectly neutral axes, they being parallel and perpendicular to the axis of the hair.

According to Hatchett, continued boiling removes from the hairs a little gelatin, and the remaining substance, which has lost a part of the elasticity and tenacity of the hair, has all the properties of coagulated albumen. They resist putrefaction in a high degree. Their colour at first alters, but the horny matter long remains untouched. M. Vauquelin found that they melt by decoction in Papin's digester, that they also dissolve in water containing four hundredth parts of caustic potash, and that all the acids act upon them. According to that celebrated chemist, they are composed of an animal matter which forms their basis, a little white concrete oil, a blackish oil, iron, oxide of manganese, phosphate of lime, carbonate of lime, silica and sulphur.

341. They are not possessed of irritability or sensibility, but their power of formation or of vegetation is very active.

The motions which the hairs may perform are communicated to them by the subcutaneous muscles, and by the contraction of the skin itself. The very coarse hairs or prickles of certain animals are moreover supplied at their root, with a small muscle whose action is to raise them. Although the shaft of the hair is strictly speaking insensible, yet as their root is applied upon a papilla provided with a nerve, they transmit to it with great accuracy the effects of the contact of external bodies which act mechanically upon them. Their vegetation or production goes on without intermission, resembles that of the epidermis and nails, and like it constitutes a true excretion. Some facts would seem to indicate that there takes place in their interior, not a true circulation, but an imbibition, and that a coloured fluid passes slowly through them from the root towards the free extremity. They have been alleged, but without proof, to be organs of absorption. Their use is to protect the skin, and, in some places especially to assist sensation. They have besides local uses.

342. With reference to the regions which they occupy, the hairs present considerable difference, and have received different names.

On the head, where they are longer, closer, and stronger than anywhere else, they are called *capilli*, *coma*, *cæsaries*.

The eyebrows or supercilia and eyelashes or ciliæ belong to the eyes. The orifices of the nose and ear are also furnished with hairs.

The cheeks, the parts about the mouth, and the chin, are occupied by the beard, *barba*, *julus*, *mystax*, or *pappus*.

The axillæ are also furnished with hairs, *glandebalæ*, as well as the pubis, the scrotum, or the lips of the vulva, and the neighbourhood of the anus.

The rest of the body, whether the trunk or limbs, is also more or less furnished with hairs. On the trunk there are more on the anterior than on the dorsal surface, which is the reverse of what is generally seen in animals, and on the limbs there is less hair on the inner than on the outer side. In general, the hairs of the greater part of the trunk and limbs are scanty, very delicate, short and scarcely visible, although in some individuals they are of large size and very abundant.

343. It is about the middle of gestation that the rudiments of the hairs begin to be perceived. They appear in the corpus mucosum under the form of globules similar to those of the pigmentum. Upon these globules rise small hollow cones, which are the sheaths of the hairs. They remain for some time under the epidermis, and at length pass obliquely through it, according to some by pores, although they have not been seen.

There is presently observed on the skin of the fœtus a fine down, *lanugo*, at first colourless, which covers nearly the whole body, and effects determinate directions in the different regions. These silky hairs, for the most part, fall off about the eighth month of gestation, and are found in the liquor amnii and meconium. It is in the last month of gestation that the ciliæ, superciliæ, and hairs of the head begin to appear. After birth the rest of the down falls off. Towards puberty the beard, the hairs of the nose and

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ear, those of the axilla, pubis, organs of generation and anus, and of the rest of the body, begin to make their appearance. After the adult period and in old age, the hairs become white and generally fall off.

In the female sex, the hairs of the head are more numerous and especially longer. There are generally no hairs on the face or around the anus, and those on the rest of the body are finer and more scattered. After the period of fecundity, the beard is sometimes developed in considerable quantity. In general, women are less subject to baldness than men.

The races of the human species present differences with respect to the hair which have been already pointed out. (§§ 112–117.)

Individuals also present numerous differences of which some relate to the colour, the shades of which vary greatly, others to the size, the length, and the thickness of the hair. Withoff found that in a portion of the skin a quarter of a square inch in extent there were 147 black, 162 brown, and 182 white hairs.

Parts greatly resembling hairs occur in certain mammifera, in which they constitute prickles. They are horny sheaths, coloured, hard, and pointed, containing in their interior a white spongy substance. Of this kind are the prickles of the porcupine. Common hairs seem to consist principally of horny matter.

344. Accidental hairs occur on various parts of the skin and mucous membrane, as well as in cysts. There even existed a popular error among the ancients, to which credit was given by Plutarch and Pliny, and which was, that the heart had been seen covered with hairs. Homer, according to some, has even spoken of the hairy heart of Achilles, but it would appear to be the breast of his hero that he had so characterized. As to the other facts it would appear, according to Senac's remark, that they were merely hearts covered with accidental cellular tissue that had given rise to them. The accidental hairs of the skin are those which occur on coloured spots or on parts of the skin thicker than the rest of that membrane. They have been seen to acquire a great development on parts of the skin that had been previously inflamed. Hairs have been seen growing on various parts of the mucous membrane. More commonly they have been found free in the cavities lined by that membrane or ejected externally, whether by themselves or forming part of concretions. Although some of these facts may be perfectly authentic, it ought not to be forgotten that hairs may be swallowed or introduced by other means. The hairs of cysts, whether cutaneous or mucous, are sometimes inserted and sometimes free, and in both cases generally mixed with fat or sebaceous matter. Those which are inserted in cysts of the ovary are commonly upon parts of these cysts evidently cutaneous. As to those of wens of the eyebrow and cranium, &c. these cysts appear to me to be only sebaceous follicles, and the hairs which they contain only hairs of the skin, which in place of directing themselves to

the surface of that membrane by the orifice of the follicles, have been deflected by the accidental enlargement of that cavity.

345. These alterations of the hairs,* like that of the nails, have all their origin and cause in the productive parts, and the produced or horny part experiences the effects of this cause. When a hair is pulled out, or when it falls off in consequence of some affection of the skin, and the latter happens to cease, it shoots up again and grows by the same organic process as the nails. This regeneration is effected in the same manner as the original production, (§ 343.) When the hairs become white through the effects of age or other causes, it is at the free extremity that the whitening commences. It is in the same manner that the autumnal change to white which is observed in many animals is effected, and this circumstance seems to indicate, that the interior of the hair is the seat of a kind of imbibition, the matter of which is furnished by the papilla of the bulb or follicle. This would also seem to be indicated by the circumstance, that after severe fevers, and in many chronic diseases, the hairs of the head, when they do not fall off, undergo a kind of diminution or atrophy; they become transparent, dry, and brittle, and when health is restored, resume their original qualities. The hair of the head has also been seen, after experiencing albinism, or without having been previously whitened, to change colour and become black. The morbid phenomenon of the plica polonica, in which the hair is said to become soft and fleshy, and to bleed when cut close to the skin, forms no exception to the general proposition, that the stem only of the hair can participate in the healthy or morbid state of the skin. It may, in fact, easily be conceded, that the papilla of the hair, if it is inflamed, may rise contained within the root of the hair to the level of the skin, and that its vascular tissue may be wounded in shaving the stem of the hair, but there is probably much exaggeration in what is related of the plica.

CHAPTER IV.

OF THE VASCULAR SYSTEM.

346. The Vascular System *(Systema Vasorum)* consists of a multitude of ramified canals, communicating with each other, and in which the nutritive humours incessantly traverse the whole extent of the body; receiving at the tegumentary surfaces the matters derived by absorption from without, and there giving off those furnished by excretory secretion; alternately depositing and taking up molecules in the closed cavities of the cellular tissue; continually

* Plenck, *De Morbis Capillorum, in Op. Cit.* S. Wedemeyer, Historia Pathol. Pilorum. Gotting. 1812, 4to.

supplying materials of composition in the substance of the organs, and constantly carrying off those resulting from decomposition.

347. In the most simple animals, the entire mass of the body, which is in all parts equally permeable, directly imbibes the materials of absorption, and rejects those of secretion in the same simple manner. In animals possessed of a higher degree of organic composition, the tegument, which is the essential seat of external absorption and secretion, is prolonged into the mass of the body by more or less numerous ramifications, by means of which the absorbed matters are distributed, and the excreted matters taken up, in various points of the mass. Lastly, in a higher degree of organization, which comprehends a great portion of the animal kingdom, vessels traverse the mass of the body in all directions, distributing and taking up the matter of nutrition in all parts.

348. As in man as well as in many animals, the blood contained in the vessels is continually carried from a central point into all the parts, and brought back from all the parts to the centre, so as to describe a circle, the name of circulatory apparatus also is bestowed upon the vascular system and the parts connected with it, the first name having reference to conformation, the other to function.

This system or genus of organs comprehends three species, of which two, the arteries and veins, contain blood. The arteries, which carry it to all the parts, and the veins which bring it back from all the parts, are united at the centre by a hollow muscular organ, the heart. The third species, the lymphatic vessels, do not carry blood, but chyle and lymph, and pour them into the veins. They ought to be considered as an appendage to the venous system.

349. The arteries and veins are in such a relation to the heart and the blood, that they may be further divided into two other sections.

The blood is brought by the veins from all parts of the body to the heart, and from thence conducted to the lung by the pulmonary artery. It returns from the lungs by the pulmonary veins to the heart, to be carried by the aorta to all the parts of the body, whence it is brought back by the venæ cavæ. The name of pulmonary or lesser circulation is given to the course of the blood from the heart to the lung and from the lung to the heart, and the name of pulmonary vessels to the organs by which this circulation is effected. The name of general or great circulation is given to the course of the blood from the heart to the whole body, and from all the parts of the body to the heart, and the names of aorta and venæ cavæ, or of general vessels, are given to the organs which convey the blood in this course.

350. The blood contained in the general veins of the body, the anterior or right half of the heart, and the pulmonary artery, is of a brownish red colour, and is called venous blood. That contained in the pulmonary veins, the other half of the heart and the aortic

arteries, is of a bright red colour, and is called arterial blood. The circulation has also been divided, with reference to the blood which it conducts, into that of the black blood, and that of the red blood. Bichat, the author of this division, of which Galen had an idea (2d Sect.) has thought proper to describe the passages of the first under the name of vascular system, containing black blood, and to unite those of the second under the name of vascular system with red blood. It will afterwards be seen that this division, which is fertile in results, rests entirely upon a physiological basis, and not upon a similarity of texture in the parts.

351. The three species of vessels bearing a great resemblance to each other, the two sanguiferous vascular systems in particular having a great mutual affinity, and the venous and lymphatic systems also greatly resembling each other, it becomes necessary, before describing each kind, to expose the general considerations in question, both with reference to the vessels generally, and with respect to their terminations.

SECTION FIRST.

ARTICLE FIRST.

OF THE VESSELS IN GENERAL.

352. The situation of the vessels is internal. The largest are in general placed towards the centre of the body, and at the surfaces there are only found divisions of extreme minuteness, and even these are separated from the external parts by a layer of substance not possessed of vascularity.

The principal vessels, whether in the trunk or in the limbs, are in general placed in the direction in which the parts bend upon each other.

In general, there occur together an artery, one or two veins, and several lymphatic vessels. Moreover, there are found beneath the skin numerous lymphatic vessels and veins, and few arteries.

353. The relative size of the vessels of the three kinds is such that in general the afferent vessels, the veins and lymphatics, are together much more voluminous than the arteries which carry the blood. Even the veins of themselves have in general a much greater capacity than the arteries to which they correspond. The relation of volume and number, or of total capacity, between the venous and lymphatic vessels is less known. It is well known however that under the skin, under the mucous membranes, and around the serous membranes, there are always numerous veins and lymphatics; and that in the muscular interstices of the limbs and walls

of the trunk, there are also numerous lymphatics along with the veins, while in the spinal canal and within the skull there are many veins of great size, and few or no lymphatic vessels. Perhaps this last circumstance may depend upon the difference between the matter with which the muscles and the nervous substance are nourished, and consequently upon the different matter that remains in the circulation.

354. The external form of the vascular system is that of a tree whose trunk is connected with the heart, and which successively divides into branches, twigs and ramuli becoming gradually smaller and smaller.

Each part, from its origin in a larger branch to its division into smaller branches, generally retains a cylindrical form.

Each twig being smaller than the branch from which it proceeds, and larger than each of the ramusculi which spring from it, there results a successive diminution from the trunk to the end of each of the ultimate ramifications.

As in general the sum of the branches which result from the division of a trunk is greater than the volume of the trunk itself, it also follows that the vascular system has the form of a cone whose summit is in the heart, and whose base is formed by the aggregate of all the ramusculi diffused through the body.

355. The number of divisions of the vascular system, from its centre of origin to its last ramifications, is not the same in all its parts. It has been greatly exaggerated in making it amount to forty. Haller has come much nearer the truth, in reducing to twenty the maximum of the successive divisions of a vessel from its trunk to its last divisions.

In certain places, the vessels bifurcate in such a manner that the trunk ceases by being divided into two branches, and the branch by being separated into two twigs. Thus the aorta bifurcates to form the common iliac arteries, which also bifurcate in their turn. In like manner the common carotid arteries divide into two. The vessels of the intestines present this dichotomous mode of division in a remarkable manner.

The angles which the vessels form in dividing, and at which the branches come off from the trunks, vary, but are, for the most part, acute in the twigs. It is proper to observe, with Haller, that these angles, to which much importance has been attached, are in a great measure destroyed or changed by dissection, in removing the cellular tissue which surrounds the vessels. There are some angles which are nearly right angles, of which kind are in general the first and largest divisions of the trunks. Thus the branches of the arch of the aorta, the cæliac artery, the renal arteries, &c.; the renal and hepatic veins, the subclavian veins, the jugular veins, &c.; the thoracic duct, at its entrance into the subclavian vein, and some others, as the anterior sacral, the tarsal and other vessels. Some vessels even form obtuse angles, of which kind are the first intercostal vessels, the inferior vessels of the cerebellum, those of the heart, and some vessels of the limbs, &c. The greater number, however, form acute angles, which are often so in a high degree, such, for example, are the spermatic vessels.

It ought to be observed, with reference to the angles which are considered as right, and even as obtuse, that most of them are in reality acute; but at a small distance from their origin, the branches, after a short course, change their direction, are reflected, and follow a retrograde course, the reverse of that of the trunk, much in the same way as the branches of the weeping-willow.

There is no general law or rule to be deduced from observation respecting the angles which are formed by the divisions of the vessels. Thus we see large branches as well as small ones, and branches near the trunk, and its origin, as well as distant ones, coming off at more or less acute angles.

What is true of the large vessels is equally so of the smallest, in the divisions of which we in like manner generally observe acute angles, with some right angles, and even some obtuse ones.

356. The branches of the different parts of the vascular system, while they divide or ramify in proportion as they recede from the origin or centre of the system, have yet communications with each other or anastomoses. The lymphatic vessels are those which present the most numerous anastomoses, the veins have many also, and the arteries, although they have fewer, have yet a very great number. These communications are effected by the meeting and uniting of two vessels of the same kind, and of equal size.

In some places, two vessels proceeding obliquely towards each other, unite into a single trunk, which follows a direction intermediate between those of the original vessels. Of this kind is the union of the two vertebral arteries to form the basilar, that of the anterior spinal arteries, that of the aorta and pulmonary artery in the fetus, that of many veins, &c.

The most common mode in which the vessels anastomose, is by forming at their meeting an arch, from the convexity of which issue branches, as is seen in the mesenteric or intestinal vessels, around the joints, in the hand and foot, &c.

In other places, two vessels, each pursuing its own direction, communicate by a transverse branch. Of this kind is the communication of the umbilical arteries with each other in the placenta; such are the communications of the arteries of the brain, of the right side with the left, and of the anterior part with the posterior, and such are also those of many veins and arteries of the limbs.

In several parts, these communications form circles, or polygons, as the circle of Ridley or Willis, under the brain, those of the iris and mouth, that which encircles the stomach, &c.

In a great many parts, or in nearly all, the vessels which anastomose in arches, uniting equally with others coming from branches, some nearer, others more distant from the centre of the vascular system, establish collateral ways for the circulation. Thus, for example, the circumflex vessels of the hip communicate upwards with the vessels of the trunk, and downwards, with the vessels of the knee, and the latter, at the same time, also communicate with twigs sent off by the vessels of the leg.

In general, the vessel or vessels which result from an anastomosis, are larger than any one of the vessels meeting together, and less than the sum of these vessels.

The anastomoses become more numerous as the vessels diminish in size and recede from the centre. They also take place between large branches at the extremities of the body, for example, in the cavity of the cranium, and in the hand and foot. In most places they connect vessels whose origin is not far from their point of union; in others, however, they unite vessels whose origin is distant, and even extremely so, as from the subclavian region to the inguinal region. The anastomoses of the blood-vessels are more numerous and larger around the joints than in the intervals; those of the veins and lymphatic vessels are also very frequent between the principal trunks; those of the veins in particular, are very numerous under the skin.

Some idea may be formed of the number and importance of the anastomoses, when it is known that the aorta* may be contracted, obliterated, and even tied, without the circulation or injection ceasing to make fluids arrive in all parts of the body; that after the largest veins,† the venæ cavæ themselves, are obliterated, the blood still circulates, and that the thoracic duct may be obliterated, or tied with impunity.‡

The object of the anastomoses is to favour and regulate the circulation of the humours.

357. The large vessels follow a tolerably straight course, in general parallel to the axis of the body. It is for this reason that incisions are made by preference in the longitudinal direction, in order to avoid injuring them.

In many places, however, the vessels have a flexuous direction. The flexuosity consists in a course alternately undulated above and below a straight line. It is increased by the state of repletion or injection of the vessels in the dead body, and in the arteries during the systole of the heart; and is diminished in the opposite circumstances. It is in particular greatly diminished by the precise dissection of the vessels. The flexuosities are very marked in the vessels of parts subject to great changes of volume, figure and situation, as the mouth, the stomach, the intestine, the bladder, the uterus, the tongue, and the testicle before its exit, &c. and of those which are subject to great motions, as the parts about the joints. Here, however, there are fewer flexuosities, but the vessels are very elastic.

* Scarpa on Aneurism.—A. Cooper and B. Travers. Surgical Essays. Part I. London, 1818.

† J Hodgson. Diseases of the Arteries and Veins.

‡ Flandrin, *Journal de Medicine*. T. LXXXVII, Paris, 1791. A. Cooper in Medical Records and Researches, &c. Lond. 1813.

The vessels of the spleen, those of the brain, and the spermatic veins are also very flexuous, without however appearing to be so for a similar reason.

The flexuosities of the blood-vessels are more marked than those of the lymphatic vessels, and those of the arteries are greater than those of the veins.

358. The symmetrical disposition of the vessels is very imperfect, and does not exist in their central parts. They are nearly symmetrical in such of their divisions as belong to symmetrical parts, and unsymmetrical in those which belong to parts destitute of symmetry. This disposition is common to all the vessels, to the lymphatics and veins as well as to the arteries. In certain animals and in the embryo, the vascular system is more symmetrical than in the adult man. Besides the general defect of symmetry, the vascular system is subject to many irregularities in its distribution.

359. The walls of the vessels are connected by their external surface, which is flocculent, with the mass of the body in which they are ramified. Their internal surface is smooth, polished, shining, humid, and in contact with the circulating humours. It presents projecting heels wherever the branches form acute angles with the trunks. The walls have a thickness, which, with relation to the volume of the vessel, increases from the trunks towards the ramifications. The cavity of the vessels, as has already been said, (§ 354.) of the vessels themselves, presents an exact cylindrical form in each division, the form of a decreasing cone as we proceed from the trunk towards the last divisions, and that of an increasing cone, from the trunk toward the branches, taking the latter in their aggregate.

360. The texture of the vessels results, more or less distinctly, from several superimposed layers.

The internal membrane is thin, whitish, more or less transparent, uniform, without apparent fibres, continuous throughout, but different in the arteries and veins. It bears a great resemblance to the serous membranes. It is moistened by a fluid, the source of which is not well known. It forms, in the different species of vessels, a greater or less number of valves or folds so disposed as to allow a passage to the humours in the direction of the circulation, and to oppose their passing in the opposite direction.

The outer membrane, which must not be confounded with the cellular sheath that loosely surrounds the vessels, is thicker than the inner, fibro-cellular, and generally formed of filaments having an oblique direction with reference to that of the vessels, and interlaced with each other.

Between these two membranes there is observed another of a fibrous structure, which is distinctly developed in all the arteries that can be submitted to dissection, as well as the large veins.

361. The outer membrane of the vascular system, and especial-

ly the middle membrane of the vessels which are furnished with one, are formed of a peculiar kind of fibre.

This fibre has received the names of elastic fibre, elastic fibrous tissue, &c. although most organs are elastic and fibrous, because it possesses elasticity in the highest degree. It was first observed by Nichols, John Hunter and Sir Everard Home,* and has engaged the attention of several anatomists and chemists of the present day.†

It forms not only the walls of the vessels, but also those of the air-tubes, and constitutes part of certain excretory ducts. It forms the envelope of the corpus cavernosum, and that of the spleen, as well as the ligamenta flava of the vertebræ. In various animals, it moreover forms the posterior cervical ligament, an abdominal coat in the great mammifera, a ligament which retracts the claws of the feline animals, and the ligaments by which bivalve shells are opened; and in most mammiferous animals, it occupies the place of the muscles of the small bones of the tympanum. But it is more particularly in the middle coat of the arteries, the ligamenta flava, and the ligamentum nuchæ, that its peculiar characters are most distinctly seen. It exists under two principal forms: the tubular, as in the walls of the arteries, and the fascicular, as in the ligamenta flava.

This fibre is opaque, of a yellowish white colour, dry, firm, and disposed in bundles always parallel or nearly so, never interlaced or connected by cellular tissue, and very easily separable. It is highly elastic: when distended, it becomes sensibly elongated, and in some parts acquires double its length, and when again left to itself, suddenly and with great force contracts. Its tenacity in the living body is less than that of the muscular tissue, and is much greater than it is in the dead body. In the two states, it is much less than that of the ligamentary tissue, which is possessed of very little extensibility. It is more tenacious in the fasciculi, and on the other hand more fragile in the vessels.

The elastic tissue contains about the half of its weight of water. When it has lost it by desiccation, it acquires a horny appearance, and a deep yellow colour, and becomes brittle and transparent, like horn. If immersed in this state in water, it greedily absorbs it, and resumes its original weight, elasticity, and general appearance. It greatly resists maceration, and the cellular tissue does not then become apparent in its interior. The action of fire hardly curls it, and it leaves little charcoal. Decoction in like manner scarcely curls it, and although it removes a little of gelatin from it, does not melt it, and does not destroy its elasticity. Acids harden it in only a slight degree, and do not render it transparent.

* Croonian Lecture on Muscular Motion, in Phil. Trans. 1795.

† H. Hauff, *De Systemate telæ Elasticæ*, &c. *Tubingæ*, 1822. Chevreul, unpublished notice.

it resists their action long, or experiences no effect from it. Dilute alkaline solutions do not alter its form, and but slightly dissolve it.

Most of these anatomical, physical, or chemical characters are directly the reverse of those of the ligamentary tissue, and differ from those of the muscular fibre, with which the elastic tissue has been erroneously confounded. It, however, in some respects, resembles the muscular fibre, and appears intermediate between that fibre and the cellular and fibrous tissues.

Its vital properties are very obscure, especially in the ligaments, and even in the large vessels.

Its functions depend upon its elasticity, which is everywhere in opposition to the action of gravity or to muscular action.

362. The walls of the vessels are themselves provided with blood-vessels and lymphatics, constituting the *vasa vasorum* of authors. The blood-vessels may be distinctly perceived in all vessels that are not less than half a line in diameter; but they cannot be traced into the substance of the inner coat. The lymphatics can only be perceived in the large vessels. The vascular system is also furnished with nerves* which are supplied by the spinal marrow and the great sympathetic nerve, and are distributed in the outer part of the substance of their walls.

363. The vessels whose trunks, branches, and principal twigs are lodged in the common cellular tissue, after dividing there, penetrate into the substance of the organs, where they ramify to such a degree as to become imperceptible, and terminate in a manner which will presently be described; but the distribution of the vessels in the organs varies in several respects, as we shall now show.

364. Their origin is more or less distant from their termination, and the course which they run consequently varies in length. In general, the vessels come off from their trunks at no great distance from the organs for which they are destined. When the contrary takes place, it depends upon some local peculiarity: thus the spermatic vessels have their origin at a great distance from the organs in which they terminate, because the testicles and ovaries were originally situated near the kidneys.

365. The number, volume, and consequently the total sum of the vessels, as well as the quantity of fluid which they carry, vary in the different organs. Most of the organs receive several vessels of each species: such are the muscles, the bones, the brain, the stomach, the intestine, the uterus, &c. In almost all cases the vessels subdivide greatly at the surface of the organs before penetrating into their interior, as is seen with respect to the brain, the bones, muscles, &c. Sometimes they penetrate by a single point into the organ, and divide in its substance, as in the spleen, the testicle, &c.

The sum of the vessels, resulting from their number and vo-

* Wrisberg, *De Nervis Arterias Venasque comitantibus; in syllog. comm.* Gotting. 1800.

lume, as well as the quantity of fluid which they carry, vary greatly. The most vascular parts are the lungs, then the tegumentary membranes, as well as the pia mater and choroid membrane; then the glands, the follicles, the vascular ganglia, the cortical substance of the brain, the nervous ganglia; then the muscles, the periosteum, the adipose tissue, the medullary nervous substance, the bones, and the serous membranes; then the tendons and ligaments; and lastly the cartilages and arachnoid membrane, in which there are extremely few or none. The epidermis, the nails, the hairs, and the ivory and enamel of the teeth, appear to be entirely destitute of vessels.*

366. On arriving in the substance of the organs, and attaining a greater or less degree of tenuity, the vessels, by their divisions and subdivisions, their various directions and anastomoses, form very complicated net-works, varying greatly in form, although always possessing the same form in the same parts. They present arborizations in the intestine and epididymis, stars on the liver, tufts in the tongue, and tendrils in the placenta. In the spleen the appearance exhibited is that of a bottle-brush; in the muscles, that of a stalk of a bunch of grapes; in the testicle and choroid plexus, that of curled hair; in the iris that of creeks, fringes in the pia-mater, trellis-work in the pituitary membrane, a plume or nosegay on the capsule of the crystalline humour, &c. These dispositions are so constant and so regular, that, on examining a portion of an organ well injected, it is easily known to what part it belongs.†

367. The vessels are more or less transparent, according to their thinness or thickness. Their colour is whitish. Whatever may be the density of their walls, especially at their internal surface, they are permeable in the dead body and even in the living, whether from without inwards, or from within outwards. They possess a considerable power of cohesion,‡ which, however, is not the same in the three species, in all their parts, or even in the different layers of which they are composed. This is equally the case with their elasticity,§ which is, in general, considerable, and which exists in the longitudinal direction of the vessels, and in that of their circumference. They are decidedly irritable, and their vital contractility ‖ is, in general, in the inverse ratio of their elasticity. They are not distinctly sensible. Their power of formation is very active.

368. The vessels are tubes by which the circulating humours

* See Soemmering, *De Corp. Human. fabricâ*, t. iv. *Angiologia*, 1800. G. Prochaska, *Disquisitio Anat.-physiol. Organismi Corp. Hum.* &c. Vienna, 1812. cap. ix. *De Vasis Sanguineis Capillaribus*, &c.

† See Soemmering, *Loc. cit.* Prochaska, *Loc. cit.*

‡ Cl. Wintringham, Experimental Inquiry on some parts of the Animal Structure, London, 1740.

§ D. Hoffman, *Diss. Inaug. Med. de Elasticitatis Effectibus in Machinâ Humanâ*, 1734.

‖ G. Werchuir, *Diss. Med. Inaug. de Arter. et Venar. vi Irritabili*, Groning. 1766. C. Hastings, *Disp. Physiol. Inaug. de vi contractili Vasorum*, &c. Edinb. 1820.

are conveyed through the whole mass of the body, which they constantly moisten. Along with the heart, they are the organs or agents of the circulating motion, as much by their elasticity as by their organic or vital contractility.

369. The formation and development of the vascular system have been best observed in the chick: in the fœtus of the mammiferous animals it has been less examined, and in the human fœtus but very imperfectly.

The veins, those of the vesicula umbilicalis in particular, are formed before the heart and arteries. It is uncertain whether the veins form before the arteries in the allantoid or umbilical vessels also. It is very probable that in the body of the fœtus itself the arteries form before the veins.

The vessels make their appearance in the substance of the umbilical membrane under the form of small rounded vesicles, separated from each other. These vesicles increase in number, and unite together, which gives rise to a very slender vascular network. These first lineaments are destitute of walls, and consist merely of cavities formed in the substance of the membrane, which ultimately becomes denser toward their circumference, and thus forms walls to them. The texture and composition of these walls are not developed until long after.

As to the original simplicity of the circulating system in the fœtus, its successive complication, the formation of the heart, that of the pulmonary vessels, &c. They belong much more to particular anatomy, and especially to embryology,* than to general anatomy.

The number of the vessels in general, and their diameter, and, consequently, their total sum, are with relation to the mass of the body so much the greater the nearer the subject is to the period of formation. The vessels in general, the blood vessels especially, and particularly the arteries, greatly increase in density in old age.

370. The circulating system presents little difference in the different sexes, although the vessels are sometimes thicker and stronger in the male. There are no appreciable differences in the races.

Individual variations, on the contrary, are very frequent and numerous in the system. They consist especially of differences in the origin, size, number, and precise situation, and exist nearly in the same degree in the three kinds of vessels.

371. Vessels, generally very minute, form accidentally in various circumstances.

Adhesions, from being at first merely glutinous, become afterwards vascular. This is especially the case with accidental teguments or cicatrices. All the accidental productions resembling organic tissues are in a similar predicament. Morbid productions,

* Ph. Béclard, *Embryologie ou Essai anat. sur le fœtus humain*, 4to. Paris, 1821.

or those which have nothing similar in the organism, are, on the contrary, generally destitute of vessels. The latter form, in the cases of which we speak, as in the embryo. The mass in which they form is at first without vessels, and most commonly consists of a coagulated fluid, in which isolated vesicles present themselves, which, by uniting, form canals without distinct and proper walls. These vessels afterwards communicate with those of the neighbouring organs. They sometimes remain for a greater or less time, or even always, different from the natural or original vessels, both in their mode of division, and especially in the absence or thinness and softness of their walls. In many cases, on the other hand, the new vessels ultimately acquire a texture precisely similar to that of the other vessels.

372. Of the alterations to which the vessels are subject, some are common to the three species, of which kind are dilatation or angiectasy and wounds. Others are peculiar to each species in particular. The former even present differences in each species sufficient to render it preferable to speak of them apart.

ARTICLE II.

OF THE TERMINATION OF THE VESSELS.

373. The termination of the vessels, *Fines Vasorum,* are the last ramuscules of the arteries and the first radicles of the veins and lymphatics. Their knowledge is one of the points of minute anatomy that have most exercised the patience of observers, and the imagination of etiologists, who have, with some appearance of reason, imagined that they discovered in it the secret of most of the functions and diseases.

374. In almost all parts of the body the termination of the vessels are ramuscules or radicles of a more than capillary minuteness, and which can be perceived only with the aid of the microscope. In some parts these terminations, but especially the radicles of the veins, present more width and an erectile disposition which renders them susceptible of undergoing a greater or less expansion. Lastly, in certain parts, the termination of the vessels, by their being mingled and communicating with each other, constitute ganglia or particular vascular conglomerations.

1. OF THE CAPILLARY VESSELS.

The capillary or microscopic vessels,* *Vasa capillaria,* so named on account of their minuteness, are much finer than hairs, and cannot be perceived with the naked eye. Although the radi-

* Prochaska, *De Vasis Sanguin. Capill. in Op. Cit.*

cles of the lymphatic vessels participate in this minuteness, yet it is more especially of the capillary blood vessels that we intend here to speak.

376. The ancients, who were ignorant of the art of injecting the vessels, as well as of that of magnifying objects by means of optical instruments, were not acquainted with the minute vessels. They imagined that there was between the last divisions of the arteries and the first divisions of the veins, an effused sanguineous substance of a spongy nature, called *parenchyma*, by Erasistratus, and *haimalope*, by Areteus, and of which they believed especially that the viscera were formed. This opinion respecting the terminations of the vessels was almost unanimously admitted by anatotomists until the discovery of the circulation of the blood; and since that period it has been admitted by a considerable number of anatomists, and even by some of those of our own times.

However, the injections of Ent,* by showing the direct passage, without effusion of the injected fluid, from the arteries into the veins, and the microscopic observations of Malpighi† and Leuwenhoeck‡ made on transparent parts of reptiles, fishes, and even bats, in which the blood is seen to pass directly from the arteries into the veins;—experiments and observations which have been a thousand times repeated since,—have repudiated, and deservedly, the alleged parenchyma interposed between the terminations of the arteries and veins, by disclosing, beyond the last divisions visible to the naked eye, microscopical divisions establishing a direct communication between them.

Subtile injections and microscopical observations soon led to the rejection of the parenchyma of the ancients, and the admission of every thing being vascular in the body;—an opinion which anatomists still hold.

377. The capillary blood-vessels are the last ramuscules of the arteries and the first radicles of the veins, or they are intermediate between the arteries and veins, and, as has been said in comparing them to the system of the vena portæ, foreign, or belonging indifferently to either. It is in these vessels that the arteries change into veins, which takes place insensibly and without determinate limits. This is known by the successive change of volume which the vessels undergo in one or other direction, by the direction in which the successive divisions or unions take place, and, at the extremity of the fins and tail of fishes, by the opposite direction of the course of the blood. However, the capillary vessels have pretty generally been described as the last divisions of the arteries, rather than as the first of the veins; whether this be really accordant with truth, and depend upon the circumstance that the minute veins, which are larger than the minute arteries, ac-

* *Apologia pro Circulat. Sanguin. in Op.* Leidæ, 1687.

† *De Pulmonibus Epist.* ii. *In Oper. Omn.*

‡ *Exp. et Contempl. Arcan. Natur. Detect. Epist. &c.* 65, 67, &c.

quire a pretty considerable volume after a small number of unions, or upon the circumstance that the veins, which are almost all provided with valves, and are more difficult to be injected than the arteries, have been less examined than they. These two reasons may have contributed to the adoption of the idea in question.

378. Be this as it may, the capillary vessels have not all the same volume. Three degrees may be established among them in this respect, by taking for the largest those which begin to be invisible to the naked eye, and for the smallest those which admit only a single coloured globule of the blood at once, and whose internal diameter does not consequently much exceed that of the globules; (72.)

The least attenuated capillary vessels undergo several successive divisions before acquiring the smallness of a coloured globule of the blood.

These minute vessels communicate together by very numerous anastomoses, so as to form true net-works.

They constitute by their aggregate the largest part of the circulatory circle, the capacity of the arterial system always increasing from its commencement at the heart to the capillary vessels, and that of the venous system decreasing from the capillary vessels to the heart.

The circulatory circle being double in man, there are in him two capillary systems: the one general, between the terminations of the aortic arteries and the origins of the veins of the body; the other pulmonary, at the termination of the pulmonary vessels. It has been advanced without proof, and against all probability, that the pulmonary capillary system has as great capacity, and contains as much blood as the general capillary system.

There are besides two other small capillary systems in the abdomen: one between the intestinal arteries and veins, the other between the hepatic extremity of the vena portæ and the commencement of the supra-hepatic veins.

379. The texture of the capillary vessels is incapable from their minuteness of being observed. These vessels have thin, soft, transparent walls, invisible to the naked eye, scarcely visible even to the microscope, differing little from the substance of the organs, and also differing little from the fluids which they contain. They appear rather to be scooped out in the substance of the organs than to be furnished with proper walls. It is very probable, however, that the internal membrane of the vessels, at least, is continued without interruption, from the arteries into the veins.

In the living body they are only distinguished by the colour and direction of the blood which passes through them, and in the dead body by the colour of the injection with which they are filled. Their constant, continued and regular course, distinguishes them from the spongy areolæ and accidental cavities of the cellular tissue.

380. Although the walls of all the vessels are permeable, yet this property is more especially remarkable in the smallest vessels.

They are possessed of great extensibility and contractility. The irritability goes on increasing, and the elasticity diminishing in the vessels in proportion as they approach their terminations, the capillary vessels being the most irritable.* Their contractility is put into play, whether by local and direct agents, or by the nervous system.

381. It is in this part of the vascular system that the most important phenomena of the organism, or at least of the vegetative functions, take place. The capillary circulation, that is to say, the passage of the blood through the capillary vessels, is of all the parts of the circulation that which, without being independent of the action of the heart, is yet less subjected to it. It is the point of the circle at which the motion of the blood is slowest; that at which the blood, divided into minute threads, has the most points of contact with the walls of the vessels, and is more submitted to the nervous action. The blood passes through the capillary system in regular order, passing directly from the arteries towards the veins. If it meet an obstacle, numerous anastomotic passages are open to it, and permit it to follow its course. But this system, as well as others, may be the seat of congestions, irritations, and constrictions, which change in it the ordinary course of the fluids. Thus, heat accompanied by moisture, applied for some minutes to the hind leg of a frog, determines a dilatation of the capillary vessels, a local retardation of the circulation, a congestion, in a word, which gives to the parts previously white, a very red colour. The same thing takes place, through various causes, in the mammifera, and in man. The application of cold, or of a diluted acid, produces effects of an opposite nature. Mechanical, or chemical irritation, produces at first the latter effect, and afterwards, by a kind of attraction, causes a concentric afflux of the fluids, which, in many vessels, then flow in an opposite direction to the natural course of the blood.

The blood becomes venous in the general capillary system, and arterial in the pulmonary.

382. The capillary blood-vessels, such as they have been above described, are not equally abundant, and have not the same volume in all parts. The sum of the vessels of each part may be estimated by the redness which it acquires in cases of congestion or inflammation, as well as when it is injected. This latter means is even preferable. The most perfect injections that have been made are those of Ruysch, Albinus, Lieberkuhn, Barth, Bleuland, Soemmering and Prochaska.

The injections of Ruysch, by filling the smallest vessels, gave

* Whytt. Physiological Essays, &c. Edinb. 1761. H. van den Bosh, *Uber das Muskelwermögender Haargefässchen.* Monast. 1786.

rise to the opinion that the whole solid substance of the body is vascular. Ruysch himself, however, discovered that in the body there were parts more, and others less vascular, and others again entirely destitute of vessels. Albinus, in examining injected parts, recent and dried successively, observed, that after the most successful injection, there always remains more or less substance not injected, according to the nature of the parts; he thus combated an erroneous opinion which had arisen especially from the examination of dried or macerated parts, in which all the portions that had not been injected had disappeared or were destroyed.

Microscopical examination, and various experiments, equally show in the living body, that there are parts more vascular than others. Thus, if the mesentery or swimming membranes of the feet of the living frog be examined with the microscope, it is seen that the smallest capillary vessels, those of one globule of the blood, are separated by considerable intervals, while in the mucous membrane of the lungs of the same animal, a puncture cannot be made with a needle of the smallest size without transfixing several. In like manner, there could not be found, at the free surface of the dermis of a man in the living state, a point in which a needle would not open several vessels, while in the ligamentous parts, the nervous substance, the cellular tissue, &c. divisions of a certain extent may be made without the escape of a single drop of blood.

If all the solid parts were vascular, and only vascular, there would be no differences between them; all the organs would be homogeneous, and there would be but a single organ; whereas, such a simplicity of organization occurs only in the animals that are destitute of vessels.

383. The sum of the capillary blood vessels, and their proportion to the solid and uninjectable substance, are not less interesting to be considered than their disposition in the different parts of the body.

The cellular tissue is not capable of being injected.

The epidermis, horny parts, hairs, and teeth, are not injectable at all.

The adipose lobules are surrounded with extremely delicate vascular net-works.

The cartilages undergo no change from injection.

The serous and synovial membranes are reddened a little by injection, but the adipose masses and fringes are surrounded by very beautiful vascular net-works.

The tegumentary membranes are the most vascular parts. The injection sometimes transudes beyond the dermis into the corpus mucosum. The capillary vessels of the skin, which are at first of the first and second magnitude, acquire the greatest degree of tenuity on penetrating into the papillæ. The fresh skin is much more coloured at its external surface. It appears equally coloured throughout, when the uninjectable parts which the vessels conceal-ed have disappeared in consequence of desiccation. The cutaneous and mucous follicles are furnished with very delicate vascular net-works. This is also the case with the microscopic alveoli of the mucous membrane of the stomach and intestine. The papillæ of the mucous membrane, like those of the skin, are furnished with a multitude of capillary vessels, which is also the case with the villosities, at least at their adherent extremity. The mucous membrane, in general, is still more injectable than the skin, that of the lungs in particular is so in the highest degree. The membrane of the pituitary sinuses is much less injectable than the rest. The conjunctiva reddens moderately, and less by injection than by inflammation. The mucous membrane of the excretory ducts, and the glands themselves, are furnished with numerous capillary vessels.

The ligamentous tissue receives few blood vessels. The dura mater receives somewhat more, the periosteum is reddened a little by injection.

The bones have but a small quantity of vessels.

The capillary vessels of the muscles are abundant; the smallest, which are tortuous, accompany and surround the muscular fibres, frequently anastomosing.

The nervous system is furnished with capillary vessels, which are more abundant in its envelopes and in the cineritious substance than in the medullary substance. The pia mater and the neurilema in general, which differ in this respect from the envelopes of many of the viscera, contain the vessels until the greater part of them have acquired a capillary tenuity. The cineritious matter of the encephalon and the nervous ganglia possess a great number of capillary vessels of all degrees. The white matter, on the contrary, whether of the brain or nerves, possesses only very small capillary vessels, and in a less proportion.

384. There is therefore in the different organs a greater or less proportion of a substance not vascular, or which at least cannot be shown to be so by injections.

M. Meyer * having introduced a colouring matter into the blood both by absorption and by injection, concluded from the different colouring of the parts of the body that there are two kinds of organs, one set composed for the greater part of capillary vessels, viz. the cellular tissue, the serous membrane, the tegumentary membranes, and the fibrous or ligamentous tissue; the other, more independent of blood-vessels, and formed of globules or of an organic pulp, viz. the glands, the bones, the muscles, and the medullary nervous substance.

This proportion also changes with age. At the commencement, at least in the ovipara, the blood shows itself and presents currents before there are solid parts. Presently after, the walls of the vessels form. The younger the animal is, and the nearer to the fœtal state, the greater is the proportion of vessels over the unin-

* Memoir on Venous Absorption, &c. in *Deutsches Archiv.* &c. and in the *Journal Complem.* vol. xi.

jectable parts. In proportion as it advances in age, on the contrary, the proportion of uninjectable parts augments, and that of the capillary vessels diminishes.

385. Beyond the capillary blood-vessels of the diameter of a coloured globule, are there other smaller vessels which afford passage to the colourless part of the blood? This is a question of very difficult solution.

Boerhaave, Vieussens, Ferrein, Haller, Soemmering, Bichat, Chaussier, and many modern anatomists and physiologists, admit serous vessels beyond the last blood-vessels, and Bleuland even thinks he has demonstrated their existence.

On the other hand, Prochaska, Mascagni, Richerand, and several others, are of opinion that there are no vessels of this kind. It is necessary to examine the facts and reasons adduced in support of these opinions.

386. Edmund King was one of the first who substituted for the hypothesis of the ancients respecting the existence of a parenchyma in the viscera, that of a purely vascular structure, which supposes that there are serous vessels, for the last capillary blood-vessels, are far from occupying or from forming the whole substance of the tissues.

Vieussens and Boerhaave especially have admitted not only one, but several orders of decreasing and colourless vessels. The disciples of Boerhaave, Haller, the most celebrated of them, and most of the physiologists up to the present day, have also admitted serous vessels, forming a continuation of the arteries beyond the point at which the veins commence. They found their opinion upon the microscopical observations of Leuwenhoek, who speaks of vessels admitting only serous globules, upon the phenomena of injection, and especially upon those of inflammation, which renders parts naturally white and transparent more or less red.

It is to be added to this, that red and injectable capillary vessels known in certain organs, are in so small proportion to the uninjectable substance, that it is difficult to conceive how their nutrition could take place without there existing circulating passages more extended and more multiplied than those of the known blood-vessels.

J. Bleuland * has added to these reasons an anatomical experiment, which, if it were repeated and confirmed, would furnish the most powerful argument in favour of the existence of serous vessels.

It is known that the red injection, which is fine and very penetrating, easily passes from the arteries into the veins through the intermediate capillary system. It is also known, that the colouring matter remains in the capillary vessels even while its vehicle transudes and is infiltrated in the surrounding substance, where,

* *Experimentum Anatomicum, quo Arteriolarum Lymphaticarum existentia probabiliter adstruitur, institutum, descriptum, et icone illustratum.* Lugd. Bat. 1784, 4to.

from the deficiency of colour, it is impossible to discern any form or any particular direction in the passages or reservoirs into which the injection has made its escape. Bleuland formed the idea of combining with the red colouring matter another white matter, which in place of being pulverulent and suspended in the vehicle, was dissolved in it. Having pushed his injections into the arteries of a part of the intestine of which the vessels were previously filled with a coarser matter and of another colour, and having afterwards separated the peritoneal coat from the intestine, he observed in the external surface of that membrane, by the aid of the microscope, besides the capillary blood-vessels which were all filled with red matter, another order of finer and white vessels, arising from the smallest arteries which had admitted the red injection, and entirely different from the vessels which are filled by ordinary injection.

But what are these white microscopic vascula, seen but once and on a portion of membrane detached from the neighbouring parts? Are they exhalent arterioles opening at the surface of the peritoneum? Are they serous arterioles continuous with serous radicles of veins, and constituting a serous capillary system? or, lastly, are they lymphatic arteries continuous with radicles of lymphatic vessels? It is almost impossible to solve these questions. Might they not rather be accidental passages?

Those who have since admitted the existence of serous vessels appear to have been ignorant of this, the most powerful fact in favour of their opinion. Those who have rejected them, have usually passed it over in silence.

387. The opinion of Mascagni, Prochaska, and others, respecting the non-existence of vessels finer than those which give passage to a single coloured globule of the blood, may be established, in the first place, upon the circumstance, that these vessels are well seen with the aid of the microscope in living animals, and by no means smaller vessels, although the microscopic instruments give so large a volume to the globules of the blood that it would be easy to distinguish much smaller objects; in the second place, upon the circumstance that the red injection, which is very penetrating, does not clearly disclose any other vessels than those which are seen in the living subject. If in this case the parts become more red, especially after desiccation, this may depend upon the dilatation of the vessels and the disappearance of the intermediate substance. If inflammation reddens the parts still more, it is by the dilatation of the existing vessels, the formation of new vessels, and the infiltration of blood between the vessels. As to the whiteness or natural want of colouring of certain very vascular parts, as the conjunctiva, it depends upon the circumstance that the capillary vessels being in these parts extremely fine, the colour of the blood cannot be perceived in them.

388. It therefore remains very difficult or impossible to solve the question as to the existence of colourless or serous capillary vessels; and, when that term is employed in the present work, it

is to designate capillary vessels which, whether they contain only the serum of the blood, or the blood in its entire state, but in series of single globules, which prevents its colour from being perceived, are colourless in the ordinary state. However, it is more consistent with reason not to admit the existence of vessels which no one has ever seen.

389. In the double circle which the circulatory passages form, the evident communication of the arterial and venous trunks takes place in the heart, and that of the lymphatic trunks with the venous trunks near that organ, in the subclavian veins. But in the diametrically opposite parts of this double circle, in the capillary systems, the communication is not so evident. The ancients supposed the arteries to communicate with the veins, but did not believe the communication to be direct. The discovery of the circulation of the blood, while it made this communication to be necessarily admitted, still left its mode undecided. We have already seen that microscopical observations and injections agree in demonstrating this communication, and even showing that it is direct. *

Microscopical inspection has demonstrated it in the transparent parts of cold-blooded oviparous animals, in the incubated egg of birds, and even in the transparent parts of mammiferous animals.

Injection has demonstrated it in almost every part of the body of man and animals, † whether by pushing the matter through the arteries, or by pushing it through the veins into the parts, as the intestine, in which the veins are destitute of valves.

Some anatomists had even admitted arterio-venous communications between the vessels visible to the naked eye and of a certain calibre. Thus Casserius represents them as taking place in the liver, Riolan describes them as occurring after a cured aneurism, Lealis remarks such communications between the spermatic arteries and veins. These are errors, that is to say, ill-observed facts, which have been contradicted by Albinus and Haller.

The communications between the arteries and veins are all capillary and microscopical; but it appears, that, in cold-blooded animals at least, there are some which give passage to several coloured globules at once, and others to a single globule only.

The disposition of these passages of communication has been observed in animals. They consist sometimes simply of a change of direction or a doubling of a minute artery which becomes a venous radicle. Sometimes a capillary artery and a vein of the same kind running in a parallel direction also send off communicating ramuscules, in which the artery changes into a vein. Sometimes, again, and this is pretty frequent, several capillary arteries terminate in or are continued into a single capillary vein. In all cases the communi-

* Malpighi, *loc. cit.*—Leuwenhoeck, *loc. cit.*—Spallanzani, Exper. on the Circulation, p. 255.

† See among others, Ruysch, *Thes. Anat.*—Winslow, *Mem. de l'Acad. des, Sc.*, &c.—Haller, *De Fabricâ Corp. Hum.* vol. i.—Mascagni, *Vas. Lymph.*, &c.; *Prodromo*, &c. —Prochaska, *loc. cit.*—Reissessen, *De Structura Pulmon.*

cation takes place by vessels of the capacity of from one to four or five coloured globules.

390. Modern physiologists have recently raised doubts respecting the direct communication of the arteries with the veins. M. Doellinger thinks that the arteries, at their extremity, cease to have walls, and that the blood flows exposed in the solid substance of the body which he calls mucous; that there one part of the blood is converted into mucous substance, and that another part continues its course, joined to the sanguified mucous substance which enters into motion, and penetrates into the venous and lymphatic vessels arising from the mucous substance as the arteries terminate in it.

M. Wilbrand goes still farther, and admits a still more complete metamorphosis in the circulation. According to him, the whole of the blood changes into organs, or into mucous substance and into secreted fluids, and the organs becoming fluid in proportion, become venous fluid and lymph again, which continue the circulation, and also become the matter of excretions.

In the former of these two opinions, a part, and in the latter the whole of the blood becomes solid, and in like manner a part or the whole of the organs is rendered fluid at each round of the circulation. In the one as in the other, the solid mass of the body is interposed between the terminations of the arteries and the beginnings of the veins and lymphatics. They both suppose that the microscopical inspection of living animals and injection are faithless means of determining the communication of the arteries and veins.

391. The direct continuity of the arteries and lymphatic vessels is not so well demonstrated as that of the veins and arteries. Many anatomists, however, have admitted, with Bartholin, the continuity of lymphatic vessels with capillary arteries finer than those which allow the coloured globules of the blood to pass through them. Haller, and most of the anatomists who have lived since his time, admit no other origins to the lymphatic vessels than the tegumentary membranes. Some authors, among whom is to be included Mascagni, admitting that lymphatic vessels also arise from the walls of blood-vessels, thus admit a communication indirectly, although they reject the direct communication.

The inspection of living animals discloses nothing to us respecting this communication. Injections sometimes pass, and even frequently, but commonly colourless, from the arteries into the lymphatic vessels; which may depend upon transudation into the cellular substance and consequent passage into the lymphatics which arise from them, or upon the passage of the minute arteries into the lymphatic vessels of their walls admitted by Mascagni, just as much as upon a direct and immediate communication, which therefore remains very doubtful.

392. The serous capillary vessels which have been admitted beyond the capillary blood-vessels, much more from physiological considerations, than from anatomical observation, do not constitute

the only hypothesis on the subject. "Absorption and secretion being certain and evident facts, as the father of medicine himself has said,* it has been sought to find by what passages substances issue from the vascular system, and by what passages they enter it." Without having been seen, they have been described, the former under the name of exhalent or secretory vessels, the latter under that of absorbent or inhalent vessels.

The exhalent vessels have been admitted by Haller, Hewson, Soemmering, Bichat, Chaussier, &c., as very simple vessels, appearing to be very minute and short productions of the capillary arteries, distributed in the tegumentary membranes, the serous membranes, and the cellular tissue.

Other anatomists, as Mascagni, Prochaska, and Richerand, admit, on the contrary, the opinion that it is by lateral pores organically disposed, that secretion or exhalation takes place.

Hunter had even admitted that it was by porosities or inorganic interstices that secretion took place, just in the same manner as transudation in the dead body. Hewson and Bichat have combated this opinion.

However, the real passages of exhalation or secretion are entirely unknown. All that is known on the subject is merely this, that in the living body fluids issue under the form of vapour from all points of the capillary system, and that several manifest themselves in a liquid form or even more or less solid; while in the dead body fine injections, in passing from the arteries into the veins, exude at the surface of the skin and mucous membrane, in the mucous and cutaneous follicles, in the excretory ducts of the glands, at the free surface of the serous membranes, and in the mucous, areolar or cellular substance, which constitutes the solid mass of the body; but never, and nowhere, are there seen ramuscules detaching themselves from capillary net-works, and terminating by an open extremity. The passages of exhalation or secretion are therefore unknown. It is very probable that it is through the solid and porous substance of the body that it takes place. However, secretion is an organic or vital phenomenon entirely different from transudation in the dead body, as is demonstrated by the difference which the various secreted humours present, and the differences of quantity of these humours. The names of exhalent or secreting vessels can therefore only designate the unknown passages by which there issue from the circulation the molecules which form the matter of the intrinsic secretions, and of the excretory secretions.

393. Nearly the same may be said of the passages of absorption. The absorbent vessels, according to the idea which is formed of them, would be radicles open at one extremity, like puncta lachrymalia, and continuous at the other with the venous and lymphatic net-works, or with the lymphatic vessels alone, or with the veins

* Δῆλον, ἡ αἴσθησις, ὡς ἐκπνοον, και ἐσπνοον ὅλον τὸ σῶμα. *Epidem.* Lib. vi. sec. 6.

alone, of which they would thus be the origin. Now, these canals have never been seen, at least their open mouths have never been so. The following are the opinions and facts known with reference to this point of minute anatomy. Aselli has said, in speaking of the lacteal or chyliferous vessels: *ad intestina instar hirudinum orificia horum vasorum hiant spongiosis capitulis.* Helvetius asserts that the intestinal villosities have spongy orifices. Lieberkühn speaks of a spongy or cellular ampulla. Hewson rejects this ampulla. Cruickshank describes and figures twenty or thirty openings, each larger than a globule of the blood, at the summit of each villosity. Sheldon makes the villosities terminate by a spongy tissue, and appears to confound follicles with them. Mascagni could not see orifices at the summit of the villosities. Feller and Werner describe an ampulla, and trace vessels into it. Bleuland admits openings at the summit of the villosities. Soemmering says that from six to ten absorbent orifices may be seen in each of them. Hedwig considers the ampullæ as spongy, and represents at their summit one or more orifices, or none. Rudolphi has never seen orifices, and those who have admitted them, appear to him to have been misled by optical illusions. This is enough to make it be concluded that the orifices which have been described do not distinctly exist. It must be added, however, that when a very penetrating injection is made into the intestinal veins, the matter, in passing into the arteries, also transudes at the free surface of the mucous membrane. It is known, with reference to the skin, that when a lymphatic vessel of that membrane has been injected, if the mercury be pushed back towards the roots of the vessel, it at length, as Haas has observed, issues from the free surfaces. Mascagni has made this experiment, and any person may easily repeat it, upon the subperitoneal lymphatic vessels of the liver. Lastly, Carlisle asserts his having seen orifices of lymphatic vessels in a cellule of the cellular tissue.

However doubtful and contradictory may be the facts, the following is the opinion generally admitted, namely that, at the surface of the tegumentary and serous membranes, in the areolæ of the cellular tissue, and, according to Mascagni, at the very surface of the vessels, there are orifices of absorbent radicles leading, according to the greater number of more modern anatomists, into the lymphatic vessels only, but according to the anatomists before Haller and some of those since his time, into the veins only; and according to others, into the capillary blood-vessels and lymphatics at once. Prochaska adds to this, among the passages of absorption, the organic porosities of the vessels, which would thus be, at the same time, the passages of exhalation and passages of inhalation. Absorption has also been considered as a purely physical phenomenon, similar to capillary attraction or imbibition, the absorption which takes place in the dead body being adduced in support of this opinion.

The truth is that the passages of inhalation are unknown. They appear to be, like those of exhalation, the porosities of the solid and permeable substance of the body. However, absorption, just like secretion, is an organic and vital phenomenon altogether different from imbibition in the dead body, as is demonstrated by the selection of the substances absorbed, and the modifications which the activity of absorption in various cases presents. When, in this work, the expression absorbent vessels is employed, it is to designate by a single word the unknown passages by which foreign substances enter, and those by which the matters of the intrinsic absorptions pass into the circulatory apparatus.

394. Imagination has not stopped at the creation of exhalent and inhalent vessels, of which we have been speaking; there have also been imagined nutritious vessels.

The following are the principal opinions which have been formed on this subject. Boerhaave and R. Vieussens having admitted colourless and decreasing vessels, the former constructed of vessels, all the parts of the body, even those which cannot be injected. According to Boerhaave's system, the smallest elementary fibres would form minute membranes, rolled upon themselves, to form the smallest nervous vessels. From these smaller vessels would result the vascular membranes forming larger vessels, and so on to the largest vessels. He also determined that the smallest nervous vessels contain an aqueous fluid serving for feeling, motion, and at the same time nutrition.

Mascagni's opinion as to the elementary composition and the nutrition of parts does not differ much from that of Boerhaave. According to Mascagni, the divisions of the arteries finish at the point where, on having arrived at the tenuity of a red globule of the blood, they change into veins. There they are furnished with exhalent porosities, as well for the secretions as for nutrition. In all parts there are orifices of absorbent vessels for taking up and containing the nutritious molecules. The elementary parts consist of absorbent vessels. These, by their union, constitute the most simple and smallest blood-vessels, which form more compound membranes.

In these two hypotheses, every thing is vascular, and nutrition takes place in the vessels; in the first, in the finest ramifications of the capillary arteries, in the second, in the finest radicles of the absorbent vessels. In both, the mass of the body is in the vessels, and in a real state of continual circulation.

Bichat's opinion respecting the nutritious vessels and nutrition is somewhat different. According to him, each molecule of the organs is in a manner placed between two open-mouthed vessels, the one nutritive exhalent which had deposited it, the other nutritive absorbent destined to take it up again.

Prochaska, while he admits the direct continuity of the arteries and veins, supposes that it is by the porosity of the walls of the vessels and the general permeability of the substances which forms the mass of the body, that nutrition takes place.

395. Nutrition, whatever may be its immediate passages, presents a continual two-fold motion of composition and decomposition. The most simple animals directly inhale and exhale the materials of this twofold phenomenon. Other animals, of a more complex organization, have a tegument more or less prolonged into the mass of the body, conducting there and taking up again the matters which are added to it, and those which separate from it. Others, still more complex, have other organs, vessels, which transport the matters of absorption and secretion from the surfaces into all parts of the mass, and from thence to the surfaces. In certain animals provided with vessels, among which is man, their number is so great, that they seem to occupy and form the whole mass of the body. But, besides the above considerations, which are derived from analogy, the arguments derived from inspection also show that the vessels only traverse the mass of the body, and do not constitute it. Inspection also shows that, whatever may be the tenuity or softness of the last capillary vessels, the arteries and veins form continuous canals.

Observation apprises us that new substances enter into the vessels, and that others also unceasingly issue from them. But this two-fold passage takes place in the finest parts of the vessels, and by paths invisible even with the best optical instruments. The substances themselves pass through these passages in a state of division, being in the form of vapour, which eludes the senses, and is imperceptible with the best microscopes. This passage, whether it take place from without inwards or from within outwards, in absorptions and extrinsic secretions, or in the closed cavities of the body, always appears to be performed through the intervention of the solid and permeable substance of the body; that is to say, of the substance called cellular, which by imbibing transmits inwards or outwards the inhaled or exhaled molecules.

It appears to be the same with nutrition. The vessels deposit and take up under the form of vapour, and by invisible passages, in the cellular substance, the molecules of the composition and decomposition of the organs.

But all these phenomena, which are apparently physical, are modified by the organized and living body in which they take place. It is especially to the unknown cause of these phenomena that the name of vital power has been given, or more particularly that of power of formation.

II. OF THE ERECTILE TISSUE.

396. The erectile, cavernous or spongy tissue, consists of terminations of blood-vessels, and especially roots of veins, which, in place of being capillary, have more width, are very extensile, and are connected with numerous nervous filaments.

397. This tissue was first observed in the penis, where it exists

of large dimensions. Vesalius * speaks of it in these terms: *Corpora hæc (cavernosa) enata ad eum fere modum, ac si ex innumeris arteriarum venarumque fasciculis quam tenuissimis, simulque proxime implicatis, retia quædam efformarentur, orbiculatim a nervea illa membraneaque substantia comprehensa.* Malpighi† appears to have made the same observation: *Sinuum speciem in mammarum tubulis et in pene habemus; in his nonnihil sanguinis reperitur, ita ut videantur venarum diverticula, vel saltem ipsarum appendices.* Hunter ‡ has seen the same thing with reference to the spongy tissue of the urethra; and observes that the spongy body of the urethra and glans penis are not spongy or cellular, but consist of a plexus of veins. This structure, he adds, is visible in the human subject, but much more distinctly in some animals, as the horse, &c.

Most of the anatomists, however, who have examined the structure of the penis, and among others, Degraaf, Ruysch, Duverney, Boerhaave, Haller and his disciples, having mistaken the nature of the cavernous and spongy tissues of the penis, and having considered them as being loose and elastic cellular tissue, forming cellules, and interposed between the arteries and veins, the greater number of modern anatomists have adopted this error. Duverney, Mascagni, the Cuviers, Tiedemann, Ribes, Moreschi, Panizza, Farnese, &c. have made accurate observations on the erectile tissue of the penis and clitoris of the elephant, the horse, man, &c.

398 Although the erectile disposition of the vessels exists in many places, yet there is a certain number in which it is much more evident. Of this number are the corpus cavernosum of the penis and clitoris, the spongy body of the urethra, the nymphæ, the nipple, the papillæ of the tegumentary membranes, &c.

399. The erectile tissue is of very large dimensions in the organs of copulation. Although it does not present the same developement in the papillæ, it may yet be very distinctly observed in them.

The papillæ, those of the tongue in particular, consist of enlarged soft nervous filaments, destitute of neurilema, intermingled with an innumerable multitude of capillary blood-vessels, tortuous, curved in the form of arches, and anastomosing with each other, the whole enveloped and kept together by a soft and mucous cellular tissue. In the state of rest, these papillæ are small, soft, pale, and indistinct. In the state of erection, on the contrary, they are enlarged, raised up, of a red colour, inflated by blood, and possessed of great sensibility.

The nipple, or the papilla of the mamma, appears to differ from the others only in being of larger dimensions. The skin and mucous membrane present the papillar and erectile dispositions, in va-

* *De Corp. Hum. Fabricâ.* Lib. v. cap. 14.

† *Diss. Epist. Varii Argum. in Op. Omn.* vol. ii.

‡ Observations on certain parts of the Animal Economy. 4to. London, 1786, p. 38.

rious degrees, in their whole extent. The volume of the nerves and the quantity of the blood-vessels are everywhere proportionate to the degree of sensibility. The skin of the pulp of the fingers, which is very vascular and nervous, experiences a degree of swelling and of manifest redness during touch, proportionate to its perfection.

400. The erectile tissue of the organs of copulation differs from that of the papillæ only in having its dimensions much larger. That of the corpus cavernosum of the penis presents the following disposition. It is enveloped by a sheath of elastic fibrous tissue, which sends prolongations into its interior. The two dorsal arteries of the penis are accompanied by an azygous vein forming a plexus, and by nerves of great size. The arteries send into the interior numerous ramuscules accompanied by nerves, and the veins receive numerous radicles through the sheath. The interior is composed of arterial ramifications coming from the dorsal arteries and central arteries, and of very numerous large veins, intermingled in all directions and anastomosing a multitude of times with each other. These branches of veins present dilatations and wide communications. When one of the arteries of the penis is injected, the injection, if very penetrating, after filling the arterial ramifications and the internal venous plexus, which constitutes the corpus cavernosum, and thus producing erection, returns by the dorsal veins. The corpus cavernosum is still more easily filled by injecting by the vein. Thus the pretended cellules of the corpus cavernosum are only very large roots of veins forming a complicated plexus, and anastomosing like capillary vessels.

The erectile tissue of the urethra and glans have the same disposition; which is also the case with that of the clitoris and nymphæ.

Erection is produced in the organs of copulation, as in the papillæ, by the repletion of the erectile vessels. This repletion may depend upon the afflux of arterial blood, which is accompanied by increased sensibility, and the retention of the venous blood, or by the union of both causes.

401. There is still a part whose texture and phenomena greatly resemble those of the erectile organs. This part is the spleen, which, for this reason, appears to be a diverticulum of the blood. If the spleen be exposed in a living animal, and the course of the blood in the splenic vein be arrested by pressure, this organ swells and greatly increases in size. It quickly returns upon itself when the circulation is re-established. The accessions of intermittent fever are accompanied, in the cold period, by a manifest swelling of this organ, which is more or less completely dissipated at the end of the accession. It would appear that the same thing takes place during digestion.

402. The erectile tissue is sometimes accidentally developed in the organism. This production has been described under the

names of varicose tumour, aneurism by anastomosis, aneurism of the smaller arteries, telangiectasis, &c.

Its anatomical characters are precisely the same as those of the natural erectile tissue. It is a more or less voluminous, more or less circumscribed mass, sometimes surrounded by a thin fibrous envelope, presenting at the interior an appearance of cellular or spongy cavities; consisting in reality of an inextricable lacework of arteries and veins, which communicate together by innumerable anastomoses, like the capillary vessels, but much wider, especially the veins, easily injectable by the neighbouring veins, which are sometimes varicose, but difficultly by the arteries.

This alteration most commonly exists in the substance of the skin, and over a greater or less extent. It then sometimes resembles the crest and other similar parts of the gallinaceous birds. The skin of the face, that of the lips especially, is frequently the seat of it. It is observed in the subcutaneous cellular tissue, or more or less deep. It has been seen occupying a whole limb. It is even said to have been observed in certain viscera.

This production is the seat of a vibration, a rustling, and a pulsation, more or less manifest, and which are increased by all the causes which excite the activity of the general circulation; but the tumours which it forms, even in the skin, are by no means susceptible of a kind of isolated erection. It most commonly derives its origin from birth, and at other times appears to depend upon an accidental cause. It sometimes continues without change; at other times, which is the most common case, it continually increases in size from the dilatation of its internal cavities, and at length bursts, giving rise to hæmorrhages, which are difficult to be repressed.

Around the anus there occur hemorrhoidal tumours, resembling the spleen in appearance, which constitute a variety of this accidental erectile tissue.

III. OF THE VASCULAR GANGLIA.

403. The Vascular Ganglia, adenoid or glandiform organs, or aporic glands, * confounded under the common name of glands with organs of excretory secretion, are also parts in which the termination and communications of the vessels affect particular dispositions. M. Heusinger has given them the name of parenchymatous tissue.

Their texture results from the union of several other tissues. They are formed of modified cellular tissue, of blood-vessels and

* Queitschius, *De Glandulis cæcis*, &c. *in Select. Med. Francof.*—Hendy. Essay on Glandular Secretion.—Hewson. *Descriptio Glandul.* &c. *Opus Posthum. in Op. Omn.*—H. F. F. Leonhardi, *De Glandulis in genere et Glandulis Aporicis*, &c. Dres-

lymphatics, and of nerves; the whole inclosed in an envelope, which sends prolongations into the interior. They are all situated in the course of the lymphatic and venous circulation, and appear destined to make the absorbed substances undergo an elaboration, and to prepare the assimilation. They thus seem to be in a kind of antagonism to the true glands or the organs of excretion. The vascular ganglia differ from each other in the quantity and the species of tissue of which their mass is formed, in the proportion of vessels and nerves, and in the mode of communication of the vessels.

404. The adenoid ganglia may be distinguished into two kinds; 1st, The lymphatic glands or ganglia, and 2dly, the ganglia of the blood-vessels, which are the thyroid gland, the thymus, the supra-renal capsules, and the spleen.

The former of these will be described along with the lymphatic vessels (Sect. IV.) The others, which form a less natural group, belong chiefly to particular anatomy. They have, however, some general characters. The ganglia of the blood-vessels* are larger and much less numerous than the lymphatic ganglia. They are of a brownish-red colour, globular and granular. They present at the interior distinct cavities, filled with a fluid, but little ramified, and closed on all sides. Excretory ducts have been imagined at different periods to have been discovered for them, but these alleged discoveries have not been confirmed. These ganglia are so intimately connected with the blood-vessels and lymphatics, and especially with the thoracic duct, that they have, with much probability, been supposed to have a very great influence upon the perfecting of the lymph and chyle, and upon the formation of the blood.

SECTION SECOND.

OF THE ARTERIES.

405. The Arteries,† *Arteriæ*, are the vessels which carry the blood from the heart to all the parts of the body.

406. Hippocrates and his contemporaries gave the name of veins to all the vessels and all the canals, excepting the trachea, which they named artery. Aristotle is the first who speaks of the aorta, which he calls the small vein. Praxagoras gives the name of ar-

* Boeckler, *De functionibus Glandulæ thyroideæ, thymi, atque glandul. supraren, &c. Argentor*, 1753.—Hecker. *Uber die verrichtung der Kleinsten schlagadern und einger aus einem gewebe der feinsten gefasse bestehenden eingeweide, der schild-und brust-drüse, der milzes, der nebennieren und nachgeburt.* Erfurt. 1790.

† Bassuel. *Nouvel aspect de l'interieur des artères, et de leur structure par rapport au cours du sang. Memoires present. de Math. et de Phys.* T. i. ann. 1750.—D. Belmas, *Structure des Artères, leurs proprietes, leurs fonctions, et leurs alterations organiques,* in 4to. Strasbourg, 1822.—Ch. H. Ehrmann.—Same title, place, and date.

tery to the aorta and its branches, which he imagines to contain a vapour. The Alexandrian school distinguishes the arteries from the veins by the thickness of the walls, and admits that the blood may, in certain circumstances, pass into the arteries. Galen, the greatest anatomist of antiquity, tries to prove that the arteries are full of blood in the natural state. He considers the venous system and the arterial system each as a tree, whose roots, inserted in the lungs, and whose branches, distributed through the whole body, meet in the heart. We must come up to Vesalius before we find the first rudiments of the art of injecting the vessels, and the first ideas respecting the texture of the blood-vessels. Their functions and alterations were not known till afterwards.

407. There are two arterial trunks: the aorta and pulmonary artery. Each of them has a branched disposition, and presents an origin, a trunk, branches, twigs, and ramuli becoming smaller and smaller until they terminate.

Each of the arterial trunks arises from a ventricle of the heart, and there presents, not a continuation of the substance of the heart, as has lately been alleged,* but an intimate and very remarkable connexion. The middle membrane of the artery is divided into three festoons, edged with ligamentous tissue, the orifice of the ventricle is furnished with a ring of the same tissue, the summit of the festoons of the artery is firmly attached to the orifice of the ventricle, and the triangular intervals of the serratures are equally occupied by ligamentous membranes. The inner membrane of the vessel is continuous with that of the heart, and the outer membrane unites with the substance of that organ.

The trunks, the branches, and all the divisions of the arteries are sensibly cylindrical. There are some exceptions, however: certain arteries become wider, and others seem to contract. The arterial cylinders diminish from the trunk to the last ramifications.

In general, the sum of the branches is greater than the trunk which furnishes them, but there are exceptions. Thus, it is not evident that the carotid artery and the brachial trunk have together a greater capacity than the arteria innominata, and, in like manner, it is not certain that the radial and cubital arteries together are more capacious than the humeral artery. In this comparison the external diameter must not be confounded with the capacity. Besides, there happen every instant changes of capacity in arterial twigs, without the branches becoming perceptibly changed, and, to mention only a single obvious example, the uterine arteries greatly enlarge during gestation, the hypogastric artery enlarges a little, and the iliac artery undergoes no perceptible increase.

The variable number of the successive divisions of the arteries, their mode of division, and the angles which the branches form with the trunks have been already indicated, (354, *et seq.*) as well

* Langenbeck. *Nosol. und therap der Chir. Krankheiten.* Goetting. 1822. vol. i.

as the anastomoses and the lateral passages which they present to the circulation. It is the same with the flexuosities.

The termination of the arteries, after they have become capillary and microscopic, takes place by their being continued into veins, whether by red capillary communications, or by communications which are colourless by reason of their minuteness.

408. Viewed in their interior, the arteries are cylindrical; their section is circular, excepting in the very large arteries, which, when empty, become a little flattened, and present an elliptical section.

Each of the two arterial trunks is furnished with three valvules at its commencement at the heart. These semilunar valvules are attached by their convex edge to the contour of the festoons of the artery. Their free edge is straight and somewhat thick, especially at the middle, which presents a small bulging. One face is directed toward the wall of the artery, and the other towards the axis of the vessel. These valvules are formed by the inner membrane of the arteries, doubled upon itself, and containing in its substance a thin layer of ligamentous or fibrous tissue. Their free edge contains a small cord of this tissue, and its middle a fibro-cartilaginous point. When these valves fall, the face which corresponds to the ventricle becomes convex, and the other which corresponds to the canal becomes concave; their free edges meet, touch each other, and they exactly close the vessel. In all the rest of their extent the arteries are destitute of valves.

The inner surface is smooth, polished, and moistened. The outer surface corresponds to the common and particular cellular tissue in which the arteries are ramified. The cellular tissue, moulded around them or separated by their presence, forms a cellular sheath for them. This sheath is confounded externally with the rest of the cellular tissue or with the substance of the organs. Internally it is attached to the artery in so loose a manner as to permit the latter to slide easily in its interior during the different motions, and to retire within it by contracting in the longitudinal direction when it is divided. This sheath is pretty firm around the arteries of the membranes. In the thorax and abdomen the sheath of the arteries is in part formed by the serous membranes. That of the spermatic arteries is remarkable for its looseness, and that of the arteries of the brain is not distinct. This part of the anatomy of the arteries deserves great consideration in pathology and in operations.

409. The texture of the arteries * results from several superimposed membranous layers. There has been much diversity of

* Ludwig. *De Arteriarum tunicis*, *Lips.* 1739. Albinus, *Acad. Annot.* Lib. iv. cap. viii. *de Arteriæ Membranis et Vasis.* A. Monro, Remarks on the Coats of the Arteries, their Diseases, &c. in Works. Delasone, *Sur la Structure des Artères*, *Mem. de l'Acad. des Sc.* 1756. C. Mondini, *De Arteriarum tunicis*, *in Opusc. Scientif.* t. i. Bologna, 1817. A. Béclard, *Sur les Blessures des Artères*, *Mem. de la Soc. Med. d'Emulation*, t. viii. Paris, 1817.

opinion as to their number, it being carrried to five by some anatomists and reduced to one by others. It may be fixed at three, an outer, a middle, and an inner.

410. The outer membrane, called also cellular, nervous, fibrous, &c. is thin and of a whitish colour, and formed of oblique fibres, interlaced diagonally with reference to the length of the vessel. Externally this tissue is rather loose, and is attached to the sheath. Internally, on the contrary, the fibres are so close that they can only be perceived on tearing them asunder. In the arterial trunks this twofold disposition is so distinct that the outer layer really appears double. In the middle-sized and small arteries, on the contrary, this layer becomes uniformly compacted and distinct from the cellular tissue of the sheath, and then bears a great resemblance to the ligamentous tissue.

This membrane is possessed of great strength and elasticity, both in its longitudinal direction and circularly. Being pliant and tough at the same time, it is not divided by the action of ligatures, even although directly applied to it. When it is torn asunder, much difficulty is experienced, and the texture of its oblique fibres is perceived, which render its tenacity equal in all directions.

411. The middle membrane, named also the muscular, tendinous, proper membrane, &c. is thick and of a yellowish colour, and is formed of nearly circular or annular fibres. This membrane, the thickest of the three, is very apparent in the trunks. It increases proportionally in thickness, as the arteries diminish in volume. Its thickness is inconsiderable in the arteries of certain viscera, and especially in the arteries of the brain. It can be divided into several layers by dissection. It is probably this circumstance that has led those into error who have admitted more than three arterial membranes. The external fibres are less close, the deeper more so, and thus progressively. These fibres do not all form the circuit of the vessel. The longitudinal and spiral fibres which have been admitted in the middle membrane do not exist there. In the places where the arteries divide, the circular fibres of the trunk separate and form on each side a half ring, and the annular fibres of the branch follow that. The middle membrane is intimately attached to the outer.

The middle membrane has so great a degree of firmness, that when separated from the others it retains its cylindrical form. It is to it that the arteries owe their faculty of remaining open when they are empty. When isolated, it is found to possess a feeble power of resistance and elasticity, in the longitudinal direction of the arteries, but is very tenacious and elastic in the direction of its fibres, or, in other words, in that of the circumference of the vessel. The firmness and elasticity of the fibres, which form it, successively diminish from the large towards the small arteries. It has been by turns compared and likened to the muscular fibre in general, the muscular fibre of the uterus, and the fibrous or ligamentous tissue. It constitutes a species of elastic tissue, a tissue of a peculiar nature, but participating of the characters of the muscular and ligamentous fibres.

412. The inner membrane of the arteries, which is also called the nervous, arachnoid, common, &c. is the thinnest of the three. It is continued from the ventricles of the heart into the arteries. It is of it that the greater part of the similunar valves of the arteries are formed. In the large branches, when empty, it presents some longitudinal folds, and small transverse rugæ in the arteries of the ham and elbow-joint. It is equally wrinkled in the retracted arteries after amputation. Its inner surface is smooth, polished, moist, and in contact with the blood. Its outer surface adheres to the middle membrane. In the arterial trunk, it can be divided into several layers. The innermost is extremely thin, and transparent; the others are opaque white. It is to this latter part especially, that the name of nervous membrane has been given. In the branches it forms but a single indivisible lamina. No appearance of fibres is distinguished in this membrane, which is very dense. It tears nearly with the same facility in all directions. It has little elasticity. It has been compared to the serous membranes and the mucous or cellular tissue. It is not vascular, like the serous membranes in general; and it is to the arachnoid membrane that it bears the greatest resemblance.

413. There also enter into the composition of the arteries, cellular tissue, vessels and nerves.

The cellular tissue which penetrates to the outer membrane, and which unites it to the middle, is sufficiently apparent, but beyond this, it is so rare and compact, that its existence has been doubted. However, when by dissection the outer membrane, and the greater part of the thickness of the middle are removed from an artery, there rise from the uncovered part fleshy granulations, as from the the rest of the wound.

414. The arteries and veins of the arteries *(vasa arteriarum)* are furnished by the neighbouring vessels, and become very apparent in the outer membrane by injections, and even sometimes without them, especially in young subjects. They have been traced to their entrance into the middle membrane, but no farther.

What are called exhalent or absorbent vessels, more correctly the unknown passages of exhalation and inhalation, are demonstrated in the walls of the arteries by the same fact, for in inflammation of the arteries an exhalation takes place at their inner surface; and, in cases of ligature, the internal coagulum is absorbed.

415. The nerves * of the arteries come from the spinal marrow and the ganglia. The arteries of the organs of the vegetative functions receive them from the ganglia, the others from the spinal marrow. The nerves of the arteries form around them net-works

* A. Wrisberg, *loc. cit.*—Lucæ, *Quædam Observ. Anat. circa Nervos arterias adeuntes et comitantes.* 4to, *cum fig.* Francof. ad Moenum, 1810.

similar to those which the pneumogastric nerves form around the œsophagus, and thus accompany them into the interior of the organs. But, besides, some filaments terminate in the outer coat, and others arrive at the middle membrane, on which they spread out into a very delicate net-work. The former are soft and flat, the latter, which are filiform and of extreme minuteness, have more consistence, and pass through a shorter course. All the arteries do not receive an equal number of nerves. The pulmonary arteries receive fewer than the aorta and its divisions. They are the more abundant the smaller the arteries are. The arteries of the brain are furnished with nerves only to the place at which they penetrate into the cerebral substance. In old age, the nerves of the arteries, especially those of the middle membrane, become less apparent. The great number of nerves which the arteries receive shows a close connexion between the nervous system and the circulatory apparatus, between the nerves and the blood.

416. The most remarkable physical properties of the arteries are the firmness of their tissue, its tenacity and its elasticity. It is to the firmness of the middle membrane that they especially owe the faculty of preserving a great part of their circular form, although empty of blood. Their specific gravity is about 108. Their thickness, which is in general considerable, is a little further increased when they are empty. It is also somewhat greater on the convex side of the curvatures than on the opposite side, nearly in the proportion of 8 to 7. It increases proportionally to the caliber of the arteries, as the latter diminishes. It is not the same however, in all the arteries of the same diameter. Thus the walls of the arteries of the brain are very thin, and those of the membranes are thick.

417. The resistance of the arteries to rupture has been examined by Clifton Wintringham. I have also made some experiments on this subject. These vessels have a great power of resistance, which is, in general, proportional to their thickness. That of the aorta is superior to that of the pulmonary artery. In proportion as the arteries diminish in size, their absolute resistance diminishes, but their relative thickness and their softness augmenting, their extensibility and their relative resistance increase. The resistance is not however the same in all the arteries of the same volume: that of the iliac artery is greater than that of the carotid. The resistance in the longitudinal direction is almost entirely dependent upon the outer membrane. The circular resistance, which is much stronger, is owing to the middle and outer membranes. The inner membrane has very little power of resistance in either direction.

418. The elasticity of the arteries is their most important physical property. If they be distended in the longitudinal direction, they yield and elongate, to return suddenly upon themselves when the distention ceases. If they be distended transversely, they yield less and return with still more force. If by injection or in-

sufflation they are filled to excess, they enlarge a little, elongate, and at the moment when the effort ceases, return upon themselves and expel part of their contents. If they be bent, they become straight again. If they be flattened by pressure, they resume their cylindrical form. In the state of life, they are in a state of elastic tension, which, when they are divided, causes the ends to retract. The elasticity of the arteries is very distinct in the largest, and diminishes successively in the small.

419. The arteries are also susceptible of a slow extensibility and retractibility. When a principal artery ceases to give passage to the blood, the collateral arteries, in replacing it in its functions, enlarge and acquire in little time a considerable volume. This enlargement is of the same kind as ordinary growth, but is much more rapid. The artery, on the contrary, which ceases to afford passage to the blood, gradually returns upon itself, and ultimately disappears more or less completely.

420. The vital properties of the arteries, like those of the other parts, are relative to their proper nutrition, and to their action in the organism. The power of formation is manifest in them in their accidental production, and in a less degree in the reparation of their lesions. Irritability manifests itself in them to a certain degree. Their sensibility is much less evident.

421. The irritability of the arteries,* which is also called tonicity, contractility, the vital power of the arteries, and their power of contraction, or the force by which the walls of the artery, in the state of life, approach its axis, even without having been distended, has been a subject of great controversy among physiologists.

Haller, who admits the muscular nature of the middle membrane of the arteries, avows that his experiments furnished nothing positive respecting their contractility, and that these vessels did not always reply to chemical and mechanical stimulants. Bichat, Nysten, and M. Magendie, have also denied the irritability of the arteries. Bichat rests upon the circumstances that mechanical irritation, at the exterior or interior of the vessel, does not produce motions; that when the vessel is opened longitudinally, its edges do not turn back; that when extracted from the body, it gives no mark of contractility; that when dissected, layer by layer, its fibres are not seen to palpitate; that when the finger is introduced into a living artery, it is not strongly compressed; that an artery intercepted between two ligatures experiences only a communicated motion; that the contraction produced by acids is a hardening, and that alkalies have no action.

Most anatomists and physiologists are of a contrary opinion, which they found upon a great number of facts. Verschuir and

* See Chr. Kramp. *De Vi vitali Arteriarum.* Argent. 1785. C. H. Parry. An Exper. Inquiry into the Pulse and other Prop. of the Arteries, &c. Bath, 1816.—Ch. H. Parry, Additional Experiments on the Arteries, &c. London, 1819.—Hastings, *loc. cit.*

Hastings have seen mechanical irritation produce contraction of the arteries. Zimmermann, Parry, Verschuir and Hastings have seen mineral and vegetable acids produce the same effect. Thomson and Hastings have seen it also produced by the action of ammonia. Verschuir, Hunter, and Hastings, have seen the action of air and temperature alone produce this contraction. Hastings has obtained the same effect by applying oil of turpentine, tincture of cantharides, the solution of muriate of ammonia, and of sulphate of copper. Bikker and Van den Bosch have obtained the contraction of the arteries by electricity; Giulio and Rossi, by galvanism. Home has even observed it to take place on applying alkali upon the nerve approaching an artery. The vital contractility, which but slightly manifests itself in the large arteries, becomes gradually more distinct in the smaller.

There may also be adduced, as a proof of the existence of the irritability of the arteries, the increase of their contraction during inflammations and neuralgiæ. Thus, in whitlow, angina tonsillaris, prosopalgia, &c. the arteries of one side are seen and felt beating much more strongly than those of the other. Differences of the same kind are sometimes seen in hemiplegia. The same thing also takes place in gestation, and in many other sanatory or morbid phenomena, accompanied with a local development of the vessels.

It may, therefore, be concluded, from what has been said above, that during life the arteries possess at the same time elasticity and irritability; that elasticity predominates in the large, and irritability in the small arteries, and that the irritability of the arteries is more or less subject to the nervous influence. As age advances, the vasa vasorum diminishing, the nerves and arteries being less nourished, and the middle membrane becoming hard, the irritability of the arteries gradually diminishes, and their elasticity itself is at length greatly impaired.

422. The sensibility of the arteries either does not exist, or is extremely obscure. Verschuir mentions only a single experiment in which an animal appeared to suffer pain from the application of a mineral acid. According to Bichat, the injection of an irritating fluid also appears to produce intense pain.

423. The office of the arteries is to lead the blood from the heart into all the parts of the body. When the ventricles of the heart, by contracting, impel a new quantity of fluid into the arteries already full of blood in motion, the velocity of the motion is increased in all the arteries. This is proved by the observation of an arterial wound. Another generally admitted effect of the systole of the ventricles, is the dilatation of the arteries. Experiments have been adduced in support of this dilatation, while other interesting experiments made by Dr. Parry seem to contradict it. It really exists, however, although it is very inconsiderable. Another more sensible effect, produced by each systole, is the elongation of the arteries. The action exercised by the arteries for pro-

pelling the blood, is their elastic resilience which contracts and shortens them, and consequently diminishes their capacity, together with a force of vital contraction which is added to the elasticity in the middle-sized arteries, and in the smaller exists alone. The velocity of the arterial blood in general diminishes from the trunks towards the last twigs. It moreover presents local variations, which are constant or accidental.

The function of the arteries is, therefore, to conduct, as tubes, the blood into all the parts, and as contractile tubes, to impress upon it a part of the motion with which it is animated. The action of the arteries upon the blood has been by turns exaggerated, and estimated at too low a rate. It is perfectly certain; 1st, That the vessels appear before the heart, both in the animal series and in the embryo; 2dly, That acephalous fœtal monsters are destitute of heart; 3dly, That in fishes there is no aortic ventricle, and that even in man the vena portæ (Sect. III.) is equally destitute of a proper muscular agent of impulsion; 4thly, That in reptiles, when the heart has been removed, the motion of the blood still continues for a long time. All these facts in reality prove, that the vessels are agents, and that even they are the original agents of the blood's motion. The arteries take part in this agency by their elasticity and irritability.

But it is not less certain that in the animals which are furnished with a heart, that organ becomes a powerful agent of the motion of the blood. It is thus that by its action the arterial circulation, although continuous, is jerked; and it is thus that the circulation is performed in the sturgeon, although the aorta is inclosed in a bony canal. In like manner, the aorta and its principal branches may be ossified in man, without any great irregularity ensuing in the circulation of the blood. It must be concluded, then, that both these powers, that of the heart and that of the arteries, are subservient to the circulation, and that the one may in part supplant the other. But the action of the heart upon the blood goes on diminishing, and that of the vessels augmenting, in proportion as we recede from the centre of the circulation. The vital contraction of the arteries is also one of the causes of their being empty in the dead body.

424. The arterial circulation is accompanied with a motion to which the name of *pulse* is given. This phenomenon has been by turns attributed to the alternate contraction and dilatation of the arteries; to the elongation of these vessels and the locomotion resulting from it; to the pressure of the finger in feeling it, or to several of these causes together. The number of pulsations depends solely upon that of the contractions of the heart. The volume or fulness of the pulse depends upon the quantity of blood contained in the arteries; its duration, upon that of the contraction of the heart; its strength, upon the quantity of blood impelled by the heart, the force with which it is impelled, the quantity con-

tained in the arteries, and that which passes through the capillary vessels. The pulse is felt for the purpose of examining the state of the circulation and the moving powers of the blood, viz. the heart and vessels.

The walls of the arteries increase in thickness and density during the whole period of growth, and continue to increase in density during the whole of the remaining period of life.

The varieties of the arteries are much more frequent than they are generally said to be. Bichat and M. Meckel * have said with reason, that they are at least as frequent as those of the veins, if not more so. It is in the large arteries especially that they are remarkable, † both on account of their frequency, and from a kind of regularity or symmetry, as well as the resemblance which they then present to the regular state of certain animals.

425. Besides the accidental vessels already spoken of (371) when a principal artery has its continuity interrupted, these still form supplementary passages for the circulation. These passages commonly result from the increase of volume of old vessels, which, from being white or colourless, as they were from their extreme minuteness, become red, or which, from being red and capillary, become more voluminous; but which, previously to this circumstance, formed collateral passages by their anastomoses (350.) In certain cases the circulation is re-established by entirely new passages, by arteries of new formation. This fact, which was supposed to exist by John Hunter, and seen by M. Maunoir and by Jones himself, although he had combated Maunoir's opinion, has been placed beyond doubt by Dr. Parry's experiments. ‡ If the carotid artery of a sheep, which gives off no branch in the whole length of the neck, be tied, or a part of it cut out, the circulation is found to be re-established, some time after, in the place where the artery has been obliterated or removed, by several nearly parallel branches occupying the interval which exists between the two ends of the artery.

426. General inflammation of the arteries is rare; local arteritis, however, is not so. Besides acquiring a red colour, the walls of the arteries become thicker and softer, and in their interior there is often a plastic, sometimes a purulent exudation, and sometimes ulcerations of greater or less depth.

427. Wounds of the arteries § present anatomical considerations of great interest. The acupuncture or pricking of an artery gives rise to a hemorrhage, which is slight if the vessel is surrounded by cellular tissue, and more profuse if it is denuded of its sheath. The hemorrhage is stopped by the coagulation of the blood, which is

* *Deutches Archiv. fur die Physiologie.*

† Fr. Tiedmann, *Tabulæ Arteriarum Corp. Humani*, Carlsruhæ, 1822.

‡ *Loc. cit.*

§ J. F. D. Jones. On the Process employed by Nature in Suppressing the Hæmorrhage, &c. Lond 1810. Beclard, *loc. cit.*

afterwards gradually absorbed. There remains for some time a small swelling opposite the puncture. There then forms a cicatrix so exact, that it ultimately becomes impossible to perceive it. A small incision parallel to the axis of the vessel separates a little, and gives rise to a greater hemorrhage than puncture does. The wound sometimes heals, and in the same manner. Transverse incision, by the great separation of its sides which ensues, gives rise to a hemorrhage more or less profuse, according as the artery is denuded or not. When the half of the circumference of the artery is cut, the hemorrhage, if left to itself, continues, or is renewed after being stopped, until death. When a small part of the circumference only is divided, if the sheath exists, the blood, after flowing more or less, infiltrates and coagulates in it, and sometimes there forms a cicatrix, which in man is much less solid than the original walls of the artery, and which commonly becomes the seat or the cause of an aneurism. When, on the other hand, the transverse division much exceeds the half of the circumference, the retraction, as well as the contraction which results from it, is such that if the sheath still exists, the blood infiltrates into it, stops and coagulates, so that in this case also a cure may be effected, but for this purpose it is necessary to cut through the arteries, and then the case enters into the following.

428. When a middle-sized artery is cut across, whether upon an amputated surface, or in the continuity of the parts, the blood issues in full flow, and by a continuous jet, alternately rising and falling, until the circulation is greatly weakened. The flow of blood then slackens and stops, whether to commence again once or oftener, when the weakness has passed off, and continue until death, or to cease altogether. In the latter case, which is of very rare occurrence in the human species, the artery being retracted into its sheath and into the surrounding cellular tissue, the blood infiltrates and coagulates round the end of the vessel. It also coagulates in the mouth of the vessel itself, to a greater or less height, always determined by the situation of the nearest branch, in which the circulation continues to take place. The end of the artery is then obstructed and stopped, much the same way as the neck of a bottle is by the cork and the wax with which it is covered. The artery being no longer submitted to the alternate distention which it underwent, gradually returns upon itself; its truncated extremity undergoes traumatic inflammation, and becomes the seat of a plastic exudation; the end cicatrizes, the blood coagulates at the interior, and as the exterior is gradually absorbed, the artery continues to contract, changes into an impermeable cord, and at length disappears, or is converted into cellular tissue up to the neighbourhood of the nearest branch which continues to carry on the circulation.

429. When an artery is distended in the longitudinal direction, it at first elongates greatly by sliding in its sheath, which the surrounding cellular tissue permits it to do. After yielding to a great

extent without breaking, it begins to tear at the interior. The outer membrane tears last, after becoming elongated and drawn out much like a glass tube which is melted and drawn at the lamp of the enameller. Once broken, the ends of the artery retract less than the stretched, and the blood spouts at first as in the preceding case, but soon stops and commonly ceases altogether. This prompt and final cessation of the hemorrhage, which almost always takes place in this case, has been attributed to the retraction of the artery and to other imaginary causes. Many cases observed in the human species, and many experiments made on animals, have convinced me that it is to the more or less numerous internal ruptures which the artery experiences before entirely separating in one point, that this remarkable phenomenon is to be attributed. The phenomena which follow are the same as after the transverse section (428.)

430. A ligature applied circularly to an artery, whether in its entire state, or upon an amputated surface, sufficiently tightened to arrest the circulation in the vessel, cuts the inner and middle membranes, and if the artery is sound, does not divide the outer membrane. If the ligature remains in place, the blood stopped in the vessel coagulates in its cavity up to the nearest branch, which carries on the circulation. The division experienced by the inner membranes, the pressure exercised upon the outer, and the presence of the ligature, determine an effusion of organizable matter, which at first produces the agglutination of all the divided parts. The part embraced by the ligature first softens, then divides in consequence of inflammation, and the ligature is cast off. The changes which subsequently take place in the vessel are the same as after its transverse section (428).

431. In the three kinds of wounds which we have above described (428–430), the ulterior phenomena differ, according as it is an amputated surface that is operated upon, or their parts in a state of continuity. In an amputated surface, not only is the principal artery obliterated, but also all its branches, which terminate at the surface, so that the trunk itself is contracted more or less. In the other case, on the contrary, the branches which arise from the tied cut or torn artery, not only continue to carry on the circulation, but dilate to supply the place of the principal trunk. They thus preserve, up to the place at which they come off, the fluidity of the blood, its motion and its impulse upon the vessel. It is to this difference that the frequency with which the arteries unite by the first intention in an amputated surface is to be attributed, and the comparative rareness of this fortunate result when the parts are continuous.

432. There sometimes occurs a cartilaginous production or transformation, with thickening of the walls of the arteries over a space generally of small extent. The productions called atheromatous, steatomatous, &c. are, like the preceding, only the prelude of the stony ossification of which the arteries are so frequently the seat. It is necessary to distinguish this ossification into accidental

and senile. The former has its seat between the inner and middle membranes, and is preceded by one of the above-mentioned alterations. The latter, on the contrary, has its seat in the middle membrane, and consists of a transformation of its fibrous rings into bony hoops of greater or less extent. The different parts of the arterial system are not all equally liable to this conversion. The aortic system is much more frequently affected by it than the pulmonary system. The internal spurs of the arteries and the valves of their trunks often present it; the arteries of the inferior extremities more frequently than those of the superior: the arteries of the muscles, the heart, the brain, and the spleen, pretty frequently; those of the stomach and liver rarely. Lastly, the whole arterial system has been seen ossified by Harvey, Riolan, and Loder. Ossification of the arteries is most commonly the lot of old age. Accidental ossification, however, is sometimes seen in young subjects, and even in infancy. Ossification of the arteries is of rarer occurrence in the female sex than in men. It is much more common in cold climates than in warm countries.

The effect of arterial ossification, and especially of that which is accidental, is to produce wearing of the membranes between which it is placed. Ossification of the arteries has been attributed to a multitude of causes. That which is accidental is a true production or deposition. The ossification of old age appears to be the last term of the successive changes which the middle membrane, which is at first soft and reddish, undergoes during life.

433. There sometimes occur excrescenses of a fleshy consistence, attached to the inner surface of the arteries, and especially to the semilunar valves which are at the entrance.

434. Dilatation of the arteries, or arteriectasis, is an affection of very frequent occurrence. It may consist, 1st, In a mere loss of elasticity without apparent alteration of the walls; 2dly, In an alteration of the dilated walls.

Simple dilatation is met with especially in the large trunks. It generally affects the whole circumference, and the tumour which results from it has the ovoidal form. It has often been observed in the arch of the aorta, and sometimes in the pulmonary artery. Dilatation with alteration of the walls affects the aorta and the different parts of the aortic system as far as towards the ramifications. The arteries of the upper extremities are much more rarely affected than the others. The alteration and dilatation which results from it are most commonly lateral. It is this that authors have described, since Fernel's time, under the name of true aneurism. The altered walls are rather thickened than attenuated.

The blood which these two kinds of dilatation contain is fluid.

435. Aneurism results from the destruction or rupture, in a word from the solution of continuity of the arterial walls, commonly preceded by the dilatation of these walls, and always by their

alteration. It consists of a cavity formed by the outer membrane dilated and strengthened by the cellular membrane and the other surrounding parts, lined at the anterior by a membrane thin and smooth in some points, bearing a great resemblance to the inner membrane of the arteries. This cavity communicates with that of the vessel by an aperture, regular or not, formed in the inner and middle membranes. It is filled with coagulated blood, and with more or less firm layers of fibrine, variously altered, and perhaps mixed with organizable matter, produced by the walls of the cavity. The blood in passing along the canal of the artery, continually penetrates into the accidental cavity.

Sometimes the aneurism increases indefinitely, and causes death by pressing upon the neighbouring organs and disturbing the functions. Sometimes it bursts externally or in the interior, and destroys by hemorrhage or effusion. At other times it becomes inflamed, suppurates and opens like a vast abscess, in which case there is sometimes hemorrhage, and sometimes on the contrary, the artery having been obliterated by the inflammation, a cure may take place. Sometimes the inflammation terminates by gangrene of the tumour, and one or other of the above-mentioned effects may be the result of the separation of the slough. Lastly, at other times, the circulation gradually slackens in the artery affected by aneurism, and becomes, at the same time, more and more active in the collateral passages, whence there finally results obliteration of the affected arteries up to the branches in the vicinity of the tumour, and the gradual absorption of the latter.

436. The arteries, whether under inflammation, or affected by an accidental production of their walls, or without apparent cause, in place of becoming dilated and bursting, sometimes contract, and even become obliterated spontaneously. The aorta has thus been found contracted and even entirely obliterated. The total obliteration of the right pulmonary artery has also been observed. I have once seen obliteration of the carotid artery, several times contraction of the brachial trunk, and often contraction and obliteration of the crural trunk and its branches. This is the ordinary cause of the gangrene of the toes, feet and legs, in old people; the change happening in a part, and at a period when the arterial twigs themselves affected by induration, are no longer capable of the rapid augmentation necessary for the establishment of a collateral circulation.

THIRD SECTION.

OF THE VEINS.

437. The Veins * are the vessels which carry back the blood from all parts of the body to the heart.

* *Diatribe Anatomico-physiologica de Structurâ atque Vitâ Venarum, Auctore,* H. Marx. 8vo. Carlsruhæ, 1819.

438. It has already been seen that the ancients made at first no distinction between the veins and the arteries. Galen, who knew their difference well, placed the origin of the veins in the liver. The distinction and connexion of the arteries and veins have been perfectly established by the discovery of the circulation of the blood. Since then, the study of the venous system has perhaps been too much neglected.

439. The veins, like the whole vascular system, have a disposition resembling the branching of a tree; but, with a reference to the direction in which the blood flows through them, they more resemble the roots of a tree than its branches. Thus their origin takes place by radicles which correspond to the ramuscules of the arteries; their termination by trunks, which open into the heart, like the origin of the arteries; and in their course they are seen to unite, as the arteries divide in theirs. If, therefore, they be considered in the direction of the course of the blood, they present a disposition the reverse of that of the arteries; and if they be examined in the same direction as the arteries, a course will be followed the opposite of that of the blood.

440. The venous system, like the arterial, is double. One system, which is general, carries the blood from the body to the anterior or right auricle; the other carries the blood from the lungs to the other auricle of the heart. There is moreover a particular and complex venous system in the abdomen, that of the vena portæ, whose disposition requires a separate examination.

441. This particular venous system constitutes a perfectly entire vascular system, that is to say, a trunk, roots and branches, placed between the last ramuscules of the gastric, intestinal and splenic arteries, which constitute its roots, and the first radicles of the hepatic veins, which are the continuation of its twigs. This vascular system, if viewed with regard to its disposition as ramified in two opposite directions, resembles the veins in its intestinal half, and the arteries in its hepatic half. Under another point of view, it is indifferent or foreign to both, as it is intermediate between them; for it is in the place where it is the continuation of the arteries that it has the venous disposition, and *vice versa*. It is chiefly on account of the nature of the blood which it contains that this vascular system is united to the general venous system.

442. In the oviparous vertebrate animals there occurs another venous system similar to the intestino-hepatic vessels. This particular system * is formed by the union of the veins of the middle veins of the body only, or of that region and the tail, which pass towards and terminate in the kidneys, in the manner of arteries, sometimes sending a twig to the vena portæ, that is to say, to the liver.

I have sometimes, in the dog, seen the vena portæ have one or two venal terminations.

* Lud Jacobson, *De Systemate Venoso peculiari in permultis Animalibus Observato.* Hafniæ, 1821.

443. The number of the veins is in general greater than that of the arteries. There are two venæ cavæ and one cardiac vein to correspond to the single trunk of the aorta. There are even four pulmonary veins to correspond to the single pulmonary artery and its two branches. But each of these venous divisions answers to the corresponding arterial branch. In almost the whole extent of the body there is a much greater number of subcutaneous veins than of subcutaneous arteries; and in the deep parts there are almost always two accompanying veins for a single artery. In the stomach, the spleen, the kidneys, the testicles, the ovaries and some other parts, the number of veins is equal to that of the arteries. In some parts even, the number of veins is less than that of the arteries, as, for example, in the umbilical cord, the penis, the clitoris, the gall-bladder, the surrenal capsules, &c.; but this is compensated by the difference of capacity. The size of the veins in general is in fact greater than that of the corresponding arteries.

The sum of the veins, or their total capacity, is therefore greater than that of the arteries. The difference has been variously estimated: we can only say, with Haller, that the veins have, at least, double the capacity of the arteries; but, besides the individual, accidental, or temporary differences, and those which depend upon the kind of death, this continually varies with age. This difference also is not the same in all parts of the body. In the pulmonary system it does not exist, for the veins are there apparently equal in capacity to the arteries. This is also the case with the renal vessels. In the testicle, on the contrary, the veins are greatly superior to the arteries.

444. The situation of the veins is in general the same as that of the arteries, these two kinds of vessels accompanying each other in their course, and uniting at their termination. Almost everywhere, a trunk, a branch, or a twig of an artery, is accompanied by one or two veins. There are some exceptions however. Thus, in the skull, the spine, the eye, and the liver, the arteries and veins affect different situations and dispositions: the vena azygos, the trunk of the intercostal veins in the space measured by the pericardium and liver, is not accompanied by an artery, and this is also the case with the subcutaneous veins.

445. The veins commence by capillary or microscopic radicles, forming a continuation of the ramuscules of the arteries. These radicles are colourless or red, according as their diameter admits a single series of globules or several at once. In some places, as in the intestine, the lung, &c. the successive joinings of the radicles of veins correspond to and entirely resemble the divisions of the arterial ramuscules. In other places, the disposition is different. Without speaking of the erectile or cavernous tissue, in which the swelling and communication of the veins are extreme, in many other parts they affect different dispositions from those of the arteries. They form plexuses at the neck of the bladder, in the spine,

and around the spermatic artery, wide canals in the spongy bones, and under the skin, they form, by their numerous communications, a great net-work with angular, and most commonly pentagonal meshes.

They are not so regularly cylindrical as the arteries, and so far from following a regular order of increase in the volume of the trunks, and of decrease in their total capacity, very large branches are sometimes seen connected with a trunk of no great size, which depends especially on the softness of the walls and the great number of anastomoses. The communication of the veins present all the varieties already indicated (356,) and, moreover, the union of very large trunks, as that of the venæ cavæ by the vena azygos; the union of superficial veins and deep-seated veins, as that of the cranial and spinal veins with the epicranial, temporal, cervical, dorsal, and other veins of the internal and external jugular veins, and of the deep veins with the subcutaneous veins of the extremities.

In general, the veins have a less flexuous, straighter, and, consequently, shorter course than the arteries.

The variations of the veins have been a little exaggerated, as those of the arteries have been represented on too low a scale. The great venous trunks especially are less variable than they have been said to be. The branches and twigs are so in a high degree.

446. The interior of the veins presents a great number of valves * or doubled prolongations of the inner membrane, in which circumstance there is a great difference between them and the arteries. The valves are very well seen on examining under water a vein that has been slit in the longitudinal direction.

Each valve consists of a replication of the inner membrane. This replication has a convex edge adhering to the walls of the vein, on the side next its roots, and a concave and free edge, directed towards the side next the heart. These two edges are a little thicker than the rest of the fold. One of the faces looks toward the cavity of the vessel, and corresponds to the blood which circulates there; the other corresponds to the walls of the vein, which is a little dilated at this point. When the valve falls, the face which corresponds to the roots becomes convex, and the other becomes concave, and the vein swells a little. The valves are so much the broader, the larger the vein is, and so much the more elongated, the narrower it is. It is to this difference especially that the varieties of form described by Perrault and several others is to be referred.

Besides the inner membrane, there also exists in the substance of the valves dense cellular tissue, and sometimes distinct fibres. Sometimes they are areolar and perforated like lace. In the veins

* H. Fabricio. *De Venarum ostiolis, in op. omn.*—J. G. Schmiedt and H. Meibomius, *De Valulis seu Membranulis Vasorum earumque structura et usu.* Helmst. 1682.—Perrault. *Essais de Physique*, t. iii.

or sinuses of the dura mater, there occur only some transverse fibres, which may be regarded as rudimentary valves.

The valves are in general disposed in pairs placed alternately, according to the two opposite diameters of the vein.

They are three and three in the great veins, as the crural and iliac. It is but seldom that they are seen quadruple, and very seldom or never quintuple. In the twigs which have a diameter of only half a line and under, they are single.

There are by no means valves at all the places where a twig joins a branch, or where a branch opens into a trunk. Nor do they occur everywhere at the same distance. They are nowhere closer to each other than in the smallest veins. Valves are found in the veins of the extremities, more in the subcutaneous than in the deep veins, in those of the face, the neck, the tongue, the tonsils, at the end of the cardiac vein, in the tegumentary veins of the abdomen, in those of the testicle, penis, and clitoris, in the internal and external iliac veins, sometimes in the renal veins, and rarely in the vena azygos.

There are none in the enchephalic veins, those of the spine or diploe of the bones, in those of the lungs, the vena portæ, the umbilical vein, the venæ cavæ, unless at the mouth of the vena azygos, in the uterine veins, or in the median vein.

In general, there are numerous valves in the superficial veins, fewer in the deep or intermuscular veins, and still fewer in the veins of the splanchnic cavities. They are numerous in the most declivous parts, and consequently in the lower limbs, less so in the upper limbs, and still less numerous in the head and neck.

The valves, which are applied against the walls of the veins when the course of the blood is free and easy, separate from them, close the vein, sustain the blood, and prevent its reflux towards the capillary vessels where it meets with obstacles in its passage.

447. The veins, like all the vessels, are surrounded by the cellular tissue of the parts in which they are placed, which forms a sheath for them. This sheath is loose around the trunks, but closer upon the branches. The sheath of the vena portæ is remarkable in the liver, where it is known by the name of capsule of Glisson.

The outer membrane, properly so called, is thinner and less condensed than that of the arteries, to which it bears a great resemblance.

The middle membrane is formed of fibres more extensive and softer than those of the arteries. These fibres appear nearly all longitudinal, when one looks upon the membrane between him and the light. Some of the inner fibres appear annular. But when one tries to separate the fibres of this membrane, the same difficulty is experienced in all directions. In the human species this membrane is much thicker in the system of the vena cava inferior than in the other. In general, also, it is thicker in the superficial than in the deep-seated veins. The inner saphena vein has very thick walls at the lower part of the leg. Near their entrance into the heart, the veins have distinctly muscular fibres. The inner membrane, which is thin and transparent, differs from that of the arteries by its extensibility and its resistance to rupture, and by its filamentous texture, which becomes evident when it is distended and torn. The great veins of the skull or the sinuses, the veins of the bones and some others, are almost entirely constituted by the inner membrane, and are as it were scooped out in the substance of the dura mater, the bones, &c.

The walls of the veins are furnished with small blood vessels and nervous filaments which are traced into a part of their substance.

448. The walls of the veins are whitish, semitransparent, and thinner than those of the arteries. In general, their thickness goes on increasing absolutely from the roots towards the trunks, and diminishing relatively to the diameter in the same direction. Their density is 115 or 110. The firmness of their walls is much less than that of the arteries, and they collapse when empty, excepting those of the uterus, the liver, &c., which are attached to the substance of the organs. They are less extensible in the longitudinal direction than the arteries, but much more so in the circular. It is generally admitted, since Wintringham's experiments, that the veins oppose a much greater force to the causes of rupture than the arteries. But, in reality, the veins are weaker in the circular direction than the arteries. They not only yield much more, but also tear across much more frequently than the arteries, while, on the other hand, they have appeared to me to resist distention in the longitudinal direction more. The walls of the veins are very elastic, but less so than those of the arteries. Their irritability or vital contractility is, on the contrary, greater than that of the arteries, but less than that of the capillary vessels. It has been denied by several physiologists, but proved by many experiments. It is sufficient to have observed the effect of local cold upon the subcutaneous veins, and to know that a vein intercepted between two ligatures, and punctured, empties itself entirely and rapidly in a living animal, while this does not take place after death, to admit the existence of irritability in the veins. Their sensibility is obscure or doubtful; Monro, in his Lectures, said he had felt the puncture of a denuded vein. The power of formation of the veins is not less evident than that of the arteries.

449. The function of the veins is to conduct the blood from all parts of the body to the heart. It has been seen that each contraction of the ventricles determines an augmentation in the continued motion of the blood in the arteries. This augmentation diminishes as the vessels become capillary. In the capillary arteries it is uniform, and this is also the case in the veins in general. In the veins, the blood is animated with the motion impressed by the heart, the arteries, and the capillary vessels. Do the

veins exercise an additional action? This is not doubtful. Let the artery of a limb in an animal be compressed or tied, the current of the blood in the veins will be slackened, but will not for all this cease. If a vein be tied, it yet empties itself above the ligature. It even empties itself between two ligatures. To the causes which have been above pointed out, let there be added the alternate relaxation of the heart, which produces a kind of attraction, inspiration, which produces a still more powerful one, and the pressure of the surrounding muscles. The valves, by dividing the column of the blood, render these different powers more efficacious. The form itself of the venous system makes the motion of the blood, in place of gradually slackening as in the arteries, although slower than in those vessels whose capacity is less than that of the veins, go on accelerating as it approaches the heart. The venous circulation is much more dependent than the arterial upon the effects of gravity and pressure.

450. The passage of the blood in the veins is continuous, and these vessels do not present pulsations. However, in some places and in some circumstances, they present something like an arterial pulse, which, for this reason, is called the venous pulse. In the neighbourhood of the heart, the venous trunks which are destitute of valves alternately experience, during the contraction of the auricles, a reflux of blood which makes them swell out during the relaxation of the auricles. In the ordinary and regular state of the functions, this twofold motion is limited to the vicinity of the heart, and is not sensible; but when the circulation is hampered, it extends into the abdomen, and becomes visible in the neck. It is the same with the influence of the motions of respiration: inspiration accelerates the entrance of the blood into the venæ cavæ and their auricle; active inspiration, difficulty or suspension of the respiration, and efforts, on the contrary, slacken or suspend it. In the ordinary state, these effects are not very obvious or extended; but they become very distinct in the opposite cases. The efforts in which the effects of active expiration are carried to the highest degree, determine in a very sensible manner the stasis of the venous blood in the head, the abdomen, and from step to step as far as the limbs; while it is to the contrary effects of inspiration upon the venous circulation that we must refer death by the introduction of air into the heart. When, in fact, by an operation or accident, a large vein is opened at the base of the neck or in the subclavian region, a deep inspiration sometimes draws air into it, which is carried into the right or anterior cavities of the heart, and which, by arresting the circulation, suddenly produces death.

451. In youth the venous system is smaller, in proportion to the arterial system, than in adult age. Its relative capacity continues to increase in old age. The walls of the veins present few observable changes, and their ossification in old age is of extremely rare occurrence.

452. The morbid alterations of the veins* have been less studied than those of the arteries.

Inflammation of the veins, or phlebitis, is an affection to which Hunter was one of the first who drew the attention of medical men. It commonly occupies a pretty large extent of the veins, and generally extends towards the heart. It often gives rise to the formation of pus, and at other times to that of a plastic matter in the cavity of the vein, around it, and even in its substance. It depends most commonly upon mechanical injuries.

453. Wounds of the veins, considered in an anatomical point of view, present a similarity to those of the arteries; but, in whatever mode they are inflicted, they are much more easily followed by ulceration or extensive and often suppurative inflammation than those of the arteries, and they unite with more difficulty. After puncture or incision, there remains between the edges a space filled by a new membrane. Ligature does not first determine the division of the inner membrane and quickly afterwards its adhesion, but that membrane is at first only plaited, and only divides very slowly to unite again in a feeble manner.

454. Accidental productions are rarer in the walls of the veins than in those of the arteries. The cartilaginous state, or a similar thickening, sometimes however takes place in the walls of the veins, which become obliterated. Morgagni saw it once in the vena cava. Ossification is extremely rare in the veins. Dr. Baillie saw it once in the vena cava inferior near the iliac veins, and Dr. Macartney once in the outer vena saphena of a man who died with an ulcer on the leg. I have observed that the walls of the veins are thicker on the side which touches an artery than in the rest of their circumference, and I once saw in an old man a femoral vein ossified on the side corresponding to the artery, which was itself so in its whole circumference and to a great extent.

Morbid productions are sometimes observed under the form of vegetations, at the inner surface of the veins, whether the vein affected be surrounded by similar productions or not.

455. Dilatation of the veins is of very frequent occurrence. Sometimes the entire venous system is affected by it. Most commonly the dilatation affects one or a few veins only, which constitutes varices. Almost all the parts of the body may be the seat of the affection; those, however, which are the most declivous, as the inferior extremities, the genital organs, and the anus, are the parts most frequently attacked. The veins which are nearest the surface, also, such as the subcutaneous veins, are those most liable to be affected. The augmentation of volume does not take place in the circular direction alone, but the varicose veins also form numerous flexuosities which depend upon an increase of length. There sometimes occur dilatations of very small extent, and limited to a part of the circumference of the vein, whether by themselves

* Hodgson, *op. cit.*—B. Travers, in Surgical Essays, part i.

or connected with more general dilatations. The aneurismal varix is another kind of dilatation dependent upon the accidental communication of an artery and a vein, and upon the passage of the blood from the former into the latter. This affection is commonly accompanied with a remarkable thickening of the walls of the dilated and elongated vein. Sometimes, moreover, a consecutive aneurism forms between the two vessels. This case is that of the varicose aneurism.

456. The veins sometimes contract by the thickening of their walls. They are sometimes closed up from the effect of plastic inflammation. Sometimes they are compressed by tumours in the neighbourhood, or embraced by a ligature. In these cases, in which their cavity becomes obliterated, and in which the circulation ceases to be performed in them, the blood passes through branches and anastomoses, and a collateral circulation is established.

The vena cava inferior has been seen obliterated, whether beneath the hepatic veins, or even at their level, in which case the blood passed through the vena azygos. One of the iliac trunks, a jugular vein, &c. have repeatedly been found obliterated. I have four times seen the crural venous trunk obliterated in the groin. In all these cases the circulation was easily carried on by collateral passages. Hunter once saw the vena cava superior and the left brachio-cephalic vein almost entirely effaced by the pressure of an aneurism. I have, however, seen a case in which the vena cava superior and its branches, being filled with plastic matter, and impermeable to the blood, death appeared to be the result of this alteration. I have several times, but not constantly, seen great serous infiltrations coincide with obliteration of the veins.

457. There sometimes occur in the veins small hard and round bodies, which might at first sight be taken for accidental osseous productions. Some have even supposed them to have been at first formed in the walls of the veins, in the edge of their valves, or even at the exterior of these vessels; but this is not the case. They are concretions or phlebolites, from the size of a millet seed to that of a small pea, varying in their consistence, formed of superimposed layers, inclosed in coagulated fibrinous blood, and often lodged in lateral dilatations of the veins in which the blood remains in a state of stagnation, or in varicose veins, and always in declivous veins. The veins in which they are, in fact, most commonly met with, are those of the anus, the neck of the bladder, the uterus, the ovaries, the testicles, and sometimes even the subcutaneous veins of the leg.

The *Hexathyridium* or *polystoma venarum*, of which Treutler found two individuals in the ruptured tibial vein of a man, who had been washing in a river, appears to be an aquatic worm, a *planaria*, which might have introduced itself there, and not an entozoarium.

FOURTH SECTION.

OF THE LYMPHATIC SYSTEM.

458. The Lymphatic System comprehends, 1st, the vessels which carry the lymph and chyle into the veins, and 2dly, Enlargements which occur in their course, and which are called conglobate glands, or lymphatic ganglia.

ARTICLE FIRST.

459. The Lymphatic Vessels, which are also called Absorbent Vessels, are so attenuated, thin, and valvular, which renders their observation and injection very difficult, that the knowledge of them is but of rather recent date. They had been seen by the ancients however. Erasistratus and Erophilus had assuredly perceived the chyliferous vessels. It was Eustachio who discovered the thoracic duct in the horse. Aselli saw and named the lacteal or chyliferous vessels of some animals. He had an accurate idea of their functions. Veslingius was the first who saw chyliferous vessels in the lymphatics of the mesentery and the thoracic duct in man. We owe the discovery of the vessels of this species in the other parts of the body to O. Rudbeck, although it has also been attributed to Th. Bartholin and to Jolyf. The discoverers gave them the names of serous, aqueous, or lymphatic vessels. Bartholin conjectured that, like the veins, they were continuous with the capillary arteries, and destined to carry the watery part of the blood. Ruysch has very well described their valves. The knowledge of the lymphatic vessels has been greatly extended by the labours of Meckel and Munro, by those of W. Hunter, and of three of his disciples, J. Hunter, W. Hewson,* and Cruickshank,† by those of the illustrious P. Mascagni‡ especially, and by some others,§ all of whom have given them open orifices, and have attributed the absorption to these orifices.

460. These vessels are commonly distinguished into chyliferous and lymphatic; but this distinction is altogether superfluous and destitute of any utility, for their dispositions, texture and functions are the same.

461. The lymphatic vessels have a disposition resembling the

* *Descriptio Systematis Lymphatici, ex Anglico Versa*, &c. *in Op. Omn.* Lugd. Bat. 1795.

† *Anatomie des Vaisseaux Absorbans du corps humain, traduite de l'Anglais par* Petit Radel. Paris, 1787.

‡ *Vasorum Lymphaticorum Corp. Hum. Historia et Ichonographia.* Senis, 1787.

§ Ludwig. German translation of Cruickshank and Mascagni, with additions. Leip. 1789. Werner and Feller, *Vasorum lacteorum atque lymph. Anat.-physiol. descriptio.* Lips. 1784. J. S. Haase, *De Vasis cutis et intestin. absorbentibus*, &c. Lips. 1786. Schreger, *Fragmenta Anat. et Physiol. fasc.* 1. Lips. 1791.

branching of a tree, as the other vessels have. The humours which they contain pass through them, as in the veins, from the ramifications, or rather from the roots, towards the trunks. The aggregate of these vessels consists of a principal trunk and an accessory trunk, in which terminate numberless roots.

462. Lymphatic vessels occur in all parts of the body, excepting the spinal marrow, the encephalon, the eye, and the placenta.

Their situation has this much remarkable, that in the limbs and in the walls of the trunk, they are, like the veins, distributed in two planes, the one superficial or subcutaneous, the other intermuscular or deep, which accompanies the blood-vessels and nerves; and that in the splanchnic cavities there occur, in like manner, a plane of lymphatic vessels situated immediately under the serous membranes, and others more deeply seated.

463. The number of lymphatic vessels is very considerable: so many as twenty are counted in the superficial plane of the lower extremities to accompany the inner saphena vein alone, and a less great, but still considerable number, to accompany the deep vessels. The superficial lymphatics are of smaller size than the deep-seated. The volume of these vessels is much less than that of the veins. Those of the inferior extremities are larger than those of the upper extremities. Those of the head are very small. As to their total capacity, it has not been exactly determined. It appears in general to be about double that of the arteries, and to equal that of the veins in the superficial plane at least.

464. The origin of the lymphatic vessels is invisible and unknown. Physiological considerations and anatomical experiments have given rise to the admission, and afterwards to the rejection of their direct and immediate continuity with the arteries. It has also been seen above that their origin by open orifices at the surface of the two teguments and serous membranes, in the areolæ of the cellular tissue, and in the substance of the organs, which had been admitted through considerations and experiments of the same kind, is not better proved.

465. As soon as they can be perceived, the radicles of the lymphatic vessels are seen to unite together, to separate, and unite anew, so as to form net-works which form in a great measure the serous, tegumentary and other membranes.

These vessels become in general larger and less numerous as they recede from their origin. In their course they continue to divide into branches which unite anew with other neighbouring branches, or even with each other, so as to form islands. These divisions, unitings, and numerous anastomoses, form in many places plexuses.

When they are full and somewhat distended they appear rather moniliform than cylindrical. It is the great number of valves with which they are furnished, and the dilatation which they present above these valves, that gives them this necklace appearance. They also pretty frequently present ovoidal dilatations. They present many variations in their course; those of one side always differ more or less from those of the other.

All the lymphatic vessels after a longer or shorter course, ramify in the manner of arteries, and seem to terminate in lymphatic glands, beyond which they reappear anew, formed of roots which collect in the manner of veins. Those of the limbs traverse long courses of several feet, without interruption of this kind; while those of the mesentery do not traverse a space of more than a few lines, without falling in with glands. Some pass by the side of a gland without stopping at it. It would even appear, according to Cruickshank, that some lymphatic vessels of the back arrive at the trunks without passing through glands; but Mascagni, whose authority is so great on this subject, asserts that no lymphatic vessel arrives at the trunks without passing through at least one gland.

466. After a course of greater or less length, and more or less interrupted by ganglia, the lymphatic vessels of the lower half and upper and left fourth of the body terminate by a very elongated trunk, the thoracic duct, in the left subclavian vein. The others terminate by a very short trunk in the other subclavian vein. These terminations are themselves subject to several variations. Are there other terminations of the lymphatic vessels in the veins? Part of this question we shall examine when we come to speak of the lymphatic ganglia; the other parts we shall consider here.

Several anatomists and physiologists have admitted this opinion,* which may be founded on the circumstances that everywhere, and especially in the mesentery, the known radicles of the lymphatic vessels have a capacity much greater than that of the vessels which form their continuation; on the circumstance that in this part of the body also there often occur in the veins, as in the lymphatic vessels, substances introduced by absorption, and even those which have been directly injected into these latter vessels; and lastly, upon the circumstance that ligature of the thoracic duct, even when there is only one, does not produce death sooner than in from ten to fifteen days, and that there are then found in the blood the substances that had been introduced into the intestine and absorbed by its inner membrane. But the communication in question has not been seen, nor is it generally admitted. It would appear to be especially in the lymphatic glands that it takes place; but we shall revert to this subject in another place, (Art. II.)

467. The surfaces of the lymphatic vessels, like those of all the vessels, are the one cellular and adherent, the other smooth and free. The latter presents a multitude of valves.

These valves, which are of a semilunar or parabolic form, are generally disposed in pairs, and are large enough to close the vessel completely. They are in general placed at unequal intervals, excepting in the vessels of the testicle, where they occur nearly at every line, which gives them more than any other the form of a

* See Ludwig, *loc cit.*

necklace. They are more or less approximated according to the parts, without their being more particularly so in the branches than in the twigs. In certain vessels there occur intervals of several inches without valves. The thoracic duct is especially remarkable in this respect. In some points the insertion of a small vessel into a larger is only furnished with a simple valve. In some places of the trunks there are observed annular valves which do not entirely close the canal. The insertion of the trunk into the subclavian veins is furnished with a double valve which effectually opposes the reflux of the blood into their cavity. All these valves, like those of the veins and arteries, are formed by a duplicature of the inner membrane.

468. The lymphatic vessels are formed of two membranes, which are very distinct in their principal trunk.

The outer membrane, which is cellular and uneven externally, is attached to the surrounding cellular tissue, which forms a sheath for it. More deeply, it is distinctly fibrillar or filamentous. It is even alleged that muscular fibres have been seen in it. The inner membrane is very thin.

Small arterial and venous vessels are traced into the substance of the outer membrane. Some persons even assert that they have seen lymphatic vessels in it. No nerves have been discovered in it.

469. The walls of the lymphatic vessels, although very thin and transparent, are dense and very tenacious, much more so than those of the veins in proportion to their different thickness. However, these vessels are extensible, and are even possessed of a high degree of retractility. Their elasticity is manifest: if they are filled and distended in the dead body, the matter which has been introduced into them is expelled.

Their irritability or vital contractility * is not less evident, although it has been denied by Mascagni and several others. If they be exposed to the air in the living body, they manifestly contract. If the thoracic duct or another lymphatic vessel be punctured after being tied, the fluid issues from it in jets, like the blood which issues from a vein, while after death it only escapes continuously. It is true that mechanical or chemical irritations do not produce motions similar to those of the muscles, but irritability varies according to the different nature of the organs.

Nothing is known with respect to their sensibility, and little respecting their power of formation.

470. The lymphatic vessels contain the chyle and lymph (79.) They conduct these humours from their roots toward their trunks, which is sufficiently proved by the disposition of their valves, which allows the humours to pass in that direction and opposes their passage in the other; by the effects of ligature, under which they swell, while they are emptied above it; and by the valves

* Schreger, *De Irritabilitate vasorum Lymphaticorum.* Lips. 1789.

which are placed at their insertion into the veins. The fluids move in them slowly and uniformly, that is to say, without presenting pulsations.

Darwin, Thilow and others, to account for the rapidity of certain secretions, have admitted a retrograde motion of the humours in the lymphatic vessels; such, for example, that fluids absorbed by the walls of the stomach might go directly through the lymphatic vessels, and by means of their communications to the kidneys and bladder. This is to admit that the valves do not oppose a great obstacle to the return of the fluids. But it is certain, on the contrary, that the valves oppose an insurmountable obstacle to the retrograde course of the fluids; and further, direct observations and experiments discover in the urinary passages substances introduced into the stomach, without the intervening lymphatic vessels presenting the least trace of them.

ARTICLE II.

OF THE LYMPHATIC GANGLIA.

471. The conglobate or ovoidal glands, which interrupt the continuity of the lymphatic vessels, are in the same relation to these vessels as the nervous ganglia are to the nerves.

These ganglia were known at a very early period. It is partly of them that Hippocrates speaks under the name of glands. Fr. Sylvius gave them the epithet of conglobate, and Lossius that of lymphatic. Agreeably to the comparison above made by Soemmering, and to avoid confusion, M. Chaussier has designated them by the name of Lymphatic Ganglia.

472. They are situated in the course of all the lymphatic vessels, beginning at the instep and elbow-joint in the limbs, and the carotid duct and external base of the skull in the head. Many of them occur in the neck, the axilla and the groin, several in the anterior walls of the thorax and abdomen, and a very great number in the cavities. They are especially abundant around the roots of the lungs and in the mesentery, consequently near parts which give access to many substances coming from without. None have been discovered within the cranium or spine.

Their volume varies, in the state of health, from that of a lentil to that of an almond. In general the smallest are placed towards the roots, and the largest towards the trunks of the vessels. The largest and the nearest to each other occur towards the root of the mesentery; the smallest in the epiploon. Those of the head and arm are small.

Their figure is oblong, rounded, and a little flattened. They are more or less uneven at the surface, and have the general form of an almond

The lymphatic ganglia are in general of a reddish white colour, like flesh, but their colour varies in the different regions which they occupy. Thus, those which are subcutaneous are of a darker colour; those of the neighbourhood of the liver are yellowish, those of the spleen brown, those of the lungs blackish, those of the mesentery very white, &c.

Their consistence is greater than that of any soft part.

473. The lymphatic ganglia are enveloped by a thin, fibrillar membrane, highly vascular, attached to the surrounding cellular tissue, and which sends fine and soft prolongations into the interior.

The lymphatic vessels whose course the gland interrupts, are distinguished into those which arrive in the gland, *vasa inferentia*, and those which issue from it, *vasa efferentia*. These two kinds are distinguished from each other by the direction of their valves. The number of vasa inferentia is very variable, there occurring from one to twenty or thirty. That of the vasa efferentia is also variable, seldom corresponds to that of the other, and is commonly less. The vasa inferentia enter by the extremities of the gland which is nearest the roots of the system, and the vasa efferentia issue by the opposite extremities, which correspond to the trunks. The vasa inferentia, as they approach the gland, divide into twigs which separate in a radiating manner around it, divide and subdivide at its surface, so as to surround it with a net-work. The vasa efferentia produce nearly the same effect at the other extremity of the gland, by their radicles and roots successively uniting so as to form trunks varying in size and number. The total capacity of the vasa efferentia seems in general less than that of the vasa inferentia. This is especially striking in the mesentery.

The lymphatic glands have also remarkable blood vessels. The arteries are sufficiently large and numerous to colour the glands entirely when injected. The veins which are still larger than the arteries, are destitute of valves. Nervous filaments are seen arriving at these organs, and passing through them; but it is very difficult to know if any filaments terminate in them, or if the whole merely traverse them. Two great anatomists are opposed to each other on this question, Wrisberg admitting, and Walter denying their filaments terminate in their substance.

474. Nor are anatomists more agreed respecting the internal conformation and texture of the lymphatic glands. Albinus, Ludwig, Hewson, Wrisberg, Monro, and Meckel consider their tissue as entirely vascular; Malpighi Nuck, Mylius, Hunter, and Cruickshank admit the existence of cellules in them; Soemmering admits both these kinds of structure, and a third resulting from their combination. The examination which I have made of this tissue in man, in various animals, and especially in the inguinal glands of cows killed during lactation, has shown to me that it results solely from vessels, but which present a more or less evident erectile disposition. In fact, of the vasa inferentia which penetrate into the substance of the gland, some acquire and retain a great tenuity, while others dilate into cellules like the veins of the penis

both having numerous anastomotic communications. The roots of the vasa efferentia present on their part the same disposition, that is to say, some have slender radicles, and others roots which are swelled or dilated into cellules. Most of the lymphatic glands present this mixture of slender ramifications and inflated parts in their interior. Some of them scarcely present any branches dilated into cellules; some others seem to consist only of a net-work of minute ramifications. These variations account for the diversity of opinion which exists on this point of anatomy.

The lymphatic glands contain in their interior a creamy or milk-like substance, which appears to be contained in the minute or wide vessels of which they are composed, and not in the cellular tissue.

475. These ganglia are larger, softer, more reddish, and contain more fluid in children and young subjects than in adults. They diminish greatly, but do not disappear, in old age. There is no decided difference in this respect between the sexes. Hewson says that they are larger in man, while Bichat says the contrary. They have been found black under the skin of negroes.

476. The function which is attributed to the lymphatic glands is that of serving to mingle fluids arriving by different vasa inferentia, and of elaborating the lymph and chyle. The fluids are then carried off by the lymphatic vasa efferentia, and perhaps in part by the veins. This last point has been denied by many anatomists and physiologists of great name, as Haller, Cruickshank, Hewson, Mascagni, Soemmering, &c.; but it is to be feared that the authority of these celebrated men has caused a truth to be rejected without examination.

Besides the facts already adduced above in favour of the opinion in question, it may be said that many observers have perceived streaks of chyle in the vena portæ. It may be added, that a very great number of anatomists, and myself a number of times, have seen the mercury introduced into the lymphatic vessels of the mesentery, pass, beyond a gland, at the same time in the vasa efferentia and in the veins of the gland. Now this passage is too easy and too constant to depend upon a double rupture, and not upon a natural communication of the lymphatic vessels and veins.

477. Besides the diseases of the lymphatic glands and vessels,* as inflammation of both, wounds and ruptures of the vessels, their varicose dilatation, their contraction and obliteration, tubercles and other morbid productions in the glands, &c. the lymphatic system, under the consideration of its being an apparatus of absorption, has been made to exert a very great and very exaggerated influence in most diseases.

* S. Th. Soemmering, *De Morbis Vasorum Absorbentium Corp. Hum.* 8vo. Traj. ad Mœn. 1795.

CHAPTER V.

OF THE GLANDS.

478. The name *Gland*,* *Glandula*, Ἀδὴν, according to Nuck, is derived from the lymphatic ganglia or glands having been compared by the ancients to the acorn, which bears the same name.

So many different objects have been comprised under the name of gland, that it becomes a matter of great difficulty to give a definition of it.

Hippocrates had said, that the glands are formed of a particular kind of flesh, granulated, spongy, not dense, of the colour of fat, of the consistence of wool, breaking under pressure, furnished with numerous *veins*, and when cut emitting whitish and serous blood. He comprehended a great number of parts under this name, and in particular the brain.

This vague idea of the glands prevailed for a long time, to which there was afterwards added the character of a rounded form. There were then comprehended along with the glands and vascular ganglia, the conarium and the hypophysis of the brain, the synovial adipose bodies, and even the tongue.

Another definition, founded on the texture, and into which there entered the idea of a mass of follicles or an aggregate of vessels with a particular membranous envelope, still comprehended many different parts, and supposed the exact knowledge of the intimate texture.

It has also been attempted to define the glands by their function, by saying that they are secreting organs. But by confounding nutrition and secretion, the greater number of the organs were included under the definition, or by distinguishing these functions from each other, while, at the same time, the intrinsic secretions were not separated from the extrinsic, the serous and synovial membranes were confounded with the glands.

To distinguish the glands from every other part resembling them in form, in apparent texture, and even to a certain degree in functions, it is necessary to take particular notice of their connexions. Bichat and M. Chaussier have taken this consideration as a basis to the definition of the glands. Haase has also adopted it, but he has supposed the vascular ganglia to possess excretory ducts. The glands are organs of a rounded form, lobular, sur-

* Wharton. *Adenographia.* Lond. 1656. M. Malpighi, De *Viscerum Structurá*, in *Op. Om.* et *de Struct. Glandul. conglob.* &c. in *Op. Posth.* Lossius and Pielow. *Disq. de Glandulis in genere*, Viteb. 1633. A. Nuck. *Adenographia curiosa*, L. Bat. 1691. G. Mylius. *De Glandulis.* Lug. Bat. 1698. L. Terraneus, *De Gland. universim*, &c. Lug. Bat. 1729. Boerhaave and Ruysch. *De Fabricá Glandular*, &c. in *Ruyschii. Op. Omn.* A. L. de Hugo. *Comment. de Glandulis in genere*, &c. Gotting. 1746. Th. de Bordeu, *Recherches Anatom. sur les Glandes*, &c. Paris, 1751. G. A. Haase *De Glandularum definitione*, Lips. 1804. Leonhardi, Op. Cit.

rounded by membranes, having numerous vessels and nerves, and *furnished with ramified excretory ducts* which open upon the tegumentary membranes and there pour out a secreted fluid. In a word, they are organs of extrinsic secretion, furnished with excretory ducts.

479. Thus defined, the glands are appendages or prolongations of the tegumentary membranes. In the animals which are furnished with vessels and a heart, and which are the only ones that have massive glands, they result from an intimate union of these two kinds of organs, for which reason their description is given here. They are, however, more connected with the tegumentary than with the vascular system, for in the animals which are destitute of vessels the glands exist, but only in a rudimentary state. The liver, in fact, the most constant of all the glands, excepting, however, the kidney, exists in insects under the form of a ramified excretory duct, opening into the intestinal canal, but free and floating in the abdomen.

480. It is also rather difficult, perhaps impossible, to fix a very precise line of demarkation between the follicles or crypts and the glands.

It has already been seen, that among the follicles there are some which are simple and solitary; that others are grouped, aggregated, or agglomerated; that others are compound, whether through their meeting in a common orifice or lacuna, or at the same time through the agglomeration of several follicles, or, lastly, through a common and ramified excretory duct. It is here that the difficulty lies, for there is no valid reason for not arranging among the glands the amygdalæ which are compound lacunæ, the molar glands, the prostate gland and Cowper's gland, which have ramified ducts, as well as the sublingual or lachrymal glands.

The most perfect and least equivocal glands are the lachrymal glands, the salivary glands, which are three on each side, viz. the parotid, the maxillary, and the sublingual, the pancreas, the liver, the kidneys, the testicles, and the mammæ. The ovaries ought to be ranked among these organs like the testicles.

481. The form of the glands is irregularly rounded, and presents many varieties. Some, which are single, as the liver and pancreas, are unsymmetrical, the others are in pairs, and are all precisely similar on both sides.

482. They are all situated in the trunk, and all, whatever may be the apparent diversity of their situation, end by their ducts at the mucous membrane or skin.

483. They differ greatly in size. The liver is one of the most voluminous organs in the body; the lachrymal and sublingual glands, and the ovaries, on the other hand, have scarcely a diameter of half an inch.

484. In their interior, some are lobed and lobulated, as the lachrymal and salivary glands and the pancreas; the mammæ are less distinctly so; the testicles are so in another manner, the kid-

neys are so only in the fœtus, and the liver is lobed only at its exterior.

In the former, the lobules appear formed of very small, but similar, and whitish particles. In the liver and kidneys there occur two substances of different colours, disposed in layers in the kidneys, and intermixed like the grains of granite in the liver.

485. The glands are enveloped by a membrane, cellular in the greater number and fibrous in the others, and surrounded in some by a serous membrane, and in others by a great quantity of cellular and adipose tissue. The internal surface of this membrane is continuous with the more or less cellular tissue which exists abundantly in the glands.

These organs have numerous blood-vessels and lymphatics, but few nerves. The latter, however, are more numerous than in the mucous membrane in general, but less so than in the skin. Most of them receive only arterial blood. The liver alone in man and the mammifera and the liver and kidneys in the ovipara, receive moreover venous blood, which accounts for the nature of the fluids, so different from the blood and entirely excretory, which these glands furnish. The number and volume, or the total capacity of the arteries, are very different in the glands, but nowhere greater than in the kidneys. The length, the course, and the mode of distribution of the vessels, also vary greatly. The difference of capacity between the arteries and veins is very slight in the glands; in fact, a great part of the blood is in them transformed into secreted fluid, and carried off by the excretory ducts.

486. These ducts commence by very minute, invisible, and probably closed radicles, which unite together in the manner of veins, to form several trunks, as in the lachrymal, sublingual and mammary glands, or form a single trunk, as in all the others. These ducts, which are multiple or single for each gland, have a course which is generally straight, being tortuous in the testicles only, and open upon the tegumentary membranes. That of the ovary is the only one which is interrupted. Those of the mammæ, before terminating, present olivary bulgings. Those of the kidney present at first a funnel-shaped cavity or pelvis, and then end in a single bladder common to both. The duct of the liver and that of each testicle have also a reservoir, which, however, is situated laterally and requires a retrograde course of the secreted fluid before it can arrive in it. The ducts of the other glands present no interruptions, bulgings, or reservoirs.

The composition of the excretory ducts always essentially results from a mucous membrane, the thickness of which diminishes in proportion as it forms finer divisions in the gland. This membrane is covered externally by cellular tissue and elastic tissue, in some ducts by erectile tissue, as in the urethra, the nipple, and perhaps some others. In some parts of the excretory passages, the mucous membrane is strengthened or covered by mucous fibres.

487. Little is known respecting the intimate texture of the glands. Malpighi advanced the opinion that each of the glandular grains, the *acini*, ought to be considered as a follicle, and each gland as a conglomeration of follicles opening into a common excretory duct. This opinion was received and admitted without contradiction until the time of Ruysch, and was even then defended against that anatomist by Boerhaave. According to Ruysch, on the contrary, what were called glandular grains are merely interlacings of minute vessels, in which the arteries are continued into excretory ducts.

In each of these opinions there is something true which ought to be admitted, and something false to be rejected. It is true, as Malpighi says, that a gland consists, like a simple or compound follicle, of a canal closed at the extremity. It is also true, as Ruysch says, that each glandular grain, and the entire gland, consists of a mixture and interlacing of minute vessels with the organs of the excretory duct. But it is incorrect to say, as he has said, that the excretory ducts are the continuation of the arteries, as it would be incorrect to say, with Malpighi, that the roots of the excretory ducts commence by bulgings or follicles. Perhaps Malpighi's hypothesis would have more probability if applied to the granulated glands, as the salivary and lachrymal glands and the pancreas, which have in fact so great a resemblance to compound follicles: and that of Ruysch, if applied only to the liver, kidneys, and testicles, whose texture is evidently so vascular and channelled, although we cannot affirm that there are true enlarged follicles in the former, and in the latter direct communications between the arteries and excretory ducts.

In support of this conjecture there might also be adduced the ease with which, in these latter glands, injections pass from the vessels into excretory ducts, and *vice versa*, and the difficulty with which the same results are obtained in the lobulated and granulated glands.

However this may be, the texture of the glands appears very certainly to result from the intimate association of ramified excretory ducts, closed at their origin, with blood-vessels, lymphatics, and nerves, situated in their intervals, dividing and terminating in their substance, the whole connected by cellular tissue and enveloped by membranes.

488. The function of the glands consists of a mode of secretion which is called glandular. All secretion in general consists in the formation of a particular humour, the materials for which are furnished by the blood. Glandular secretion differs from the others (the follicular and perspiratory secretions) only in the greater complexity of its organ.

With only a single exception, the same blood, the arterial blood only, is carried into all the glands. The number, volume, direction, and mode of distribution of the vessels, and the degree of minuteness at which they arrive by their successive divisions, can only exert an influence upon the quantity of blood which arrives in the gland, and upon the rapidity of its course. However, a part of the blood being carried back by the veins, and another fluid by the lymphatic vessels, the glands pour forth by their excretory ducts humours differing so widely from each other as the saliva, the tears, the bile, the urine, the spermatic fluid and the milk.

What then are the nature and cause of the conversion of the blood into secreted humour? It has been thought that the change and its cause are purely mechanical, and depend upon the size and form of the openings through which the humours issue from the vessels. It has been supposed with much greater probability that the effect in question is produced by a chemical change, that is to say, another elementary composition. But this change takes place only in organized bodies, and in certain of their organs. The difference therefore depends upon modifications of their substance, just as we see different vegetables planted in the same soil and immersed in the same atmosphere, produce, some gum, others an acid, others resin, &c. Glandular secretion, like the other secretions, is therefore a function of the organized and living substance. The vessels carry to it the materials contained in the blood, the production is even probably disposed or prepared by the disposition of the vessels and the mode of circulation which results from it; but it is in the tissue which forms the roots of the excretory ducts that we are to look for its essential and immediate instrument. Secretion in general, and glandular secretion in particular, are evidently subjected to the nervous influence. The effects of the passions upon the secretions in general, those of diseases, of hysteria, hypochondria, &c. are well known, and experiments made by Mr. Brodie have confirmed the results obtained by direct observation on this subject.

Ligature of the veins of a gland greatly increases the product of its secretion.

489. The glands begin to form by their excretory duct. In the embryo, the duct is free and floating, as in insects. The glands are afterwards lobate, for example the kidneys, as they are in the arachnides and crustacea. They are in general very large in the fœtus and child. They diminish proportionally as the organs of the animal functions are developed. Some of them shift their place towards the period of birth; the testicles and ovaries. These glands and the mammæ become greatly enlarged at the period of puberty, and shrivel in old age.

490. The glands present numerous individual varieties and malformations. Some of them are sometimes entirely wanting. Those of generation are the most subject to this circumstance. One of the paired glands may be wanting, or may be smaller than the other. Some of them occasionally remain divided into lobes or of very large size as in the fœtus. Others are sometimes united, as the two kidneys, into one. Others may remain in their original

position, as the testicles and ovaries. The latter, on the contrary, are sometimes carried to the exterior of the abdomen. The kidneys may also be situated too low, or in the pelvis.

491. Atrophy of the glands is sometimes observed, whether through external pressure, or through an accidental production developed in their substance. It also takes place through defect of action, or even without appreciable cause. Hypertrophy sometimes takes place in consequence of the cessation of action of other organs, and especially of a paired gland. It is pretty frequently accompanied by some alteration of tissue.

492. Inflammation of the glands is of frequent occurrence, and often developes itself by being propagated along the excretory duct, from its orifice to its roots in the gland. The inflammation is often suppurative, and sometimes plastic; whence result obliteration of the ducts and induration of the tissue.

493. Accidental productions, whether healthy or morbid, are very common in the glands. The ovaries are the most subject to them, but especially to analogous productions. The testicles, the liver and the mammæ are very subject to morbid productions. The lachrymal and salivary glands, and the pancreas, are, on the contrary, very little exposed to either kind of accidental productions.

494. The glandular tissue does not produce itself accidentally. When it is cut, the roots or trunk of the excretory duct being divided, the secreted matter is poured into the wound, which has a great tendency to become fistulous and to remain so.

495. Here ends the description of all the systems or kinds of organs which belong especially to the vegetative functions; those which remain to be described belonging more particularly to the animal functions. This distinction would be better defined, did not one of the tegumentary membranes, the mucous membrane, belong chiefly to the functions of nutrition and generation, while the other, the skin, is principally subservient to the sensations. It is the tegumentary system that connects the two classes of functions and organs.

CHAPTER VI.

OF THE LIGAMENTOUS TISSUE.

496. The Ligamentous or Desmous Tissue, *Textus desmosus*, is white, flexible, very tenacious, and forms very solid connexions and envelopes.

It has been designated by the names of fibrous, albugineous, tendinous, aponeurotic tissue, &c. The last two names, like that of ligamentous, have the inconvenience of designating a particular kind of this tissue, and the others that of indicating a quality common to many others; for which reason the name *desmous* appears to me preferable, because, although it signifies ligamentous, it has not been applied to the ligaments in particular.

497. The most ancient anatomists, Hippocrates and Aristotle, confounded all the white parts under the name of nerves; whence the names aponeurosis, synneurosis, inneuration, musculus semi-nervosus, &c. The Alexandrian school, and Galen especially, clearly distinguished the ligaments, tendons and nerves.

Galen and Vesalius had already noticed the similarity which exists between the ligaments and certain membranes, and Ad. Murray had pointed out the very great resemblance which exists between the tendons, the ligaments and the aponeuroses. Isenflamm* has also offered some remarks on this tissue; but it was Bichat who first considered all the parts possessed of this tissue together, under the name of fibrous tissue. He comprehended in it the elastic tissue which I have separated from it (361), and excluded another kind which I have united to it, and which is the fibro-cartilaginous tissue of the articulations and tendinous grooves.

FIRST SECTION.

OF THE LIGAMENTOUS TISSUE IN GENERAL.

498. The Ligamentous Organs do not form a continuous whole. A centre, however, has been sought for them, and it has been tried to associate together all the parts of this system.

A very ancient opinion, anterior to Galen, but announced in one of his treatises, attributed to the pericranium the origin of all the *nervous* membranes. It has been thought that the Arabians, by translating into their language the word *meninx* (μηνιγξ) by a word which has the same signification, and also that of mother (μητηρ), considered the membranes of the brain as the generator of all the other membranes. This however is an error, the blame of which is to be ascribed to Sylvius, who has represented the meninges as fecund membranes and mothers. At a much later period Bonn, and quite recently Clarus, have in some measure attributed the same quality to the enveloping aponeuroses. Bichat has pointed out the periosteum as the central part of the fibrous system. But this system, which is formed of parts independent of each other, properly speaking, has no centre. Some of its parts are even entirely isolated from the others. It is a very generally distributed tissue, having much affinity to the cellular tissue, and in various places continuous with it.

499. The ligamentous tissue presents itself under two principal forms, that of the band or cord, as the ligaments and tendons, and

* *Bemerkungen über die flechsen, in Beiträge fur die Zergliederungskunst.* Band. I. Leipzig, 1800.

that of membrane or envelope, as the periosteum, the meninx, the sclerotica, &c. These two forms, the funicular and membranous, are confounded in certain parts, which are elongated and rounded at one extremity and expanded and flattened at the other, as is the case with certain tendons. Moreover, the membranous form, although in general destined to form envelopes, also sometimes forms bands. Such are the capsular ligaments, the aponeuroses of insertion, &c. According to its connexions, the ligamentous tissue has also been divided into parts subservient to the bones, the muscles, and the other organs; and, according to its uses, into parts serving for attachments or envelopes, or for both uses.

500. The colour of the ligamentous tissue is white. Its aspect is in general shining or silky.

501. The texture is essentially fibrous. The fibres of which it is composed are very minute filaments, which are parallel or interlaced. In some long and slender tendons, the fibres are, as it were, interwoven. In the aponeuroses they are commonly disposed in several planes crossing each other, and sometimes as it were interwoven together. In some parts of this tissue, the fibres are so closely united, that the whole seems homogeneous and not fibrous, of which kind are the cartilaginiform ligaments; but in all the other parts, in dropsical subjects, or in parts submitted to maceration, the bundles of fibres may be separated from each other, and the fibres themselves may be separated under the form of delicate filaments like the threads of the silkworm. It is not well known if this be the last term of division, but it is probable that it is so. These filaments are white, tenacious, possessed of little elasticity, flexible, and probably full and solid. Fontana and M. Chaussier consider this fibre as primary and particular; Isenflamm considers it as formed of cellular filaments impregnated with gluten and albumen; Mascagni says that microscopic inspection seems to demonstrate that those primary filaments result from a mass of absorbent vessels surrounded by a membrane formed of these same vessels and from another resulting from very minute blood-vessels forming a subtile net-work. It will be seen that this is nothing more than the idea already exposed in § 394. These filaments appear to be very condensed cellular tissue. Maceration softens them and converts them into mucous or cellular substance.

The various ligamentous organs are enveloped with sheaths formed by the cellular tissue. Those, moreover, which have distinct fasciculi contain cellular tissue in their intervals. Lastly, the fibres are themselves surrounded and connected together by that tissue, which infiltration and maceration render very apparent. Adipose tissue also occurs in the substance of the ligamentous organs. The ligamentous tissue has, in general, little vascularity; some small blood-vessels, however, are found at its surface and can be traced into its substance. To see them well, it is necessary, after injecting them with red, to dry the part, and then soak it with volatile oil of turpentine to render it transparent.

Some parts of the ligamentous system are highly vascular; of which kind are the periosteum especially, and the cranial meninx. Lymphatic vessels are perceived in the larger organs of this kind. It is doubtful whether they have nerves.

502. The ligamentous tissue naturally contains a large proportion of water. Desiccation renders it hard, transparent, elastic, and brittle, gives it a reddish or yellowish colour, and renders its fibres very indistinct. It resists maceration long. This process, however, softens it, renders it flocculent at its surface, separates its fibres, rendering the cellular tissue apparent in its substance, and at length converts the fibres themselves into mucous substance. Fire violently crisps it, and leaves a large quantity of charcoal. Decoction first curls it much, renders it yellow, hard and elastic, and at length reduces it to gelatine. Mineral acids in the cold and warm states dissolve it; nitric acid commences with curling it. Cold acetic acid swells it and reduces it to a gelatinous mass, and when hot melts it entirely. The alkalies swell and soften it. In this state its fibres easily separate, and present the colours of the rainbow.

503. The elasticity of recent ligamentous tissue is very trifling, but is more decided when it is dried. It has hardly any extensibility when the effort is sudden, whence the strangulations produced by the ligamentous parts, and the lacerations of this tissue by violent distentions. On the contrary, when the causes of distention act slowly and gradually, the ligamentous tissue yields and becomes thinner, its fibres separate, and even disunited if the slow distention is carried to a great length. The increase of volume which the fibrous tissue undergoes through excess of nutrition, must not be confounded with this phenomenon. The retractility of the fibrous tissue is exercised in the same proportion as its extensibility. It takes place quickly if the distention has been sudden without going so far as to produce laceration, and slowly if it has been gradual and slow. The tenacity or power of resistance of this tissue to rupture is enormous; it continues unabated after death. It has no irritability or vital contractility; nor can the motions of contraction alleged by Baglivi to have been observed in it, or the oscillatory motions supposed by La Case, be admitted. The sensibility of this tissue is extremely obscure or doubtful. Those who admit it, agree that it is only developed by certain mechanical agents, which have a specific influence upon its different parts. Thus the dura mater is said to be sensible to the impression of some stimulants which have no effects upon other ligamentous parts; the ligaments, to the distention or violent pulling which precedes their rupture, while the same thing does not take place in the tendons. There still remain many doubts on this subject. It has, however, been erroneously inferred, from experiments favourable to the opinion of the insensibility of the ligamentous parts, that they experience no impression from irritating

causes. These causes, on the contrary, develope inflammation, morbid sensibility, and various alterations in them. The power of formation which the ligamentous parts possess is very active.

504. The function of this tissue, which is entirely mechanical, is that of forming very strong bands, cords, and envelopes, which serve to connect the bones together, to attach the muscles to the bones, to contain certain parts, to transmit efforts, &c.

505. The ligamentous tissue is at first, in the embryo, soft and mucous like all the other parts. During the fœtal life and in childhood, it retains a great degree of softness and flexibility. It is then possessed of little consistence, more vascular, of a bluish white colour, with pearly or silvery lustre, and easily soluble in boiling water. Some parts, as the meninx, the sclerotica and the periosteum, are thicker than in the adult. The tendons and aponeuroses on the contrary are thinner and more slender. In old age, on the other hand, it becomes yellow, less shining, firmer, more coriaceous, drier, less vascular, and less soluble in boiling water than it was in adult age.

Notwithstanding the hardness of the ligamentous system in old age, it has not a very great tendency to ossify. The tendons never ossify but in places where they rub, and where they have a fibro-cartilaginous texture, and at their extremity which is inserted into the bones. The rare occurrence of ossification of the tendons in old age is so much the more remarkable, that in various animals, as certain birds, insects, and crustacea, ossification or a similar hardening always takes place in the regular development of these parts.

506. The different parts of the fibrous system, although sufficiently similar to form a genus of organs, are yet not identical. The tissue of the tendons is less compact than that of the ligaments, and that of the cartilaginiform ligaments is condensed so as to be almost homogeneous in appearance. The chemical composition of all these parts is nearly the same. The tendons, however, yield much more easily to the solvent action of boiling water than the other ligamentous parts.

507. The ligamentous tissue unites after being divided, torn, or ruptured, as is seen to happen to the ligaments after luxations. The tendo Achillis, or any other large tendon being broken, if the two ends are kept motionless and in contact, there first takes place an agglutination between them, then an organic union, which although at first more extensile than the tendon, in course of time acquires its power of cohesion or tenacity, and its almost inextensibility. Fibrous unions take place between the ends of divided muscles, and sometimes after fractures of the bones.

508. The accidental production of the ligamentous tissue is not unfrequent, and presents itself under various forms. There occur membranes of this kind around certain cysts which are seldom entirely enveloped by them. Certain solid tumours also have envelopes of the same kind. Preternatural joints also have more or

less distinct fibrous capsules. There sometimes occur fibrous laminæ or bridles in the serous membranes, and especially in the pleura.

The isolated fibrous or ligamentous bodies were seen at a very early period, but were confounded with schirrhus. M. Chambon has described them under the name of scleromes. Walter and Baillie were acquainted with them. Bichat, and after him M. Roux, have described them; but it is to Bayle and M. Laennec that we are indebted for the full knowledge of them. They have the globular form, their surface is uneven, and as it were lobulated. The largest anfractuosities contain vessels and infiltrated cellular tissue. When cut up, they are seen to be formed of lobules and convoluted bands, connected by cellular tissue, and of fibrous prolongations. They possess few vessels in their interior. They are at first small and soft like the fibrine of the blood. They gradually increase in size, and change in their texture. They rarely become cartilaginous, but frequently osseous. Stony ossification developes itself in them in an irregular manner, and resembles a mulberry calculus in their substance. They often form in the substance of and near the surfaces of the uterus; sometimes in the ovary, and in the accidental cellular tissue of the serous membranes, and are then formed of layers like a bulbous root, in the cellular tissue, and it has been said in the bones also. They have been seen in the fingers and eye-lids, and under the mucous membrane of the nose. Funguses of the dura mater are sometimes bodies of this kind. They have even been seen once in the brain.

Irregular fibrous productions occur in the cicatrices of the liver, bones, and skin, in the scrotum, and around fistulæ.

509. There is a production which comes very near the ligamentous tissue: it is that of a white compact tissue, not fibrous, nor laminar, nor cellular, semitransparent, chatoyant, feeble, and tenacious. Some wasted organs seem to be transformed into this tissue. The cicatrices of the skin, that of the cellular tissue after the cure of chronic phlegmons, and after that of old fistulæ, and some white granulations of the serous membranes, resembling Pacchioni's glands, are of this kind.

There should also be referred to it, the sclerosis which is observed in the cellular tissue and skin in elephantiasis of the limbs, scrotum, and vulva, and which has also been seen in the subperitoneal cellular tissue, in a case of cancer.

It is to this production also that most of the polypi of the uterus, and especially of the vagina, and certain tumours projecting under the skin which they raise up, should be referred, these polypi and tumours having a white, compact, feeble, and tenacious tissue, differing from the fibrous tissue, but approaching more to it than to any other.

These varieties of the accidental white tissue resemble morbid productions in their tendency to extend and sprout again.

510. The inflammation of the ligamentous tissue is little known, but is not of very rare occurrence.

It generally terminates by resolution, pretty frequently also by production of a plastic or organizable matter, which is sometimes absorbed, and sometimes gives rise to accidental ossification. Chronic inflammation of this tissue makes it lose its tenacity, and also sometimes gives rise to its ossification.

Some funguses of the dura mater, certain polypi of the nasal fossæ, and posterior parts of the nostrils, certain epulies, and some tumours of the periosteum, are morbid productions or cancerous alterations of the ligamentous tissue.

SECOND SECTION.

OF THE LIGAMENTOUS ORGANS IN PARTICULAR.

511. Keeping the fibro-cartilaginous tissue out of sight for the moment, the fibrous organs may be divided into those which attach the bones to each other, those which connect the muscles with the bones, and those which form envelopes.

ARTICLE I.

OF THE LIGAMENTS.

512. The Ligaments,* *Ligamenta*, *Nervi colligantes*, Σύνδεσμοι, are fibrous parts which attach the bones and cartilages to each other.

The same name has improperly been given to many other parts, and especially to bridles formed by folds of the serous and mucous membranes, to serous and adipose prolongations, &c.

The true ligaments are attached by their two extremities to the bones and periosteum, and that so firmly, that in the adult it requires a very advanced putrefaction to detach them. In children they separate from the bones along with the periosteum after a short maceration.

The fibrous tissue which forms them is very dense, and disposed in more or less distinct bundles very closely connected. Some have even the apparent homogeneousness of cartilages.

By decoction they are resolved, although with great difficulty, into gelatine and albumen.

513. The ligaments are often affected with inflammation, whether through mechanical causes, as those of sprains and fractures in the articular parts of the bones, or through the vicinage of inflamed synovial membranes, or through the specific causes of rheumatism of the joints or the gout. Inflammation gives rise to

* Jos. Weitbrecht. *Syndesmologia sivè Historia Ligament. corp. hum. &c. cum figuris.* 4to. Petropol. 1742.

two different effects in the ligaments, an extreme softening and a loss of their tenacity or accidental ossification. The latter change is the more frequent. The other is especially observed in the scrofulous diseases of the joints.

514. According to their connexions and uses, the ligaments are distinguished into articular and non-articular or mixed. The articular are those which are attached by their extremities to different bones which they connect together, and are the most important. The non-articular are those which being attached to parts of the same bone, serve to close notches, as at the orbitar arch and at the upper edge of the scapula, or to close an aperture and give attachment to muscles, as the obturator ligament of the infra-pubic foramen. The mixed ligaments are those which, like the sacro-sciatic and interosseus ligament of the fore-arm and leg, attach themselves to different bones, but are especially subservient to the insertion of muscles.

The articular ligaments are distinguished into capsular and funicular.

The capsular ligaments or fibrous capsules consist of cylindrical ligamentous sheaths which surround the articulation, are attached by their two ends to the two articulated bones, and are lined internally by the synovial membrane. These capsules, while they connect the bones in a firm manner, permit motions in all directions. They are nearly peculiar to the shoulder and hip joints, although rudiments of them occur in some others, in which irregular bundles strengthen the synovial membrane in several points of its contour.

The cords or ligamentous bundles of the articulations are rounded strings or flattened bands, situated for the most part at the outside of the joints, and only some of them within the articular cavities. Both kinds permit motion in some directions, and prevent or limit it in others.

The external ligaments are for the most part placed at the two sides of the articulation, and for this reason are called lateral ligaments. Many of the joints are furnished with them. Others are anterior or posterior. Some, on account of their direction, are called crucial ligaments. All these ligaments, which are attached by their two ends to the bones, correspond by one of their surfaces to the synovial membrane, and by the other to the surrounding common cellular tissue, muscles and tendons.

The internal ligaments are surrounded by a sheath furnished by the synovial membrane which is reflected at their two extremities, (212.)

ARTICLE II.

OF THE TENDONS.

515. The ligaments of the muscles or the tendons,* *Tendines*, Τένοντες, are ligamentous parts to which are fixed the extremities of the muscular fibres.

Of the tendons, some, which are funicular, have the form of elongated, rounded or flattened, but narrow cords, and are the tendons properly so called, while the others are broadened and membraniform, and constitute the aponeurotic tendons or the aponeuroses of attachment.

Both kinds are for the most part placed at the extremities of the muscles, and serve to attach them. Others which are placed in the muscles and interrupt their fibres, are tendons and aponeuroses of intersection or enervations.

Among the tendons of insertion, there are some, which, consisting of a multitude of small isolated fibrous bundles, have neither the funicular nor the membranous form. There are others which form arches attached by their two extremities, and under which vessels pass; of which kind is the tendon under which the femoral vessels pass to become popliteal, &c.

Among the tendons there are some which have the form of a cord in the greater part of their length, and while at one of their extremities, or at both, expand into membranes.

There are others which are simple at one extremity, and divide at the other into several cords or into laminæ of greater or less breadth.

516. The connexion of the tendons with the muscular fibres is very firm. It has even been asserted that there are a real continuity and identity between these parts. But, besides the difference of density and colour, besides the remarkable difference which is perceived with the microscope between the two tissues, there are seen aponeurotic tendons whose fibres have a direction different from that of the muscles. The tendons are much less vascular than the muscles. They are proportionally longer in children. They separate from the muscles by decoction, are resolved into cellular tissue by maceration, are not irritable like the muscular fibres, &c. They are not the continuation of the muscular fibres, but only that of the cellular tissue of the muscles.

By the other extremity the tendons are attached to the bones, and generally near the joints. And some aponeurotic tendons, in place of directly attaching themselves to the bones, expand and are confounded with the envelopes of the muscles.

The tendons are surrounded with common and loose cellular tis-

* Albinus. *Annot. Acad.* Lib. IV. Cap. 7, and Tab. 5.

sue, or with mucilaginous bursæ, according to the extent of the slidings which they experience.

Some are kept in place by rings or sheaths.

The colour of the tendons is white, shining, with blue and green reflections, and silky or velvety aspect.

The fibrous tissue of which they are composed contains in its intervals, in the larger at least, cellular tissue and small blood vessels.

Some tendons have a fibro-cartilaginous texture. They are such as rub against bones. They even at length become bony in these points.

Their essential properties are their inextensibility and power of cohesion, which render them qualified to transmit the action of the muscles to the bones, this being the only function which they have to perform.

They are rarely altered. Puncture produces an indolent swelling in them which slowly disappears by resolution.

ARTICLE III.

OF THE LIGAMENTOUS ENVELOPES.

517. In certain parts, envelopes are formed by ligamentous membranes, similar to those which the cellular tissue furnishes to the other organs. These membranes are the following:

I. ENVELOPES OF THE MUSCLES.

518. The envelopes of the muscles, or the enveloping aponeuroses, also furnish, in some places, insertions to muscular fibres. They are of two kinds, some surrounding the muscles of the limbs, others investing those of the walls of the trunk.

519. The enveloping aponeuroses of the limbs, *Fasciæ Musculares*,* are ligamentous membranes which surround the muscles of the limbs and keep them against the bones. These membranes have the form of sheaths. Their outer surface corresponds to the cellular and adipose tissue, as well as to the subcutaneous vessels and nerves. Their inner surface corresponds to the muscles, furnishes attachments to some of them, sends between the greater part of them laminæ, septa or prolongations which separate them from each other, furnish attachments to them, and terminate by being inserted upon the ridges and lines of the bones. Their extremities are attached to the bones, receive insertions or expansions of the tendons, lose themselves insensibly in the cellular tissue, and in other places form annular ligaments to the tendons. They consist of one or more layers of ligamentous tissue of variable thickness, and are proportionate in their thickness to the number

* Ad. Murray, *De Fascia Latâ.* Upsal, 1774.

and strength of the muscles which they surround. They present openings for the passage of vessels from the deep to the superficial plane, and *vice versa*. They are furnished with tensor muscles, whether proper, or simply by expansion of their tendons. Their uses are to keep the muscles in place, and furnish attachments to them. They exercise by their resistance a slight pressure upon the deep vessels, and thus favour the venous and lymphatic circulation. Their knowledge is of great importance in a pathological point of view, on account of the strangulations to which they may give rise. Nor is it less so in surgery, by reason of their connexions with the muscles and vessels.

The thigh, the leg, the foot, the hand, the fore-arm and the arm, are furnished with aponeuroses of this kind.

520. The aponeuroses of the walls of the cavities of the trunk, or the partial aponeuroses, invest, cover, and even envelope, at least in part, certain muscles. Of this kind are the compound aponeurotic sheaths of the recti and pyramidales muscles of the abdomen; the aponeurosis of the back, which covers the muscles of the vertebral grooves; the temporal aponeurosis; the pelvic, transversal, superficial, jugular aponeuroses, &c. Some of them, and especially the latter, are not very distinct from the cellular tissue, into which they are continued.

II. OF THE SHEATHS OF THE TENDONS.

521. The sheaths of the tendons are ligamentous canals which surround and fix the tendons in their place.

Some of them are sufficiently long to form true canals; others, which are much shorter are called annular ligaments. Of these annular ligaments, some are entirely circular. The others, as well as the sheaths, are completed by the neighbouring bones, whence result osteo-ligamentous sheaths. They are, as well as the tendon which they contain, lined by vaginiform synovial membranes. These sheaths are very solid and strong. They contain each one or more tendons. They are especially numerous at the free extremity of the limbs, more in the direction of flexure, and also stronger in this direction than in that of extension. They keep the tendons in their places, prevent their displacement during the action of the muscles and the motions of the joints. They also, in some places, serve as pullies which change the direction of the tendons, and modify that of the motions.

III. OF THE PERIOSTEUM.

522. The envelope of the bones, or the periosteum, surrounds the bones in their whole extent, excepting the articular surfaces. The teeth alone, which however are not bones, are destitute of it.

This envelope is interrupted at the amphiarthrodial and diarthrodial articulations, but is not so at the immoveable articulations.

Its outer surface is flocculent, and covered with filaments which are confounded with the surrounding cellular tissue, and which, in other places, are continuous with the ligaments and tendons.

The inner surface is attached to the bone by innumerable prolongations which accompany the vessels into its interior and into its substance. This surface is very firmly attached to the bones where they are thick and spongy, but less firmly in the other parts. Its adhesion is also less firm in children than in adults.

The thickness of the periosteum is variable, and proportionate to that of the bones.

Its texture is fibrous, and in the places against which tendons rub fibro-cartilaginous. It has very numerous blood vessels,* and in this respect forms a remarkable exception in the ligamentous tissue. Lymphatic vessels have also been perceived in it. No nerves have been observed.

The periosteum is at first thin, and possesses little vascularity previously to the period of ossification. It becomes thick and vascular at that epoch. The use of madder does not colour it.

The functions of the periosteum are to envelope the bones, sustain the vessels, unite the epiphyses, in childhood, to the body of the bone, and serve at that period for the insertion of ligaments and tendons.

The use of forming the bones has been attributed to it, but without proof, for ossification of the short bones is seen to commence at the centre of the cartilage, and consequently at a distance from the periosteum. There have also been attributed to it the faculties of determining the form of the bones, limiting their growth by retaining the bony juices, &c. As to the part which it may perform in the increase of the bones in thickness, the repairing of bones when divided or affected with necrosis, it will be afterwards examined (Chap. VIII.)

The periosteum when divided unites again. When removed, a superficial necrosis commonly follows, and it is reproduced after exfoliation. When it is inflamed, resolution sometimes takes place, and at other times gangrene. Sometimes it suppurates, and then more or less quickly separates from the bone, which becomes affected with necrosis. At other times the inflammation being plastic, a deposition takes place in its substance, forming a periostosis, which is sometimes dispersed by absorption, and at other times ossifies. The periosteum is sometimes the seat of a degeneration or a cerebriform cancerous production, at the centre of which the bone itself is not much altered.

523. The perichondrium, or ligamentous membrane which en-

* See Ruysch. *Adv. Anat.* Dec. iii. Tab. ii. fig. 8.—Albinus. *Icon. oss. fœtûs.* Tab. xvi. fig. 162.

velopes the cartilages, differs from the periosteum only in being much less vascular. It has the same uses, with respect to the cartilages, as the periosteum has with respect to the bones, and, moreover, gives to those which are thin and flexible, a resistance to rupture, and a tenacity which they do not of themselves possess.

IV. OF THE FIBROUS ENVELOPES OF THE NERVOUS SYSTEM.

524. The nerves have a proper envelope, the neurilema, which is of the same nature as the ligamentous tissue. Around the spinal marrow, this envelope loses the solidity of the ligamentous tissue, and around the brain, where the pia-mater is its continuation, it becomes purely cellular and vascular. The neurilema, which is much less vascular than the pia mater, is still a very vascular part of the ligamentous system.

525. The dura mater or meninx, which is vascular like the periosteum, differs from that common membrane of the bones, in being lined by the arachnoid membrane, which converts it into a fibro-serous membrane, inasmuch as it forms a coat or capsule to the brain and spinal marrow, contains sinuses or venous canals in its substance, within the skull, the only place where it also serves as a periosteum, and forms prolongations or septa between the divisions of the encephalon.

V. OF THE COMPOUND FIBROUS MEMBRANES.

526. The pericardium and the perididymi or vaginal coats are, like the dura mater, fibro-serous membranes resulting from the intimate union of a ligamentous membrane with the external or parietal lamina of a serous membrane.

In the nasal fossæ and their sinuses, in the cavity of the tympanum, and in the mastoidal sinuses, at the arch of the palate, and in some other places, the periosteum is immediately covered by a mucous membrane which is intimately united to it, thus constituting a fibro-mucous membrane.

These compound membranes resemble, in their texture, functions, and alterations, the two kinds of tissue of which they are formed.

VI. OF THE FIBROUS CAPSULES OF SOME ORGANS.

527. Lastly, the eye is contained in a capsular membrane called sclerotica and cornea; the testicle in one which is named albuginea; both remarkable for their thickness and solidity. The ovaries, the kidneys, the liver, and some other parts, have envelopes of the same kind, but not nearly so thick or solid. Most of these capsules, in fact all of them excepting the sclerotica, have fibrous internal prolongations which extend into the tissue of the organ.

They are perforated by some openings for the passage of vessels, but have little vascularity themselves. Their common uses are to determine the form of the organs which they envelope, to contain, support, and protect the internal parts.

THIRD SECTION.

OF THE FIBRO-CARTILAGINOUS TISSUE.

528. The Fibro-cartilaginous Tissue is fibrous and tenacious like the ligamentous tissue, of which it really forms a part; white, very dense and elastic, like the cartilaginous tissue; and seems intermediate between the ligaments and cartilages.

529. Galen has named certain ligaments neurochondroid, νευροχονδρωδεις συνδεσμοι; Vesalius calls them cartilaginous ligaments; Morgagni considers them as intermediate between the ligaments and cartilages; Weitbrecht comprehends them among the ligaments; Haase, on the contrary, arranges them in his Chondrology, under the names of ligamentous and mixed cartilages. Bichat has proposed a fibro-cartilaginous system, composed of the cartilaginiform ligamentous tissue of which we here speak, and a part of the cartilaginous tissue, which will be described in the next chapter; but this system of organs does not seem to me to exist in nature, for which reason I have not retained it. The fibro-cartilages of which we speak appear to me to be but a variety of the desmous tissue: they are cartilaginiform ligamentous organs.

530. The fibro-cartilages are temporary or permanent.

The temporary fibro-cartilages are those which pass regularly, constantly, and at determinate epochs, into the osseous state: they are the fibro-cartilages of ossification. They are met with in the substance of the tendons and ligaments. They are purely fibrous in the beginning, and afterwards become fibro-cartilaginous, and ultimately osseous. The patella and sesamoid bones are developed in this manner. The places where the tendons rub against the bones, those, for example, where the gemelli are applied upon the femur, and where the peronæus longus lateralis slides upon the tarsus, are also constantly the seat of fibro-cartilages of this kind. The stylo-hyoid and thyro-hyoid ligaments contain grains of the same nature in their substance. The sclerotica, in certain animals, presents opaque dots, equally fibro-cartilaginous, which afterwards form bony plates.

531. The permanent fibro-cartilages, or at least those which remain during the greater part of life, are of several species. 1st, There are some which are free at their two surfaces. These are the inter-articular ligaments, *menisci*. They are met with in the temporo-maxillar and sterno-clavicular articulations, sometimes in that of the acromion with the clavicle, and always between the femur and tibia, and between the ulna and pyramidal bone. These

ligaments, which are perfectly isolated at their two surfaces, adhere by their edges or their extremities. 2. Others adhere by one of their surfaces. Of this kind are the fibro-cartilages which are met with wherever a tendon rubs against a bone, and whose presence is owing to the circumstance that the periosteum becomes cartilaginous in these places; and those which the ligaments present upon which tendons slide, as is the case with the calcaneo-cuboidal ligament, against which the tendon of the tibialis posticus muscle rubs. Such are also the fibro-cartilaginous rims attached to the edge of the glenoid and cotyloid cavities. In general, wherever the fibrous tissue is exposed to habitual friction, this tissue assumes a cartilaginous texture and aspect, as is seen at the annular ligament of the wrist, and the transverse ligament of the odontoid process. The pulley of the obliquus major also affords an example of the same kind. 3. Certain cartilaginous ligaments adhere by their two surfaces. The intervals between the bodies of the vertebræ and the interval between the two ossa pubis, are filled up with organs of this kind. Thus, according to their form and connexions, there may be distinguished three kinds of cartilaginiform ligaments.

532. These organs, although always fibrous like the ligaments, and very dense like the cartilages, present a great number of varieties, with reference to the consistence and homogeneousness of their tissue. The menisci, or inter-articular ligaments, for example, present very distinct fibres at their circumference, and towards their centre, which is thin, assume an appearance becoming more and more compact and homogeneous, without however deserving, even in that place, to be considered as true cartilages. The cartilaginous periosteum has more resemblance to these latter. In the amphiarthrodial ligaments, a very apparent fibrous tissue exists at the exterior. In proportion as it approaches the centre, it becomes converted into a kind of pulp or white pap which resembles cartilage, less in its consistence however than from the disappearance of the fibres and its apparent homogeneousness.

533. There enter into the composition of the fibro-cartilages the same parts as into that of the ligamentous tissue. Few vessels occur in them. Their chemical composition has not been sufficiently examined. By desiccation they become yellow and transparent, like the ligaments. Decoction acts upon them in the same manner as upon these latter: it melts them entirely into jelly, so that they do not in this respect participate of the nature of the cartilaginous tissue.

534. Their physical properties are similar to those of the ligaments and cartilages. Their tenacity or force of cohesion, which is very great, and even exceeds that of the bones, approaches them to the ligamentous tissue. On the other hand, they are very elastic, and quickly return upon themselves when they have yielded, whether to distention or to pressure. It is when they are compressed that their elasticity is most remarkable. They resist the

destructive action of pulsatile tumours more than the bones and cartilages. In aneurisms of the aorta, the vertebræ are worn and destroyed before the fibro-cartilage which separates them. This property is a consequence of their elasticity. The vital properties of the fibro-cartilages are obscure, like those of the ligamentous tissue in general.

535. In their formation, several of these parts pass through the fibrous state; others pass directly from the mucous state to the fibro-cartilaginous state. It is only accidentally, and in a variable manner, that the permanent fibro-cartilages become bony in old age. This, however, happens more frequently to them than to the ligaments, but less frequently than to the cartilages.

536. The temporary fibro-cartilages have for their use to serve as a type or mould to bones. Those which are permanent sometimes form flexible, elastic, and very firm bonds, and sometimes serve to facilitate slidings, by the consistency which they give to the surface.

537. The morbid states of the fibro-cartilages are little known. They unite again after being divided, as is seen after the operation of symphyseotomy.

Their accidental production is not of very rare occurrence. The centre of an intervertebral ligament may be taken as the type of the species, and as an object of comparison. The accidental fibro-cartilages are, in fact, fibrous, like the ligaments, of a milky white like the cartilages, pliant, moist, and elastic. According to their form, connexion, and uses, the accidental fibro-cartilages may be divided into two kinds. Some of them are means of union of certain fractures which have been consolidated, whether on account of motions, like those of the neck of the femur, the patella and others, or on account of an extensive loss of substance in one of the bones of the fore-arm, leg, metatarsus, metacarpus, skull, &c. places where the fragments cannot be brought together, other fibro-cartilages form on the end of amputated bones, the surfaces of supernumerary articulations, upon and around the surface of supplementary articular cavities, and in some false anchyloses. Formless fibro-cartilages occur in some compound tumours of the thyroid body, in certain cysts, and in some cicatrices, especially those which sometimes take place in the lungs, in consequence of the evacuation of the tubercles. Plates of the same kind are found at the surface of the spleen. The fibrous bodies of the uterus are sometimes soft and pulpy at the centre, like the intervertebral ligaments. Lastly, there are sometimes formed regular fibro-cartilaginous masses, of a globular form, lying loose in the serous cavities in which they have penetrated. Dr. Trouvé, of Caen, gave me a tumour of this kind, of the size of a nut, which was found along with another of the same nature in the peritoneal cavity. This tumour, which is distinctly fibrous at the exterior, is soft like the intervertebral ligaments, towards the centre, and there contains a bone of the size of a small pea.

538. Inflammation of the fibro-cartilages has been little observed. All that is known is, that in certain cases, the desmo-cartilaginous parts become extremely soft in consequence of an afflux of fluids, forming a kind of congestion. This is observed in gestation, at the symphysis of the pelvis, and has been observed even in man, in the same articulations. The vertebral column presents this softening in a very marked degree in cases of rachitis. There results from it a flexibility of the intervertebral ligaments which makes the column bend with the greatest facility, and, if the individual keeps habitually in a bad attitude, causes the spine to bend laterally in several places, and ultimately involves the vertebrae themselves in the deformity.

One of the varieties of the vertebral disease also consists in the softening and swelling of the intervertebral ligaments, which at length ulcerate and are destroyed.*

CHAPTER VII.

OF THE CARTILAGES.

539. The cartilages, Χόνδροι, are white, hard, flexible, very elastic, brittle parts, of homogeneous aspect, which form the skeleton of the vertebrate animals lowest in the series (the chondropterygious fishes), which take the place of the bones in the other vertebrata at the commencement of their life; and of which some, persisting in the adult state, form parts which are solid, hard, and flexible at the same time.

540. The old anatomists, and those of the Italian school, disputed much respecting the matter which forms the bones and cartilages, and their differences. Gagliardi and Havers in vain searched for this difference in the intimate texture of the parts. More useful observations have been made in the last century on the cartilaginous tissue. We are indebted to Haase† for a very good dissertation on this subject; but that anatomist, like several of those who preceded and followed him, has confounded the chondroid ligaments with the cartilages, which renders his general description somewhat vague. Bichat has separated from the other cartilages those which are thin and very flexible, to form of them, along with the cartilaginiform ligaments, the fibro-cartilaginous system; but these latter are true ligaments, and the former true cartilages.

541. The cartilages are either temporary or permanent, the former constantly, regularly, and completely disappear at a determi-

* It would be extremely difficult to cite a well authenticated case of such a disease. K.

† J. G. Haase. *De Fabricâ Cartilaginum.* Lips. 1767.

nate period of their growth, and are replaced by the bones. The latter remain much longer, and sometimes more than a century, in the cartilaginous state. Several of them, however, at length ossify, sometimes even at the end of the period of growth. The temporary cartilages will be described along with the bones, (Chap. VIII.) We shall speak only of the cartilages named permanent. They form a pretty natural genus of organs, and also present some differences.

SECTION I.

OF THE CARTILAGES IN GENERAL.

542. Some cartilages have an elongated form, of which kind are the costal cartilages; others are thick and short, as the arytenoid cartilages and the cricoid cartilages; but the greater number are broad and thin. Some of them are attached to the bones, of which they cover certain parts; others are prolongations of them, and are firmly united to them; others are connected with the bones by ligaments; others are attached to each other, and have no other connexions with the bones.

The cartilages are of a pearly white colour, and semi-transparent when in thin laminæ. Although they are the hardest parts of the body after the bones, they are easily cut.

543. Examined in their substance, the cartilages present neither cavities, nor canals, nor areolæ nor fibres, nor laminæ;—nothing, in short, that indicates an organic texture; but appear homogeneous. However, it appears that they have a distinct and different kind of texture in each species of cartilage. This circumstance will be examined as we proceed.

All the cartilages, excepting those of the articular surfaces, are enveloped by a fibrous membrane, the perichondrium, which has few vessels, and is not so intimately connected with the cartilages as the periosteum is with the bones. Neither nerves nor vessels are known in the cartilages. The cellular tissue does not become apparent in them during life, and after death it requires a maceration prolonged during several months, even in young subjects, to reduce them to a mucous substance resembling the cellular tissue, and which, in their ordinary state, must be in an extreme degree of condensation.

544. The cartilages contain a great quantity of water,* or of serous fluid, which oozes out at the surface when they are cut, and which moistens it. In the adult man the proportion of water which they contain is to the solid substance as $2\frac{1}{4}$ to 1. Cartilage when dried becomes semitransparent, yellowish, and capable of be-

* Chevreul, *De l'Influence que l'eau exerce*, &c. in *Ann. de Chimie et de Physique*, t. xix.

ing torn. When immersed in water it in four days reacquires its weight and volume, its white colour and its flexibility, and loses its transparency.

545. When submitted to the action of boiling water, in thin laminæ, it at first curls and becomes yellow and opaque.

The prolonged action of boiling water upon the cartilages establishes a difference among them, founded also upon other characters; the articular cartilages are resolved into jelly by decoction, the others, on the contrary, resist its action. Alcohol renders the cartilages a little opaque. Diluted acids have no action upon them, when concentrated, they act as upon the epidermis. Their chemical analysis is imperfect. It has been vaguely repeated, after Haller, that they are composed of gelatine and earth. According to Mr. Allen, they consist of gelatine and a hundredth part of carbonate of lime. Hatchett says, that they are formed of coagulated albumen and traces of phosphate of lime, but it is not known of what kind of cartilage he speaks. M. Chevreul has found, that the cartilaginous bones of the shark are composed of oil, mucous, acetic acid and some salts. Mr. J. Davy has found cartilage to be formed of albumen 4 to 5, water 55, and phosphate of lime 0.5.

546. The most remarkable physical properties of the cartilages is elasticity. They do not elongate and return upon themselves, like the elastic tissue, nor, like the chondroid ligaments, do they in general yield to pressure, and afterwards resume their thickness; but they are flexible, and return to their original state with force and celerity when the cause of flexion ceases to act. The articular cartilages alone are elastic in the same manner as the fibro-cartilaginous tissue.

547. The vital properties and the phenomena of formation, irritation, and sensation, are extremely obscure in the cartilaginous tissue. It is not known if it be to the articular cartilages, or rather to the synovial membranes which cover them, that the pain is to be attributed which the foreign bodies of the articulations cause when they become engaged between the surfaces.

548. The functions of the cartilages depend solely upon their physical properties; upon their solidity, which renders them fitted for preserving the form of certain parts, and their flexibility and elasticity, which allows them to yield, and immediately resume their original form.

549. In the embryo and fœtus the cartilages are soft, mucous, and transparent, like jelly or glue. The proportion of water which they then contain is excessively large. In the child they still have little colour or elasticity, and are very transparent and soft. They then acquire the whiteness, firmness, and semiopacity by which they are characterized. In old age they become whiter or yellowish, more opaque, less flexible, more brittle and drier; the proportion of water diminishes in them, and that of the earthy substance increases. They generally end with ossifying, at least in

some points. This change sometimes commences at the adult age, but especially in old age. Inflammation gives rise to it prematurely.

550. The organic action of nutrition appears to be very slow in the cartilages. The use of madder does not colour them, that substance appearing to have affinity only with the earthy substance of the bones. They become yellow in jaundice. The cartilaginous bones of the vertebral column of the lamprey appear and disappear each year, from which they must be inferred to possess a great organic activity, which is also the case with the rapid growth of the larynx towards the period of puberty.

551. Incidental cartilaginous productions are very common. They possess all the characters of the natural cartilages; their colour, apparent homogeneousness, &c. They present all the varieties of texture of the cartilages, and even more, and may also be distinguished into two kinds. The imperfect accidental cartilages are sometimes in the state of jelly, or have the consistence of the boiled white of an egg. They have a milky, or yellowish, or pearl gray colour. They ossify in part or in whole, rather than become perfect cartilages. They are met with under the form of incrustation in the arteries, and especially in the aorta and cerebral arteries, under the form of cysts around morbid productions and acephalocysts, forming fistulous passages in the lungs, under the form of irregular masses in goitres and other compound tumours, and under that of isolated bodies in the joints.

The perfect accidental cartilages are those which present the characters of the natural tissue, and especially its firmness. They occur, forming small cysts filled with phosphate of lime. They are often met with in the state of isolated bodies, of moderate size, and of a roundish form, in the synovial membranes, or at their exterior, whence they penetrate into the cavity by pushing the membrane before them, and enveloping themselves in it as in the finger of a glove, the base of which, after being attenuated, is cut off across. They ossify imperfectly in whole or in part, commencing at the centre. Cartilaginous bodies of this kind are also met with in the splanchnic cavities, and especially in the tunica vaginalis, into which they penetrate like the preceding.

Perfect cartilages also occur under the form of incrustation or plates, in the subserous cellular tissue of the spleen, the lungs, and the pleura costalis, in the substance of the valves of the heart, especially in the left side, in the subserous tissue of the diaphragmatic pleura and peritonæum, and in that of the liver; in herniæ, and rarely in the anterior wall of the abdomen. All these incrustations have a great tendency to ossify. Cartilages also occur in shapeless masses in the compound tumours, under the accidental cellular tissue of the serous membranes.

Accidental cartilages are sometimes formed by transformation of other tissues. An old woman who was some years ago at the Hospital of the Faculty of Medicine at Paris, and who had on her forehead a broad conical horny excrescence which grew upon the cicatrix of a burn, having died, the bones of the skull were found to be transformed into cartilages under this horn. M. Laennec saw a cartilaginous transformation of the mucous membrane of the urethra. I have seen the same thing in the vagina, in a case of prolapsus uteri, and in the prepuce, in the case of congenital phymosis, in an old man. I am at the same time of opinion that these three cases belong rather to the desmo-cartilaginous productions.

552. Alterations of the cartilages * are rare and most commonly consecutive. They resist for a very long time the destructive action of aneurismal tumours, and the propagation of diseases of the neighbouring organs. The alterations to which they are subject, and the reparation of their injuries, are somewhat different in the different kinds of this tissue.

SECTION II.

OF THE DIFFERENT KINDS OF CARTILAGES.

553. The cartilages may be divided into three principal kinds, with reference to their form, their connexions, their texture, their properties, and their functions.

ARTICLE I.

I. OF THE ARTICULAR CARTILAGES.

554. The diarthrodial articular cartilages † are flat and broad cartilaginous laminæ, which invest or incrust the surfaces of the bones in the moveable articulations. These laminæ have a free surface, covered by the synovial membrane which is closely attached to it, and a surface which also adheres intimately to the surface of the bone, without a continuity of tissue however existing between them. Their circumference, which is thinner than the rest, extends to that of the articular surfaces of the bones. Their thickness, which is inconsiderable and proportionate to their breadth, is from one to two lines in the largest, and a fraction of a line in the smallest. It is not the same in the whole of their extent. Those which invest convex bony surfaces are thicker at the centre than in the rest of their extent. Those of the concave surfaces, on the contrary, are thicker at the circumference than at the centre.

* Dœrner, *præside Autenrieth, De gravioribus quibusdam cartilaginum mutationibus.*—Tubing. 1798.

† W. Hunter. Of the Structure and Diseases of Articulating Cartilages, in Philos. Trans. 1743.—Delasone, *Sur l'Organisation des Os*, in *Mem. de l'Acad. des Sc.* Paris, 1752.

555. The texture of these cartilages is at first sight as indistinct as that of the others, so that they resemble a layer of wax spread over the bone, but may be discovered by certain modes of procedure. It is fibrous. Maceration of an articular part of a bone, continued for six months, effects the destruction of the synovial membrane, the only membrane covering the cartilage which is destitute of the fibrous perichondrium, and produces disunion of the fibres of which it is composed, which rise perpendicularly from the surface of the bone like the pile of velvet. If a cartilage thus disposed by maceration be dried, the fibres become smaller and thus separate from each other, becoming more distinct. Decoction, when not prolonged so as to dissolve the cartilage, produces at first the same effect as maceration. The action of fire also discloses the structure in the same manner. These cartilages have no vessels. Delicate injection and microscopic inspection show the capillary vessels terminating at their circumference and at their adherent surface, without ever penetrating into their substance.

These cartilages, which are compressible and elastic, deaden the effects of pressure and concussions. The smoothness of their surface facilitates the motion of the diarthrodial articulations. They become much thinner in old age.

556. In preternatural joints, no true cartilages are produced, but only desmo-chondroid tissue, a tissue which, in truth, greatly resembles that of the diarthrodial cartilages. In the natural diarthrodial articulations, the destruction of the cartilages is sometimes followed by their nearly perfect reproduction; only the new cartilage produced at the surface of the bone, being thinner, has a somewhat bluish appearance, which is owing to its semitransparency. The edges of the old cartilage are free, and extend over the very thin contour of the new cartilage.

In the joints of old persons affected with various other alterations, the diarthrodial cartilages are sometimes found converted into villous fibres, free and floating. When laid bare in amputation at the joints, if the wound unites by first intention, the cartilage and its synovial membrane do not unite, but remain free behind the cicatrix. If the wound remains open, if it inflames and suppurates, the cartilage is seen at the end of some days to soften, and afterwards gradually to disappear from the circumference to the centre, in proportion as the granulations extend to the surface of the bone, and even before they reach it. Inflammation of the diarthrodial cartilages is in general of rare occurrence; and, when it takes place, commonly terminates by ulceration or absorption. This ulceration of the diarthrodial cartilages is most commonly consequent to inflammation of the synovial membrane or bone, sometimes to that of the cartilage itself, but it also sometimes seems not to be preceded by any inflammation. Sometimes, before ulcerating, the cartilage softens and assumes a fibrous appearance. This ulceration most commonly takes place in young subjects, or before middle age. It is accompanied by a pain, which is at first slight, but which gradually increases in intensity. When the ulceration stops and heals, there takes place a reproduction of cartilage, of which we have already spoken, or a bony production of the nature of ivory or enamel, or, lastly, a union of the surfaces by anchylosis. In the case of true anchylosis, the cartilages are always absorbed.

557. The cartilages of the synarthrodial articulations, are extremely thin laminæ, placed between the bones which are articulated in an immoveable manner, and holding firmly on each side to these bones by a kind of suture. Their edges, in the interval between the bones, are intimately attached to external and internal periosteum, which passes from the one to the other bone. They thus greatly contribute to the solidity of these articulations. These cartilages, in the sutures of the skull, are thinner at the interior than at the exterior of the wall, which in part accounts for the quicker disappearance of the sutures at the interior than at the exterior of the skull. With respect to the frequency of their ossification, they are intermediate between the temporary and the permanent cartilages.

ARTICLE II.

OF THE COSTAL, LARYNGEAL, AND OTHER CARTILAGES.

558. The costal cartilages * are the longest and thickest cartilages of the body. They constitute cartilaginous prolongations to the bony ribs. The first of them may also be considered as anterior or sternal cartilaginous ribs. The cartilages are all attached to the anterior extremities of the ribs by engrenure, like the synarthrodial cartilages. The first is even continuous with the sternum at the other extremity. The next six are articulated with the sternum by diarthrosis. The three following are in the same manner articulated with those which precede them. The last two are immersed in the intermuscular cellular tissue.

559. The texture of these cartilages is very obscure, and at first sight they appear homogeneous. However, by maceration prolonged for at least six months, the costal cartilages divide into oval laminæ or plates, separated from each other by circular or spiral lines, and united together by some oblique fibres which they send into each other. These laminæ are themselves divided into radiated fibrils, and the fibrils at length into minute bundles, which are at length reduced into mucous substance. All these divisions or separations are first produced at the circumference of the cartilage. The centre is more homogeneous, and is the last part that divides. This separation may be accelerated by drying in the sun

* Hérissant, *Sur la structure des cartilages des côtes de l'homme et du cheval*, in Mém. de l'acad. des sc., 1748.

a costal cartilage that has been macerated for two or three months. Acids produce a similar effect.

560. The costal cartilages are somewhat flexible and highly elastic. In inspiration, the motion impressed upon the ribs by the muscles, bends them and twists them upon themselves; and when the muscular action ceases, they tend of themselves to resume their original direction, and are thus agents of expiration.

561. After adult age, and in old age, the costal cartilages cease to be or to appear homogeneous. Their perichondrium becomes opaque, and there are produced, between it and the cartilage, and in its substance, bony plates, more or less numerous and broad, which sometimes end with forming a more or less complete bony sheath. This change almost always happens to the first, commencing at its sternal extremity. The other sterno-costal cartilages also experience it, but in a less degree. The asternal costal cartilages, or those of the false ribs, experience it still less, or not at all. At the same time the costal cartilages become yellowish, then reddish in their centre, which also presents more or less large and numerous bony dots, which sometimes at length occupy the whole cartilage. This latter phenomenon shows itself more frequently and sooner in the asternal cartilages than in the others.

These changes in the cartilages are commonly the effect of age. They commence towards the middle of life, and go on continually increasing. Persons of a hundred and thirty and a hundred and fifty years, however, have been seen to have costal cartilages in their natural state.

When the cartilages begin to undergo this change, desiccation causes them to break across in the centre, which has become areolar, and not at the surface, which has, on the contrary, become denser.

They frequently ossify, and at an early age, in persons affected with phthisis.

562. The costal cartilages, when denuded, do not produce granulations, but are covered by those of the neighbouring parts. When broken, they do not unite by a cartilaginous substance, but a cellular lamina is produced between them, and the broken place is enveloped with a bony ring furnished by the perichondrium, and which is more or less regular, according as the fragments have remained more or less exactly in opposition. I have sometimes seen in man, and repeatedly in the horse, the fractures of ossified asternal cartilages, united by a bony callus.

The costal cartilages are subject to some vices of original conformation, and are even liable to be wanting in whole or in part. In the latter case, it is always the extremity next to the rib that exists. When the thorax is deformed, when it is contracted, as sometimes happens after the cure of pleurisy, the cartilages of the affected side bend and become deformed.

563. The nasal cartilage, that of the auditory canal, and that of the Eustachian tube, are in a manner articulated to the bones by

engrenure. Those of the larynx, on the contrary, are only attached to the bones by ligaments, and are connected together by moveable articulations.

These cartilages have still a certain thickness. When their perichondrium is raised, their surface is found to be smooth and compact. Long continued maceration divides these cartilages into fibres or filaments more or less short. Boiling and mineral acids produce the same effects.

These cartilages are flexible and elastic. By their solidity they preserve the form and cavity of the organs which they contribute to form. Those of the larynx present the remarkable peculiarity of a very rapid growth at the period of puberty. These same cartilages sometimes ossify at adult age, at least in part. Chronic inflammation of the mucous membrane of the larynx, and its ulceration, greatly hasten this ossification, which, in fact, always takes place in phthisis laryngea, and is of frequent occurrence in phthisis pulmonalis.

When the thyroid and cricoid cartilages are divided, they unite by bony laminæ of the perichondrium, which are thicker at the exterior than at the interior of the larynx.

ARTICLE III.

OF THE MEMBRANIFORM CARTILAGES.

564. The Membraniform Cartilages are those which Bichat has placed in his fibro-cartilaginous system. They are very thin, and possessed of great flexibility.

They are the palpebral cartilages or tarsi, the cartilage of the ear, those of the nostrils, the cartilage of the epiglottis, the median cartilage of the tongue, and the cartilages of the trachea and bronchi.

These very thin cartilages are furnished with a perichondrium, which is very thick and very strong compared with themselves, and sends into their substance fibrous and cellular prolongations, some of which even pass entirely through them. Their surface also is very uneven and porous. Maceration continued for two or three months softens them, and reduces them to the state of distinct fibrils at first, and finally into cellular or mucous substance.

They are very flexible, perfectly elastic, and much less brittle and more tenacious than the other cartilages. Like the preceding, they concur in forming organs or canals, of which they preserve the form and caliber. They are rarely ossified, and only at a very advanced period of life. The wings of the trachea alone present a more or less extended ossification in the adult. In cases of phthisis, however, the cartilaginous wings of the bronchi have been found ossified. In gouty persons also, and after inflammation of the ear, the cartilage of that part has been seen to become bony. In the case of goitre, and even without this cause of pressure, the cartilaginous wings of the trachea are sometimes found compressed from one side to the other, and their middle part bent at an angle. The same change of form is also observed in the bronchi.

CHAPTER VIII.

OF THE OSSEOUS SYSTEM.

565. The osseous system*, or the skeleton, Σκελετὸν, results from the union of the bones, which are the hardest and driest parts of the body.

566. It is of all the systems that which shows itself last in the animal series; it appears along with the nervous centre (the spinal marrow and brain) to which it serves as an envelope.

567. The same sense has not always been attached to the words bone and skeleton. In the writings of Hippocrates and Aristotle is found the source of the two principal ideas attached to these words, and which are still a subject of controversy among zootomists.

The author of the Treatise on the Nature of the Bones attributes to them the uses of determining the form, the straightness, and the direction of the body. This idea has prevailed, and it is still generally admitted, that the principal functions of the osseous system are to determine the form of the body, and to facilitate its motions. Agreeably to this definition, the hard parts of the other articulated animals, and especially those of the insecta and crustacea, ought to have been assimilated to the bones, for it is in the latter that voluntary motion and the preservation of the form of the body are carried to the highest pitch. Willis, in speaking of the crab, uses the following words:—*Quo ad membra et partes motrices, non ossa teguntur carnibus, sed carnes ossibus.*

Aristotle, however, who already considered the spine as the origin, or centre, from which the bones are derived, had given the first intimation respecting the distinction which has in these latter times been made between the bones and the other hard parts of

* The best works on Osteology are the following:—A. Monro, Anatomy of the Bones and Nerves.—Edin. 1726, 8vo.—W. Cheselden, *Osteographia*, &c. London, 1733. fol. B. S. Albinus, *De Ossibus corp. hum.* Lugd. Bat. 1726, 8vo.—Id. *De Sceleto hum.* ibid. 1762. 4to.—Id. *Tab. Scelet. et Muscul.* ibid. 1747. fol. max.—Id. *Tab. Ossium.* ibid. 1753. fol. max.—Boehmer. *Institutiones Osteologicæ.* Hallæ. Magd. 1751.—Tarin. *Osteographie.* Paris, 1753. Bertin. *Traité d'Osteologie.* Paris, 1754. Ed. Sandifort. *Descriptio Ossium Hominis.* Lugd. Bat. 1785.—Loschge. *Die Knochen,* &c. *Abbildungen und Kurzen Beschr.* Erlang. 1804, fol. Blumenbach. *Geschichte und Beschreibung der Knochen.* Gotting. 1807.

animals. According to this idea, the skeleton, or osseous system of the vertebrate animals is, in fact, first, and principally seen to consist of a longitudinal column, which furnishes superiorly, or posteriorly, an envelope to the spinal marrow and brain, and anteriorly, or inferiorly, another envelope to the organs of nutrition, and especially to the central parts of the vascular system. Other less constant appendages are subservient to motion through their articulations. All the parts of the system, besides, may furnish attachment to muscles.

The question, therefore, is, whether all the hard and dry parts of the body of animals, those which determine its form and facilitate its motions, are to be called bones and skeleton; or if these names are to be restricted to the hard parts, peculiar to the vertebrate animals, which form a central and median column in the body, with a cavity for the nervous trunk, and another cavity for the heart and aorta, and frequently lateral appendages for motion.

According to M. Geoffroi Saint-Hilaire, one of the naturalists who has engaged most deeply in the study of this point of zootomy, and who has treated it with his original talent, there is no doubt on the subject, and all the difference between the skeleton of an articulate and a vertebrate animal, between the rachis of a crustaceous animal or an insect, and that of an osseous animal, depends upon the absence of a spinal marrow in the former, and its presence in the latter; a difference which renders necessary a rachis with two canals in the vertebrate animals, and one with a single canal in the crustaceous.

568. Be this as it may, and to return to our subject, there are three things to be considered in the osseous system; the bones themselves, their articulations, and the skeleton which results from their union.

SECTION I.

OF THE BONES.

569. The Bones, *Ossa*, Ὀστέα, are the hardest parts of the human body, those which by their union form the skeleton.

570. Each of the bones, and many parts of bones, have received particular names. These names ought to be so much the more precise and appropriate, that the names of many other parts of the body are formed from them.

The name of several bones is an adjective taken substantively with a common termination: for example, the frontal, occipital, parietal, &c. * M. Dumeril † has proposed, as a means of giving

* This is the case only in the French language; in the English, these names are all adjectives, and prefixed to the substantive *bone; frontal bone, occipital bone,* &c. R. K.

† *Projet d'une nomenclature anatomique*, in *Magasin Encyclopedique*, t. ii. Paris, 1795.

precision and accuracy to the language of anatomy, to give the same termination to all the names of bones, and to them only.

571. The number of the bones is very great, but differently determined, according as we take the subject at a particular age, or different subjects at different ages; and this is what has most commonly been done. If, for example, it be wished to determine the number strictly, taking the adult subject, the sphenoid bone then occurs united to the occipital, and often to the ethmoid; but the sternum is still divided into three parts, and the hyoid bone is still composed of at least three distinct pieces.

The following is an enumeration of the bones which most anatomists agree in describing as distinct.

Twenty-four moveable vertebræ.

Five pelvic vertebræ, united to form the sacrum or pelvic bone.

Three or four caudal vertebræ, united to form the coccyx.

Twelve ribs on each side; a single sternum, formed of three distinct pieces in the adult.

An occipital bone, a sphenoid bone, an ethmoid bone, a frontal bone, two parietal bones, two temporal bones, each containing three ossicula tympani; a vomer, two upper maxillar bones, two palate bones, two zygomatic bones, two nasal bones, two lachrymal bones or ossa unguis, two inferior turbinated bones, an inferior maxillar bone.

A hyoid bone, composed, even in the adult, of three or five distinct pieces.

The bones, which remain to be enumerated, are all paired or double, and are those of the limbs or extremities; viz.

The scapula, the clavicle, the humerus, the radius, the ulna, the eight bones of the carpus, the five of the metacarpus, the two phalanges of the thumb, the three phalanges of each of the other fingers, and five sesamoid bones.

The coxal bone, the femur, the tibia and patella, the fibula, the seven bones of the tarsus, the five bones of the metatarsus, the two bones of the great toe, the three bones of each of the other toes, and three sesamoid bones.

572. The situation of the bones is always internal, or deep. Whether they form cavities for the nervous and vascular centres, or form the limbs, they are all covered by the muscles and the teguments, none of them being external.

573. The bones vary greatly as to size, some being a fourth, fifth, or sixth of the length of the body, while others have scarcely a diameter of a few lines. With reference to size, the bones are divided into large, middle sized, small, and very small, or ossicula.

574. The form of the bones is symmetrical. Some are single and median, the others lateral and in pairs. In the former, the lateral halves are similar to each other; in the latter, each of the bones is similar to that of the opposite side of the body. There are in this respect only very slight irregularities.

The single bones, which are all situated on the median line, are the vertebræ, as well those which are moveable, as those of the sacrum and coccyx; the sternum, the occipital bone, the sphenoid, the ethmoid, the frontal bone, the vomer, the inferior maxillar bone, and the hyoid bone.

All the rest are paired or double, and are situated on the sides of the median line, at a greater or less distance from that line.

The bones are divided according to their form, and according to the proportion which their three geometrical dimensions bear to each other, into long, broad, short, and mixed. In the first, one of the dimensions greatly preponderates over the other two; in the broad bones, the length and breadth greatly exceed the thickness; in the short bones, the three dimensions are nearly equal; and the mixed bones participate, in different parts of their extent, of the characters of the bones of two kinds.

575. The long bones, *ossa longa seu cylindrica*, are situated in the limbs, where they constitute broken or jointed columns. The number of these bones, in each fraction of the limbs, increases, and their length diminishes, as we recede from the trunk. Each long bone is divided into a body or middle part, and two extremities. The body or diaphysis, is cylindrical in some of them, and in others has the form of a triangular prism. It is generally a little bent or twisted. The extremities are enlarged.

The broad bones, *ossa lata, seu plana*, are situated in the trunk, where they constitute walls of open cavities, and more or less solid. These bones, which are flattened in two opposite directions, are curved, and some of them twisted. They are semicircular, quadrilateral, or polygonal. Their edges are generally a little thickened.

The short or thick bones, *ossa crassa*, are situated in the vertebral column, in the hand, and in the foot, where, by their assemblage and multiplicity, they form solid and moveable parts. They are globular, tetrahedral, cuneiform, cuboidal, or polyhedral.

The mixed bones, *ossa mixta*, are those which partake of the character of several kinds. They are numerous: the occipital bone, the sphenoid bone, the temporal bone, the coxal bone, the sternum. The ribs participate of the character of the broad, short, and long bones. The long bones themselves resemble the thick bones at their extremities.

576. There are distinguished in the external conformation of the bones, parts, or regions of their extent.

In the single bones there are, in general, either an azygous and median parts, and lateral parts, as the body and processes of the sphenoid bone, the body and the apophysal masses of the vertebræ, &c. or lateral parts only, united in the median line, as the two halves of the frontal bone, &c.

Many bones divide into parts or regions, determined by their mode of formation or development. Thus, the haunch bone is divided into ilium, ischium, and pubis, the sphenoid bone, the ethmoid bone, the temporal bone, &c. into several regions equally distinct by the mode of their development.

In other bones, the division into regions results solely from the situation and uses of the parts. Thus, the outer surface of the frontal bone is divided into an orbitar and nasal region, a frontal region, &c.

There are also admitted in the bones geometrical regions or parts of their extent. Thus, there are distinguished and described in the long bones, a body or central part and extremities; in the broad bones, faces, edges, and angles, &c. but these terms are not strictly applied, for planes and angles are very rare and imperfect in the organization.

577. The bones present at their surface eminences and depressions which are greatly diversified.

The eminences of the bones are distinguished into epiphyses and apophyses. The epiphyses have relation to the development, and will be described when we speak of it.

The apophyses are bony eminences, continuous with the substance of the bones. They are extremely numerous and highly diversified. Few objects in anatomy have, accordingly, been more differently arranged. They are distinguished into articular and non-articular. The former will be described as we proceed.

The non-articular apophyses are somewhat rough. Their size and their very diversified form allow them to be divided into three kinds. Some, which are long and projecting like a branch or a bony ramification, bear the name of branches, processes, and apophyses, properly so called.

Others, which are shorter and thicker, bear the name of protuberances, tuberosities, and tubercles.

The others, which are elongated, narrow, and little protruding, bear the name of crests, ridges, and lines.

The synonymy of these different kinds of eminences is very complicated and difficult. They are generally designated each by names derived from trivial and rather loose comparisons, sometimes also by names derived from their situation, their size, their direction, and their uses.

Their general use is that of affording insertion to ligaments and tendons.

578. The external cavities of the bones are, like their eminences, distinguished into articular and non-articular. It is of the latter only that we have to speak here.

Of these cavities, some traverse, and others do not traverse, the substance of the bone. Of the latter, some have a widened entrance, sloped in all directions. These are fossæ, fossettes, and digital impressions. The others have the bottom wide, and the entrance narrow, and are lined by the mucous membrane, and filled with air. These are sinuses, and when they are divided into several cavities, cells, or cellules. Others are elongated, narrow, more or less deep. These are called furrows, channels, meatuses, and grooves. The cavities of this latter kind, when they exist on the edge of bones, bear the name of notches or incisions.

Of the cavities which traverse the bones from side to side, some follow the shortest course, through a thin bone, and are holes, slits, or fissures, others follow a longer and variously contorted course, and are canal, conduits, &c.

Sometimes several bones unite to form a cavity, as the skull and vertebral canal, the pelvis, the thorax, the nasal fossæ, the orbits, &c.; or even to form a hole or a conduit, as the spheno-palatal hole, the foramen lacerum posterius, &c. the orbital, palatal, and other conduits.

Of these simple or compound cavities, some lodge organs, others furnish insertions, and others serve to transmit, or afford a passage to certain parts.

In certain places of the bones, there occur a multitude of small eminences and depressions, very close to each other. This constitutes impressions or inequalities which serve for insertions.

579. The bones have internal and closed cavities, which are called medullary cavities, because they contain the medulla, or fat of the bones (169).

The long bones have a large cylindrical medullary cavity, which occupies their body, or middle part, and which, at its extremities, communicates with the areolæ of the spongy substance. This cavity lodges the medullary system, and renders the bone lighter under the same volume, and stronger with the same weight.

The extremities of the long bones, the short bones, the broad bones, and especially their thick edges, contain areolar cavities which also lodge marrow.

Lastly, there are some also whose substance is compact, containing only microscopic medullary cavities.

580. The bones have also vascular canals for the vessels of the marrow, and for those of their proper substance.

Each long bone has at least one canal of this kind, which passes obliquely through the walls of the medullary cavity, penetrates into it from above downwards in the humerus, the tibia and the fibula, and from below upwards in the femur, the radius and the ulna. This canal gives passage to the vessels and nerves of the medullary membranes.

The extremities of the same bone, the short and thick bones, and the thick edges of the broad bones, are furnished with a very great number of wide canals, which in like manner afford passage to vessels, and especially to large veins.

Lastly, the whole surface of the bone is riddled with a multitude of small holes or orifices of canals into which very small vessels penetrate.

581. The density of the osseous tissue is very great, but it is not the same in all parts of the same bone. With reference to this circumstance, the substance of the bone is distinguished into compact and spongy or areolar. The first is cortical, or situated at the exterior of the bones. The other is internal.

The compact substance is that whose density is such that no interstices are perceived in it by the naked eye, although it is perforated with many medullary and vascular canals visible to the microscope. In the long bones, these canals are longitudinal. They have frequent lateral communications with the great medullary canal, and the outer surface of the bone. They are smaller towards that surface than towards the other. Their mean diameter is the twentieth of a line.

The areolar, or spongy substance is that which forms small cavities, distinctly visible to the naked eye. This substance presents several varieties, of which the principal are the following:—It consists of filaments more or less fine, and of laminæ of a like tenuity, in the extremities of the long bones, and in the substance of the short bones; of reticulated filaments and laminæ at the internal surface of the medullary canal of the long bones; and of strong laminæ, forming narrow areolæ in the broad and thin bones, especially in those of the skull.

The two substances, or varieties of the more or less dense tissue of the bones, are arranged in a particular manner in each kind of bone.

In the long bones, the body is formed of compact substance, and the inner surface of the canal is bristled with some reticulated filaments and laminæ. Towards the extremities, the compact substance greatly diminishes in thickness, the areolar or spongy substance becomes more and more abundant and fine, the great canal ends by becoming continuous with the spongy substance, with which the whole extremity of the bone is filled.

In the broad bones, the two surfaces are formed of compact substance. Wherever the bone is thin, these two laminae touch each other. On the contrary, where it is thick, they are separated by a layer of spongy substance, proportionate to the thickness of the bone. In the bones of the skull, the inner table, which is still denser, but thinner and more fragile than the outer table, bears the name of vitreous lamina, and the spongy substance, that of diploe.

The short bones are formed of spongy substance, surrounded by a layer of compact substance.

Lastly, the mixed bones, in the disposition of the two substances participate in the nature of the kinds of bones to which they belong.

The two varieties of tissue, or the two substances of which we have been speaking, are, in reality, one and the same tissue, one and the same substance, differently disposed, rarefied in one part and condensed in the other. A piece of compact substance is exactly the same thing as a lamina or a filament of spongy substance. A given longitudinal section of a long bone, contains, to appearance, the same quantity of osseous tissue as another equal longitudinal section of the same bone; but in the one, the substance, or tissue, is condensed, and leaves a large canal in its centre, while in the other, the tissue is rarefied, and the canal replaced by a multitude of spongy areolæ. These two substances can be transformed into each other. The essential difference which they present is, so to speak, foreign to them; it depends upon the presence and the penetration of the medullary tissue, and upon its numerous vessels in the very substance of the spongy bone, and upon its contact on one of the faces only of the compact bone.

582. The texture of the bones * is one of the points of anatomy that has given rise to the greatest number of writings and investigations. Malpighi, the first author who deserves mention, considers the tissue of the bones as resulting from laminæ, fibres, and filaments, with an intermediate bony juice. It is, according to him, like a sponge filled with wax. Gagliardi admits laminæ or bracteæ, and bony threads of different forms, which resemble them. Havers is pretty much of Malpighi's opinion, and admits laminæ formed of fibres, and connected by the bony juice. Lasône describes laminæ formed of ossified fibres, connected with each other by oblique filaments. Reichel, having examined portions of bones softened in a mineral acid, saw that they might be divided into laminæ, and then into fibres, forming a porous and tubular whole, which is continuous with the spongy substance. Scarpa concludes, from the examination of healthy and diseased bones, of bones entire and deprived of earthy substances, and of bones before and after their entire development, that the osseous tissue, even the compact substance, is a cellular and reticulated tissue, entirely similar to the spongy substance. Medici has observed, and the circumstance has long been known to those who extract gelatine from bones, that the compact substance of the long bones, deprived of earthy salts by the action of a weak acid, divides into several laminæ or layers, adhering to each other by fibres.

583. To examine the texture of the bony tissue, it being extremely hard, one is obliged to have recourse to chemical processes which, in decomposing the bone, must have some action upon the part which remains subjected to examination. Be this as it may, if a bone be immersed for some days in a vegetable acid, or in a mineral acid diluted with water, the saline substance which enters in large proportion into the bone, is removed from it, and the bone, retaining its form and size, but having lost a part of its

* Malpighi. *De Ossium Structurâ, in op. posth.*—D. Gagliardi, *Anatome Ossium novis inventis illustrata.* Romæ, 1689.—Cl. Havers, *Osteologia nova, &c.* Lond. 1691.—*Description exacte des os, comprise en trois traités, par* J. J. Courtial, J. L. Petit, et Lémery.—Delasône, *Mém. sur l'organisation des os*, in *Mém. de l'Acad. Royale des Sciences.* Paris, 1751.—J. F. Reichel, *de Ossium ortu atque structurâ.* Lips. 1760.—B. S. Albinus, *De Constructione ossium*, in *Annot. Acad.* Lib. vii. cap. 17.—Perenotti, *Mém. sur la construction et sur l'accroissement des os.* *Mem. de Turin*, t. ii. 1784.—A. Scarpa, *De Penitiori ossium structurâ commentarius.* Lips. 1795, and Paris, 1804.—V. Malacarne, *Auctuarium obs. et icon. ad osteol. et osteopath. Ludwigii et Scarpæ*, Patav. 1801.—Howship, Microscop. Observ. on the Structure of Bone, in Medico-Chir. Trans. vol. vii. Lond. 1816.—M. Troja, *Observationi et experimenti sulle ossa*, Napoli, 1814.—Medici, *Esperienze intorno alla tessitura organica delle ossa, in opuscoli scientifici*, t. ii. Bologna, 1818.—*Considerazioni intorno alla tess. org. delle ossa, scritte da M. Medici, &c. in risposta alle oppos. fatt. dal S. D. C. Speranza, e dal S. Cav. A. Scarpa*, Bologna, 1819.

weight, equal to that of the earthy matter abstracted, has become flexible and tenacious like the cartilaginiform fibrous tissue. In this state it is reducible to glue or gelatin. In this state also, if it be softened by maceration in water, the compact substance, which presented no apparent texture, divides into laminæ, connected together by fibres. The laminæ themselves, somewhat later, or with more difficulty, divide into fibres, which, by a more prolonged maceration, swell, and become areolar and soft, like the cellular or mucous tissue.

A long bone, examined by this procedure, divides at its middle part into several layers, of which the outermost envelopes the whole bone, and of which the next, becoming thinner towards the extremities, are continuous with the spongy substance with which they are filled. The broad bones are formed of two laminæ only, and the short bones of a single lamina which envelopes them; this latter, like the others, presenting at its internal surface filamentous and laminar prolongations which constitute the spongy substance.

The bony fibre differs therefore especially from the other animal fibres in the great quantity of earthy substance which it contains.

In fact, if in place of removing this earthy substance and examining the organic residuum of which we have just spoken, this latter be destroyed, by submitting a bone to the action of fire, there remains a white substance, preserving the volume, form, and a great part of the weight of the bone. This hard, but very fragile substance, is an earthy salt, which forms part of the bony tissue. The other tissues leave, after combustion, a similar residuum or ashes, but in much less proportion, and not preserving, like those of the bones, the form and a part of the solidity of the whole.

584. The bony fibre is therefore a fibre very similar to the cellular fibre, but differing from it in the very great quantity of earthy substance which enters into its composition. Various ideas have been formed as to the intimate nature of this fibre. The opinion most generally admitted consists in viewing the tissue of the bones as an areolar organic tissue like the others, but containing earthy substance in extremely narrow cavities, much in the same manner as water is interposed in the tissue of a moist sponge. Others consider the bone as an intimate mixture or a combination of gelatine and phosphate of lime. Mascagni regards it as formed of absorbent vessels filled with phosphate of lime. These hypotheses, however, do not rest upon any fact, or rather are in contradiction to facts. At the same time it is not known in what exact proportion the earthy substance exists to the organic substance of the bones.

585. Some tissues belong essentially to the organization of the bones: these are the periosteum, the marrow, and the vessels.

The periosteum is a very vascular fibrous membrane which envelopes the bone, as has already been seen (522.)

The medullary membrane is a very vascular cellular membrane, which contains the marrow, and serves as an internal periosteum to the bones (169–178.)

The blood-vessels of the bones, which are pretty numerous, and of different volume, are distinguished into those which first ramify in the outer periosteum, and then penetrate into the small nutritious foramina of the compact substance; those which penetrate, without ramifying, into the medullary canal, where they are distributed to the membrane of that name, and then penetrate through the inner surface into the compact substance, where they communicate with the preceding; and, lastly, into those which penetrate through the large and numerous foramina of the short bones and spongy parts of the long and broad bones, to be distributed in the spongy substance, and communicate there, in the long bones, with the vessels of the two first orders. Some anatomists have given the names of nutritious vessels of the first order to those of the medullary canal of the long bones; nutritious vessels of the second order, to those of the spongy part; and of the third order, to those which pass from the outer periosteum into the compact substance. In general, each of the nutritious canals contains an artery and a vein. Those of the second order contain very large veins, with very thin walls, which appear to consist only of the inner membrane. These veins appear to have great communication with the medullary cavities of the spongy substance.

Lymphatic vessels are seen at the surface of the large bones only.

No other nerves are seen in the bones than those which accompany the vessels of the medullary membrane.

586. The great hardness of the bones depends upon their chemical composition. Of all the organized parts, in fact, as has been seen, they contain the greatest proportion of earthy substance. It must have been known all along that the bones are combustible, and that they leave an earthy residuum. It has also long been known that the bones furnish gelatine or glue by decoction. It was Scheele who announced that the earthy part of the bones is phosphate of lime. A hundred parts of fresh bone are reduced to about sixty by calcination.

According to the analysis of M. Berzelius, human bones, deprived of water and fat, have the following composition: animal matter reducible to gelatine by decoction, 32.17; insoluble animal substance, 1.13; phosphate of lime, 51.4; carbonate of lime, 11.30; fluate of lime, 2.0; phosphate of magnesia, 1.16; soda and muriate of soda, 1.20.

Fourcroy and M. Vauquelin, in their first trials, did not find phosphate of magnesia in human bones. According to M. Hildebrandt, there is none of that substance in them. According to Dr. Hatchett, there is sulphate of lime in them, which, according to M. Berzelius, is a product of calcination. Lastly, Fourcroy and Vauquelin admit, moreover, in the bones, iron, magnesia, silica, alumina and phosphate of ammonia, but no fluate.

Besides the differences of composition dependent upon age, individual constitution, and morbid affections, circumstances which make the proportion of the animal substance and the earthy substance vary, all the bones have not exactly the same composition in the same individual. Thus the bones of the skull generally contain a little more of earthy substance than the others. The petrous portion of the temporal bone is of all the parts that which contains most.*

587. The bones are of a yellowish white colour and opaque, but it is especially by their hardness, their little flexibility, and their resistance to rupture that they are remarkable, and it is by these properties that they perform their part in the organism. However little flexibility and compressibility they possess, they are elastic.

They also possess a slow but real extensibility and power of contraction. Thus the maxillar sinus, the nasal fossæ, the orbit, &c. are gradually enlarged by the development of tumours in their interior. These cavities also return upon themselves when they are freed of these causes of extension. The alveoli contract and become effaced after the loss of the teeth, &c.

They possess no other kind of contraction. Sensibility exists in them only in the morbid state. Their power of formation is very remarkable in these two respects, that all the phenomena which belong to it, as their first formation, separation, alterations of texture, &c. take place in a very slow manner, while the faculties of reproduction and accidental production are greater in them than in any other tissue.

588. The formation of the bones, ossification, or osteogenesis† is a phenomenon which has much occupied the attention of observers, and which is, in fact, highly worthy of it.

The bones experience in their development, transformations so much the more remarkable, that the different states through which they pass correspond to similar, but permanent states, which are observed in animals.

After being fluid like all the other parts, they become, first,

* John Davy, in Monro's Outlines of the Anatomy of the Human Body. Edinb. 1813.

† H. Eysson. *De Ossibus infantis, cui tractatui annexus est* V. Coiter, *Ossium Infantis Historia,* 12mo. Groning. 1659.—Th. Kerkring. *Osteogenia fœtus.* Lugd. Bat. 1717.—R. Nesbitt, The Human Osteogeny. Lond. 1736.—J. Baster. *De Osteogenia.* Lugd. Bat. 1731.—A. Vater et Ulmann. *Osteogenia. Viteb.* 1333.—Albinus. *Ann. Acad.* lib. vi. vii—Id. *Icones Ossium Fœtus Humani. accedit Osteogeniæ brevis Historia.* Lugd. Bat. 1737.—Duhamel. *Mem. de l'Acad. Roy. des Sc.* 1739, 41, 43–46.—Haller, *Experimenta de Ossium formatione in Op. Min.* ii.—Hérissant, *Mem. de l'Acad. Roy. des Sc.* 1768.—C. F. Senff. *Nonnulla de Incremento Ossium Embryonum in primis Graviditatis mensibus.* Halæ, 1801.—J. Fr. Meckel. *Deutsches Archiv. fur die Physiolog.* b. i. h. 4.—J. Howship. Exper and Observ. on the Formation of Bone, in Med. Chir. Trans. vol. vi. Lond. 1815.—A. Beclard. *Mem. sur l'Osteose, in Nouveau Journ. de Med.* vol. iv. 1819.—Serres. *Des Lois de l'Osteogenie, Analyse des Trav. de l'Acad. Roy. des Sc.* 1819.

soft, mucous, or gelatiniform; secondly, cartilaginous, and some of them fibrous and cartilaginous; thirdly, osseous.

The bones are mucous, transparent, and colourless, at a period very close upon conception. They then grow by vegetation, and form a continuous whole which is subsequently divided.

The cartilaginous bones, or temporary cartilages, do not make their appearance until the end of the second month after conception. This state can be perceived only in the bones or the parts of bones which harden somewhat late, for it is doubtful whether those which ossify at a very early period pass through the cartilaginous state, a state which appears rather destined to perform the functions of bones previously than to be a period of ossification.

The osseous state commences successively in the different bones, from about a month after conception, in those which ossify soonest, to about ten or twelve years after birth, in those which are longest in becoming ossified. There are even certain accessory bony points which do not begin to form until towards the fifteenth or eighteenth year.

589. The order in which the bones begin to appear and to harden, has seemed capable of being reduced to rules.

Thus the clavicle and maxillæ being very early in their development, and the sternum, the pelvis, and the limbs being later, it has been said that the earliness is in relation to the importance in the animal kingdom, or rather in the class of vertebrate animals, where we in fact see, from the class of fishes upwards, the clavicles and maxillæ developed at a very early period, while the sternum, pelvis, and limbs are so in but a very small degree.

It has also been established as a general proposition, that the bones which are first formed are those which are near the sanguineous and nervous centres, the ribs and vertebræ being in fact developed at a very early period.

It has also been said, that the long bones appear first, then the short bones, the clavicle, femur and tibia, appearing from the commencement, and the bones of the tarsus and carpus at a much later period.

Lastly, It has been thought that the large bones ossify first and the others successively.

There are many exceptions to these rules.

590. Ossification commences at the end of the first month in the clavicle, and successively in the inferior maxillar bone, the femur, the tibia, the humerus, the upper maxillar bone, and the bones of the fore-arm, in which it commences about the thirty-fifth day. It commences about the fortieth day in the fibula, the scapula, and the palatal bones, and the following days in the proral portion of the occipital bone, in the frontal bone, the arches of the first vertebræ, the ribs, the great wing of the sphenoid bone, the zygomatic process, the phalanges of the fingers, the bodies of the middle vertebræ, the nasal and zygomatic bones, the ilium, the metacarpal bones, the extreme phalanges of the fingers and toes,

the condyles of the occipital bone, and then in its basilar portion, in the squamous portion of the temporal bone, in the parietal bone, and in the vomer, in all which bones it commences about the middle of the seventh week. In the course of the same week it also commences in the orbitar wing of the sphenoid bone, and at the end in the metatarsal bones, the phalanges of the toes and the second phalanges of the fingers. In the six following days it commences in the body of the sphenoid bone, in those of the first sacral vertebræ, and in the ring of the tympanum. About the middle of the third month it shows itself in the costiform appendage of the seventh vertebra, before the end of the third month, in the labyrinth, and towards the end of the same month, in the ischium and inner pterygoid process; towards the middle of the fourth month, in the ossicula tympani; at mid term, in the pubis, the calcaneum, the second phalanges of the toes, the lateral masses of the ethmoid bone and the turbinated bones of the nose; a little later in the first pieces of the sternum; towards the sixth month, in the body and odontoid process of the second vertebra, and in the lateral and anterior masses of the first pelvic or sacral vertebra; a little later still in the astragalus; towards the seventh month in the sphenoidal turbinated bone; at a later period, in the median ridge of the ethmoid bone, towards the period of birth, in the os cuboides, the first vertebra of the coccyx and the anterior arch of the atlas; a year after, in the coracoid bone, the os magnum and os unciforme of the carpus, and in the first cuneiform bone; about the third year in the patella and pyramidal bone; about the fourth year, in the third and second cuneiform bones; about the fifth year, in the os scaphoides of the tarsus, the trapezium and os lunare; towards the eighth year, in the scaphoid bone of the carpus; a year after, in the os trapezoides, and lastly, about the twelfth year, in the os pisiforme.

591. Ossification does not everywhere result from the transformation of cartilage into bone. The diaphysis of the long bones and the centre of the broad bones, which are developed at a very early period, pass immediately from the mucous to the osseous state. The other parts of the system are at first cartilaginous, and it is in them that the successive phenomena of ossification may be best observed.

The cartilage, which for a longer or shorter period takes the place, and performs the functions of the bone of which it has the form and of which it gradually acquires the volume, is at first hollowed with irregular cavities, then with canals lined by vascular membranes filled with a mucilaginous or viscous fluid; it becomes opaque, its canals become red, and ossification commences towards its centre.

The first point of ossification, *punctum ossificationis*, always appears in the substance of the cartilage, and never at its surface. It is surrounded by red cartilage at the place which is in contact with it, opaque and full of canals at a little distance from it, and at a still greater distance homogeneous and without vessels, but only perforated with some canals of blood-vessels which tend towards the osseous centre. The osseous point continually increases by growth at its surface, and also by interstitial addition in its substance. The cartilage, successively perforated by cavities and canals lined by sheaths of blood-vessels, gradually diminishes in proportion as the bone increases, and at length disappears. The canals of the cartilage themselves, which are very wide at the commencement of ossification, become smaller and smaller, and at length disappear when it is completed. In the place of a cartilage more or less thick, but at first full or solid, without cavities and without distinct vessels, at a later period perforated with canals lined by vascular and secreting membranes, there is found a very vascular bone, full of areolar or spongy cavities, invested with membranes and filled with adipose marrow. The bone afterwards becomes less vascular as age advances.

592. The cause of ossification, like that of organic formation in general, is unknown. From Hippocrates and Aristotle to Scarpa, Bichat, and Mascagni, a multitude of more or less ingenious hypotheses have been proposed on this obscure subject.*

It has been said, that the last divisions of the arteries ossify, or are filled up with bony matter, and that after being filled with bony matter, they burst, and allow it to escape around them. It has also been said, and with more probability, that they form, and allow to escape the ossifying matter, whether by exhalant extremities, or by lateral porosities. But what is this bony matter? Is it earthy substance? Where do the arteries pour forth this substance? Is it in the interstitial areolæ of a cartilage, as has commonly been said since the time of Herissant? or in absorbent vessels which are filled up, as Mascagni alleged? These are so many mere hypotheses. All that is known is this;—that the vascularity greatly increases before ossification, and that it always precedes that process; that the cartilage diminishes and disappears in proportion as the bone forms and augments; and that the bone, which is highly vascular at the period of its formation, becomes afterwards less and less so. As to the state in which the bony substance is deposited, it is under the fluid form, and its successive hardening depends either upon the continual addition of a greater proportion of earthy substance, or upon the absorption of the vehicle which gave it its fluidity. Ossification does not depend upon the deposition of the earthy substance in an organic tissue, but upon the simultaneous formation of a tissue containing at once both the animal substance and the earthy substance.

The phenomena of ossification are different in the different kinds of bones.

593. Ossification takes place at a very early period in the long bones, commencing in them from one to two months after concep-

* See Soemmering, *De Corporis. Hum. fabricâ*, T. 1, *De Ossibus*.

tion. Before the commencement of ossification, no cartilages are observed in them. It is the same also with them at the commencement of ossification; there then being observed only a mucilaginous substance between the osseous cylinders. These osseous cylinders are at first thick and short, whence there results that they may elongate greatly before growing thick. They correspond to the point at which the principal medullary artery is afterwards perceived. At the commencement of the third month, there are perceived cartilaginous extremities at the end of these elongated bony cylinders. Do these issue by vegetation from the interior of the canal? These cartilaginous extremities have the same conformation as the extremities are to have at a later period; they ossify, as has been said, in treating of ossification in general. Most of them only ossify at the centre, and then form epiphyses, which remain a greater or less time distinct at the ends of the bones. In some of them ossification goes on from the commencement, by the extension of the body of the bone, in the centre of their cartilaginous mass.

594. The broad bones of the skull begin to ossify between the sixtieth and seventieth days. The pericranium and dura mater are then very vascular. There exists between these two membranes a mucous substance which is itself very vascular. The first bony points appear in the places which are most full of blood vessels, under the form of isolated grains, afterwards disseminated and collected into net-works. They then form a lamina thin at the middle, and furnished with radiating bony fibres at the circumference. The surfaces of the bone are covered, and the intervals between the radiating fibres are filled up, by a reddish and very vascular mucilaginous substance. The pericranium and dura mater are still very red and vascular at that period.

595. The short or thick bones ossify in the same manner as the extremities of the long bones. They are preceded in their formation by cartilages which have the form, and ultimately the volume of the bones which are to replace them. These cartilages are at first homogeneous and full, and afterwards present the successive changes already described: cavities, vascular membraneous canals, filled with viscous fluid, and bony points which extend from the centre to the circumference.

The patella and sesamoid bones form in a tissue which is at first fibrous, then cartilaginous, and in the same manner as the short bones.

The mixed bones, are intermediate in their formation, as they are in their external figure, and internal conformation, between the bones of the two different classes.

596. Many bones form by several distinct points of ossification.

Several median bones, whether broad or thick, form by two lateral parts, which afterwards unite in the median line. Of this kind are the arches of the vertebræ, the frontal bone, the body of the sphenoid bone, the squamous portion of the occipital bone, the inferior maxillar bone, and the middle pieces of the sternum. But in several of the median bones also, ossification commences at the middle, and extends towards the sides, as in the body of the vertebræ, the basilar portion of the occipital bone, the crest of the ethmoid bone, the body of the hyoid bone, and the first and last bones of the sternum, whether the bone is formed of two lateral portions at an earlier period, at the period of its conversion into cartilage for example, or whether it be originally single.

Many bones, broad as well as short, are formed of several principal or original points of ossification, which unite more or less quickly. Frequently these points correspond to distinct bones in other genera or classes of animals. Of this kind are the points of ossification of the vertebræ, the occipital bone, the sphenoid bone, the temporal bone, the maxillary bone, the sternum, the coxal bones, the sacrum, &c. There even occurs in the ruminating animals an example of the collateral union of two long bones to form the cannon bone.

597. Lastly, a great number of bones, especially of long bones, and some broad and short bones, have accessory or secondary points of ossification, which are called epiphyses* on account of their being implanted upon the body of the bone, by means of a cartilage which lasts for a longer or shorter period. The large long bones of the thigh, arm, leg, and fore-arm, have at least one epiphysis at each extremity.

The clavicle, the metacarpal, metatarsal and phalangeal bones, have epiphyses at one extremity only.

Of the broad bones, the coxal bones, and the scapulæ have marginal epiphyses analogous to these terminal epiphyses of the long bones. The ribs have epiphyses at their dorsal extremity, and at their tubercle.

Of the short bones, the vertebræ are almost the only ones that have epiphyses; they have them at the two faces of their body, and at the summit of all their processes which are not articular. Of the other short bones, the calcaneum is the only one that has an epiphysis. It is situated at its posterior extremity.

The epiphyses begin to form at very different periods, from about fifteen days before birth, to fifteen or eighteen years after, and remain for a longer or shorter time distinct before uniting with the body of the bone. The periods at which they unite are comprehended between the fifteenth and twenty-fifth year. Of all the epiphyses, the one which ossifies first, is that of the lower extremity of the femur, ossification commencing in it previous to birth; and it is one of the latest in being united to the body of the bone. That of the upper extremity of the radius, which is one of the last to ossify, is perhaps, on the contrary, the one which is soonest in uniting.

* Platner. *De Ossium Epiphysibus*, 1736.—Ungebauer. *Epistola de Ossium trunci corp. hum. Epiphysibus Sero Osseis earundemque Genesi.* Lips. 1739.—Beclard, *loc. cit.*

598. The growth of the bones takes place in an evident manner, by the successive addition of new bony substance around that which was first formed.

The growth in length takes place by the elongation of the body of the long bones at their extremities. For this purpose, the ends of the bony cylinder are covered with bony filaments or villosities immersed in the not yet ossified extremity, hollow and vascular, which continually elongate, becoming more and more slender as the vessels ramify more, and as the ossification slackens. At the same time, the cartilaginous extremities, commencing at the centre, are gradually transformed into bones which constitute epiphyses.

The growth in breadth takes place, in the flat bones, in the same manner, whether by the successive addition of bony substance in the edge of the bone, as in the bones of the skull, or by the osseous formation, under a marginal epiphysis which covers its edge, as in the scapula and coxal bone.

The growth in thickness takes place in all the bones in the same manner. The periosteum, which until this period is very vascular, secretes and deposits between its fibres, at the surface of the bone, osseous substance, at first mucous, then hard, which being thus successively added to the surface, increases the thickness of the bone.

599. The growth of the prominences of bones takes place in the same manner as that of the long bones furnished with epiphyses, that is to say, between the body of the bone and the base of the eminence; as in the trochanters, &c. In others, it is at the surface itself that the growth takes place, precisely in the same manner as the growth in thickness of the bones. Most of the eminences grow in this way. As to the hollowing of the external cavities which are not articular, it is in many places determined by pressures, which without really depressing the bone, nevertheless produce a depression of it, by rendering its nutrition less active than in the surrounding parts.

The articular eminences and cavities are moulded upon each other. This is also the case with the cavities destined to lodge soft or fluid parts, and the medullary cavities of the bones. Their existence and form are greatly dependent upon those parts which they contain. Thus the conformation of the skull, and that of the vertebral canal depend greatly upon that of the nervous centre which they lodge. The lower part of the vertebral canal, when empty, is triangular, just as the cotyloid cavity becomes when the head of the femur has been for a long time removed from it, both these parts being formed of three bony points.

600. Be this as it may, the termination of evident growth, in length and breadth, depends upon the uniting of the long bones with their terminal epiphyses, and of the broad bones with their marginal epiphyses, or with each other. The termination of the growth in thickness depends upon the cessation of the osseous for-

nation at the surface of the bones. This last kind of growth continues somewhat longer than the first.

The growth of the bones nevertheless continues to take place, but locally, and in an insensible manner, although sometimes in a manner which is still pretty sensible.

The sensible growth depends upon a kind of juxta-position at the extremities, edges, and surfaces of the bones. The insensible growth, on the contrary, is interstitial, and depends upon a true intus-susception. Striking examples of the latter are seen in some morbid cases especially ; in empyema, spina-ventosa, &c.

601. The growth being terminated, the bones remain the seat of a habitual support or nutrition. Deposition and absorption go on very slowly and in an insensible manner in them in the state of health, and especially in old age. But in certain cases of disease, very decided changes take place in the properties of the bones, which clearly show that changes not less great are operated in their composition.

602. The facts relative to the growth and habitual nutrition of the bones, are especially proved by the effects of madder upon them.

Mizauld first,* and Belchier † a long time after, were the first who observed that when madder *(Rubia tinctorum)*, is given to animals mixed with their food, their bones become red. Duhamel, Boehmer,‡ Detlef,§ J. Hunter,|| and several others have made curious experiments on the same subject. Rutherford¶ has explained the effect of madder on the bones alone, and to the exclusion of all the other parts of the body, by a chemical affinity of the colouring matter of madder for the earthy substance of the bones.

Duhamel found in his experiments, that the bones of young animals are coloured much sooner than those of old animals ; that the progress of their tincture and ossification is so much the more rapid the more vigorously their growth goes on ; that when the madder is discontinued, the bones become white again, and that the return to their original colour is effected by the superposition of white layers upon the red. This last fact is also fully demonstrated by Hunter's experiments. Duhamel, however, imagined, notwithstanding these decisive experiments, that the bones enlarge in thickness by extension.

* Ant. Misaldus. *Centur. Memorabilium seu Arcanorum omnis generis*, 1572.

† Philos. Trans. vol. xxxix. 1736.

‡ *Radicis Rubiæ Tinctorum affectus in Corp. Anim.* Lips. 1751.—*Ejusdem prolusio, quâ callum Ossium a Rubiæ tinctorum radicis pastu Infectorum describit. Ibid.* 1752.

§ *Ossium calli Generatio et Natura perfracta in Animalibus rubiæ radice pastit, Ossa demonstrata.* Goet. 1753.

|| Exper. and Observ. on the Growth of Bones, from the papers of the late Mr. Hunter, by Ev. Home, in Transac. of a Society for Improvement, &c. vol. ii. London, 1800.

¶ *Disput. Med. Inaug. De Dentium Formatione et Structura*, &c. Auct. R. Blake. Edinb. 1798.

As to the growth in length, Duhamel's experiments also led him to think that this growth, which he compares to vegetation, takes place by the extension of their parts. It is probably so in slow and insensible growth, but the rapid elongation which takes place before the epiphyses become united, evidently depends upon an addition of bony substance to the end of the body of the bone, as is proved by the following experiment of Hunter's. The tibia is laid bare in a young hog, and perforated at the two extremities of the ossified body, the interval between the two holes being carefully measured. Some months after, when the growth has made progress, the same distance is found to exist between the two bones, and all the elongation that has taken place has been beyond the hole, at the extremities of the diaphysis.

These experiments, which leave little to be desired with respect to the growth of the bones, do not by any means afford results so satisfactory respecting the habitual nutrition of the bones. To redden the bones of a young animal, it is sufficient to give it a few drams of madder, during a period of some days, while the same substance given in greater quantity, and during weeks or months, to an adult animal, hardly imparts any colouring to them.

603. After the growth in extent has ceased, the bones still undergo farther changes, the most remarkable of which is their decrease.* The medullary canal of the long bones continues to increase in diameter from the moment of their formation. So long as the growth in thickness continues, the walls of the canal being augmented at the exterior, preserve their thickness, and even increase in that direction.

Duhamel made a very curious experiment on this subject, although he drew false inferences from it. Having laid bare and surrounded with a metallic wire a long bone of a young animal which he killed some time after, he then found the wire covered over by the bone which had increased in thickness, and the canal having acquired the diameter of the metallic ring, he concluded from this circumstance that the bone had enlarged by expansion, by the widening of its canal. This is not the case, however. The bone had increased at its exterior by addition, and diminished at the interior by abstraction, whence resulted the enlargement of the canal.

In fact, when the growth of the bone in thickness is accomplished, the canal continuing to enlarge by internal absorption, its walls become thin in a singular degree, insomuch that, after having been thicker in the child than the diameter of the canal, and in the adult nearly as thick, they present in old age but a very small fraction of that diameter. The spongy cavities of the short bones, of the broad bones and of the extremities of the long bones, generally enlarge in the same manner, so that, by this diminution of the substance of the bones, the substance of the skeleton of aged persons is rendered much lighter than that of others.

* Albinus. *Annot. Acad.*—F. Chaussard. *Recherches sur l'Organ. des Vieillards.* Paris, 1822.

The broad bones of the skull pretty frequently undergo a diminution in thickness of another kind in old age. It results from the absorption of the diploe, and the approximation of the outer table to the inner, so as to produce at the same time a great diminution of thickness and an external depression. It is in the parietal prominences which are frequently affected by it, that this wasting generally commences.

Pretty frequently also, in old age, the articular surfaces of the bones of the inferior members and the faces of the vertebræ are widened and flattened, as if they had at length yielded to pressure.

604. The form of the bones is not the only property that undergoes changes from the advance of age. Their consistence also exhibits remarkable changes; the bones of children are more flexible and less brittle than those of adults, and may be bent or twisted in the living subject without breaking. Those of old persons, on the contrary, are denser, harder, and more fragile than those of adults, which circumstances added to their having become thinner, renders fractures very common in old age. There is also a sensible difference in the proportion of the earthy substance, it being greater in old age than in the adult state.

Thus after the growth in dimensions has terminated, the increase of density continues in the bones, as in all the other parts of the body.

605. Accidental ossification* is of very frequent occurrence, and was known at a very early period. This ossification is rarely perfect, and may in this respect be distinguished into several varieties.

The least perfect kind of accidental ossification is called earthy. It produces a white, opaque, chalky, soft, and even sometimes semi-fluid substance. It is composed of animal matter, in small proportion, and earthy substance, and is commonly met with in cysts. Phlebolites are sometimes of this kind. It also occurs in isolated and formless fragments, in abscesses in the lungs, in the fibrous body of the uterus, in the cellular tissue, and in the ligaments of persons affected with gout, in the brain, &c. Lastly, it is frequently met with infiltrated in the bronchial glands, the lungs, the liver, the kidney, the heart, &c.

The stony accidental ossification is of very frequent occurrence. It is hard, opaque, and contains a greater proportion of earthy substance than the bones in their natural state. It is often met with under the form of a more or less thick incrustation under the serous membranes, and especially in the walls of the arteries. It also occurs under the form of cysts. It is observed under the form of isolated masses in the fibrous bodies of the uterus which have been ossified, and in the pineal gland, where it constitutes the substance called *acervulus*. It is also sometimes met with un-

* J. Van Heckeren. *De Osteogenesi Præternaturali.* Lugd. Bat. 1797.—P. Mayer. *Mem. sur l'Ossification morbide*, in *Archives Gener. de Med.* t. i. Paris, 1823.

der the form of infiltration of the pancreas. What has been described under the name of petrifaction of certain organs, or of the fœtus, is nothing else than an infiltration of very compact stony bone, so as to cause the animal matter of the organ to disappear almost entirely.

The accidental production sometimes differs still more from the bones, resembling in hardness and polish the enamel of the teeth. This accidental enamel sometimes replaces certain diarthrodial cartilages.

Accidental ossification sometimes greatly, or entirely, resembles the natural bone, in its periosteum, its medullary spongy cavities, its texture, its semitransparency, and its chemical composition ; but this perfect production is of rare occurrence. It has been met with under the form of an isolated body in the dura mater. I have also seen it, but almost entirely compact, under the form of laminæ, situated in the anterior vertebral ligament. The bony plates which cover the costal cartilages are of the same nature. There is also sometimes observed a perfect, but compact, ossification, under the form of the hydatiferous cyst.

Accidental ossification, which also presents several varieties, is often an effect of age. Many old persons, however, are not affected with it. Its causes are most commonly irritation and chronic or latent inflammation. It is more frequent in cold than in warm countries. It commences with a plastic production, and sometimes passes through the semicartilaginous or fibrous states, but at other times does not. In general, it produces no inconvenience by its bulk or mechanical effects.

The transformation of permanent cartilages into bone may be regarded as intermediate between natural and accidental ossification.

606. Exostosis * is also an accidental bony production, sometimes perfect, and often stony, and ivory looking. The periosteum being irritated or inflamed, there takes place, at its inner surface, in its substance, and in a part of greater or less extent of its breadth, a deposition of soft, organizable matter, which constitutes periostosis. It terminates variously. In many cases it ossifies, constituting at first a kind of epiphysis or bone distinct and separable from the natural bone, to which the exostosis is at length firmly attached. Sometimes it consists of a very circumscribed nodus, which has been rapidly developed. At other times it forms slowly, and consists of a voluminous and foliated mass. Sometimes also, a whole limb, or even a larger portion of the skeleton is affected by it.

Spina-ventosa, in place of always consisting of a morbid production, is sometimes formed of organizable substance, which after having distended and dilated the natural bone, ends with ossifying more or less completely in its interior.

* On Exostosis, by M. A. Cooper, in Surgical Essays, Part I. Lond. 1818.

607. When a bone is denuded of the periosteum,* if the subject is young, if the bone is not altered itself, and if it has not remained long uncovered, the wounded soft parts, if restored to their natural position, unite by first intention.

In opposite circumstances, and in those in which the inflamed periosteum separates from the bone by suppuration, in that in which it becomes gangrenous, and when the periosteum suppurates or mortifies, &c. the bone deprived of its nutritive apparatus, becomes affected with necrosis at its surface, and to a greater or less depth. The living parts in the vicinity of the dead portion, become inflamed, soften, are at length detached from the dead part, and suppurate. The dead portion having thus become free, falls off. The subjacent granulations at length produce a cicatrix which covers the bone, adheres to it, and forms a new periosteum.

608. After amputation,† matters go on in one or other of the two ways above described.

When the bone and its nutritive apparatus have not been hurt above the amputated place, and especially when the union of the wound is immediate, the end of the bone commonly unites by first intention with the soft parts.

On the contrary, when the wound remains open and suppurates, when the periosteum has been torn or detached above the place of amputation, or when the medullary membrane has been irritated and inflames, the end of the bone becomes affected with necrosis, and there is detached a slice comprehending its whole thickness, and generally gaining obliquely upon its outer surface, because the periosteum is commonly more injured, or is injured higher than the medullary membrane.

In both cases, moreover, the end of the bone ultimately undergoes other changes. In general it becomes greatly diminished in volume and weight. The canal, which is at first filled by the spongy rarefaction of the compact substance, is re-established, but is closed at the extremity by a bony production placed over it like a lid.

609. Deep necrosis‡ of the long bones presents at the same

* Tenon. Three Memoirs on Exfoliation of the Bones, in *Mem. et Obs. sur l'Anat. Pathol. et la Chir.* &c. Paris, 1816.

† Van Horne. *Dissertatio de iis, quæ in partibus membri, præsertim osseis, amputatione vulneratis, notanda sunt.* Lugd. Bat. 1803.—L. L. Brachet, *Mem. de Phys. Path. sur ce que devient le fragment de l'os après une Amputation*, in *Bullet. de la Soc. Med. d' Emul. de Paris*, 1822.

‡ Chopart and Robert. *De Necrosi Ossium Theses Anatomico-Chir.* Parisiis, 1766.—Troja. *De Novorum Ossium, &c.* Paris, 1775. Blumenbach, in Richter, *Chir. Biblioth.* B. VI.—David. *Observ. sur une Maladie Connue sous le nom de necrose.*—Koeler. *Experimenta circa regenerationem ossium.* Gotting. 1786.—J. P. Weidmann. *De Necrosi Ossium. Franc. ad Mœn.* 1793, fol.—Russel. Practical Essay on a Certain disease of the Bones called Necrosis. Edinb. 1794.—A. H. Macdonald, *De Necrosi ac callo.* Edinb. 1799.—Macartney in Crowther's Pract. Obs. on the Diseases of the Joints. Lond. 1808.—Charmeil. *De la Regeneration des Os.* Metz. 1821.

time interesting phenomena of separation and osseous production.

When the medullary membrane of a long bone is destroyed in a living animal, by introducing into its canal a foreign body which tears or cauterizes it, the whole limb to which the bone belongs swells, becomes painful, and has its temperature increased. At a later period abscesses form, which open and remain fistulous. There is seen, or felt, through the openings, a moveable bone in the midst of the pus, and contained in another bone which is hollow. The internal bone which becomes in time more and more loose, sometimes gets engaged by one of its extremities in one of the apertures of the external bone, and is even at length expelled. It is then seen to have the length of the diaphysis of the original bone, and a variable thickness, but which sometimes entirely equals that of the original bone. The new bone, however, being freed of the foreign body, and being connected from the commencement with the extremities of the old bone, which are now become its own extremities, gradually contracts within itself. The suppuration diminishes, and at length entirely ceases, when the walls which have approached each other to such a degree as to touch, are agglutinated together, and at length become entirely confounded.

The new bone, which is at first very soft and flexible, to such a degree as sometimes to be bent by the action of the muscles, when the old bone, engaged by one extremity in one of the fistulous openings, no longer forms a solid support to it, ultimately acquires and preserves a density and hardness superior to those of the original bones.

The medullary cavities form in the new bone in proportion as its tissue, which is at first uniformly lax, acquires density at the exterior.

All these changes take place as if spontaneously in the human species, in circumstances and under the influence of causes which appear to act upon the periosteum to produce inflammation in it, and probably also upon the medullary membrane, that is to say, upon the internal nutritive apparatus, in such a manner as to alter its texture and functions.

The long bones, in which necrosis occurs most frequently, are the following, being arranged nearly in the order of their frequency : the tibia, femur, the humerus, the mandibular bone, the bones of the fore-arm, the clavicle, the fibula, and the bones of the metatarsus and metacarpus.

Two theories have been proposed on this subject, the authors of which have only erred in making them exclusive, for things sometimes take place in the one way and sometimes in the other.

Troja, David, Bichat, and many others, have admitted that the expelled part is formed by the entire body of the original bone rendered more or less thin by absorption and by the solvent action of the pus, and that the new bone results from a new formation, of which the external nutritive apparatus, that is to say the periosteum and its vessels, has furnished the materials, which being deposited in its substance, and especially in its internal surface, have passed through all the states of fluidity and successive hardening which the regular bones present, excepting that the bony hardening commences in many points at once.

Experiments made on living animals show, that when the periosteum is torn off, it is reproduced along with the bone; but the hardening of the latter is retarded during the whole of the time necessary for the reproduction of its vascular envelope.

When it is a new bone that is formed, the separated piece has the same volume and appearance as the original bone, presenting the same processes, impressions, lines, and inequalities.

Other pathologists,* and in particular MM. Leveillé and Richerand, maintain that in all cases the necrosis in question is confined to an internal portion of the substance of the walls of the medullary canal, and that the new bone simply results from the outer part of the original bone which the necrosis has not affected, and which has only undergone changes of volume and consistence.

It is certainly so in many cases, and then the slough has a diameter sensibly less than the original bone, and its surface is rough and uneven. [It has, however, been shown by Dr. Knox,† that this theory of the regeneration of bone in cases of necrosis, is not applicable to all cases of necrosis. He instances many cases he has seen of necrosis from gun-shot and from other causes, the celebrated case of D'Angerville and the specimen of necrosed scapula in the museum of Charenton, as cases which all preceding theories fail to explain. With reference to such cases it may be distinctly *proved, that where the entire shaft of the bone* is dead, and new bone has formed, the new bone will be found to proceed from, and to be produced *by the extremities of the old bone*; but if it be a portion of the shaft only which has died, implicating, however, its entire thickness, that then the reproduction of bone to supply the place of the dead portion takes place close to the line of ulceration or separation of the living from the dead portion, wherever that may be, the growth of new bone then is in all cases from some point or other of the old bone.

This theory, which will be found more fully explained in the appendix, is not exclusive; it simply explains the reproduction of bone in cases which had previously been totally misunderstood.] Tr.

The extremities of the long bones become affected with necrosis, and are reproduced much less frequently than their body. It is not uncommon, however, to observe these phenomena at the upper extremity of the humerus. They have also been observed at the lower extremity of the bones of the fore-arm. I have extracted from the interior of a new bone the lower extremity of the tibia, which had become affected with necrosis after a fracture which

* Leveille and Richerand are the mere copyists of Scarpa, and it is sufficiently singular that M. Beclard should have omitted Scarpa's name.

† Edinburgh Medical and Surgical Journal. 1822 and 1823.

happened two or three years previously. The articular cartilage was all that was wanting at this extremity.

The broad bones are also subject to necrosis, but their reproduction is rare or imperfect. The scapula, however, after being affected with necrosis, has been seen to be replaced by two other bones.

Necrosis of the short bones is much more common than is supposed. It commonly exists under the form of a slough inclosed at the centre of the bone. This constitutes many of the alleged cases of caries of the bones of the tarsus, carpus, &c.

610. The bony substance of new formation by which the solutions of continuity in bones are united, is named *callus*.*

When a long bone is fractured, besides the rupture of the osseous substance, there takes place a rupture of the medullary membrane, and commonly also of the periosteum, as well as of the vessels of these membranes and of the bone. There results from these vascular and other divisions, a more or less considerable effusion of blood around and in the interval of the fragments. If the latter are kept in perfect contact, an agglutination is presently effected between them and between the other divided parts. There also supervene a swelling and distention of the soft parts that have been divided and of those which surround them, which become compact like inflamed cellular tissue. The marrow, at the place of the fracture, especially participates of this state. All these parts, and especially the agglutinating or organizable substance which distends them, successively ossify, and form at the exterior a bony ring of greater or less extent, the thickness of which diminishes from the centre or from the seat of the fracture towards the two extremities, and at the interior a fusiform bony mass. The bone, however of which the two fractured portions are thus brought together, seems until now to be in no degree affected by the changes which are taking place around it. It is only from this period, and in proportion as these temporary external and internal ossifications diminish and disappear by absorption, that the agglutination of the fragments becomes converted into a permanent bony union.

Several pathologists, and in particular Bonn, Callisen, and J. Bell, have contented themselves with observing the facts without attempting to explain them. Numerous hypotheses, however, have been proposed for the explanation of these remarkable phenomena. Boerhaave, Haller, and Detlef, his disciple, have admitted that the fragments are united by a glutinous or coagulable matter.

J. Hunter, Macdonald, and Howship, have thought that this organizable and agglutinating matter is furnished by the blood.

It is well known that Duhamel and Fougeroux have admitted that the periosteum furnishes a bony ring which unites the fragments. Blumenbach has given the figure of a human bone sur-

* Duhamel, *Mem. de l'Acad. Roy. des Sc.*, Paris, 1741.—Boehmer, *De Ossium callo*, Lips. 1748.—P. Camper, *Observationes circa callum Ossium Fractorum*, in Essays and Observ. Phys. and Liter. vol. iii. Edin. 1771.—Bonn, *De Ossium Callo*, &c. Amstel, 1783.—Macdonald, *op. cit.*—J. Howship, in Med. Chir. Trans. vol. ix. Lond. 1816.—Breschet, *Quelques Recherches Hist. et Experim. sur le cal.* Paris, 1819.

rounded by a ring of this kind. M. Pelletan taught the same thing in his clinical lectures. Camper had observed that there are an external callus and an internal callus. Bichat, M. Dupuytren, M. Cruveilher, and others, have admitted that these external and internal ossifications are provisory.

Many pathologists, and especially Bordenave, Bichat, Richerand, Scarpa, &c. have maintained that the union of divided bones is effected by cellular and vascular granulations, like that of the soft parts, which is true of the one and the other only in cases where the division is external and suppurative, and not when it takes place, as well as the union, without external wound and without suppuration.

I have already elsewhere* remarked, that all that these hypotheses want, in order to be theories or exact expression of facts, is to be combined, or not to be exclusive. This was Troja's opinion, and is also that of M. Boyer, M. Delpech, &c.

In fact, in the uniting of a simple fracture, there take place in succession, agglutination of the fragments by an organizable fluid, the materials of which are furnished by the blood; ossification of a similar substance, infiltrated all round the fracture, both internally and externally; lastly, vascular and osseous union between the fragments themselves.

The periosteum, which, when it exists, appears to perform so important a part in the production of the callus, is no more indispensable here than in the reproduction after necrosis. It has been removed from the ends of fractured bones in birds, and has been reproduced at the same time that the callus formed.

Comminuted fracture of the long bones, and especially that which is produced by fire-arms, is accompanied, in its union, by a large and permanent osseous production. It is in this production especially, in the same manner as in exostosis, as well as in reproduction after necrosis, that a great mass of new osseous matter may be seen. After being fluid it becomes solid, soft, flexible, and elastic, so that it might almost be mistaken for cartilage. But this substance contains numerous bony dots; and if the observation is made in an animal that has taken madder, it is found to be of a rose colour, or even red, which is never the case with cartilages. It afterwards becomes hard like a common bone, and even more so. This permanent bony tumour bears the name of *callus*.

611. Wounds of the bones differ from fractures, in the state of the solution of continuity itself, and in its mode of filling up, which is different from that described above. The bony tissue being very hard, and possessed of little flexibility, a sharp instrument which cuts it obliquely really produces a multitude of small fractures in the fragment which it raises, just as happens to a chip of dry wood raised by the blow of a hatchet. As to the subsequent union of this cut, as that of a fracture with wound, it commonly does not take place until after an exfoliation, and by the formation of suppurating granulations.

* A. Béclard, *Propositions sur quelques Points de la Médecine*, Paris, 1813.

612. The loss of substance of the long bones, in young and healthy subjects, is followed by a more or less extensive, and sometimes complete reproduction. In birds,* the periosteum may even be removed, together with a large portion of one of the bones of the fore-arm, and these parts are in time reproduced by a kind of vegetation of the two ends. In the human species, when the loss of substance of a bony cylinder is considerable, and the disposition of the parts does not admit of the fragments being brought together, there is produced, by the sinking and elongation of the ends, a cartilaginiform fibrous substance, which does not acquire the hardness of bone in its whole extent.

These more or less advantageous results of the reproduction of a portion of bone that has been removed, have given rise to the practice, in certain cases, of cutting out portions of diseased bones in their state of continuity.†

613. When the callus after having commenced is subjected to repeated motions of flexion, twisting, distention, &c. it remains flexible, as in the preceding case, or no union takes place at all, and the ends of the bones remain in contact. This is also the case when the ends of bones are separated by a layer of muscular tissue of any thickness.

614. The broad bones have a stronger power of reparation and reproduction than the long bones. After the bones of the skull have been trepanned a production is formed which is seldom bony to the centre. After the same operation, if the separated bony operculum is reapplied, it sometimes unites.‡ The phenomena of reproduction are very imperfectly known in the short bones.

615. The separation of the epiphyses § takes places, in young subjects, from mechanical causes, like fractures, and the parts thus separated unite again by means of a similar callus. Chronic inflammation of the joints of the long bones also sometimes, in children and young persons, causes the separation of their epiphyses, which are not yet united. Both of these kinds of separations are rare. A case of false joint in consequence of the fracture of the neck of the femur, has lately been published as an example of separation of the epiphysis in an adult.

616. When an aneurismal tumour meets with a bone in the course of its development, the latter is gradually destroyed in the place which is in contact with the tumour, without any residuum of its substance remaining. This destruction bears the name of usure.

617. The morbid anatomy of the bones‖ has already given rise to numerous works and engravings. It still, however, presents,

* Charmeil. *Op. Cit.*

† Roux, *De la Résection, &c.* Paris, 1812.—Champion, *De la Résection des os dans leur continuité.* Paris, 1815.

‡ Merrem, *Animadversiones quædam, &c.* Giess. 1810.

§ Reichel, *De Epiphysium ab ossium diaphysi diductione.* Lips. 1769.

‖ A. Bonn. *Descriptio Thesauri Ossium Morbosorum Hoviani.* Amstel. 1783.—Ed. Sandifort, *Museum Anat. Acad. Lugduno-Batavæ.* Lugd. Bat. 1793.—C. F. Clossius, *Uber die Krankheiton Der'knochen.* Tubingen, 1798.—J. Howship, in Med. Chir. Transac. Vol. viii. and x.

on some points, many obscurities to be cleared up, which, perhaps, depend more than is imagined upon vague comparisons which have been made between the alterations of the bones and those of the soft parts in general, without specifying any tissue in particular. It is a point of anatomy and pathology which is highly worthy of attention.

618. Original vices of conformation * are rare in the long bones; less so in the short bones; frequent in the broad bones; rare in the bones of the limbs; more frequent in those of the trunk, especially in the sternum and ribs; still more so in the bones of the head; and more so in those of the arch than in those of the base.

The most common variations are observed in the junctions of the bones, then in their figure, then in the form of their holes, and, lastly, in their apophyses.

Most of these vices of conformation, like those of all the parts, appear to depend upon a defect of formation. Some of them, however, seem to depend upon an excess of formation. They are of rare occurrence in the bones and in the parts of bones which are first ossified, and, on the contrary, more common in the parts which form last.

619. The bones are sometimes consecutively altered so as to be increased or diminished in size. Besides the spina ventosa and osteosteatoma, already mentioned, and which are merely a dilatation of the bones; the exostoses, whether external or internal, which are only the periostosis and the spina ventosa ossified; the bones are also sometimes the seat of a hypertrophy. The bone is then tumefied, and there is an interstitial deposition which keeps up or increases their original density. In all cases there is an augmentation of weight. At other times the swelling results simply from the rarefaction of the compact substance. The bone, which is less dense, and more voluminous, has not then sensibly increased in weight. I have in my possession a very fine example of this kind of alteration, symmetrically occupying the two parietal prominences in a skull of a young subject: the bone, which is greatly rarefied, is extremely vascular. These two kinds of tumefaction, when they affect the long bones, sometimes determine the contraction or disappearance of the medullary canal. This case has been described under the name of enostosis.† I presented to the Faculty of Medicine a skeleton of which almost all the bones present this alteration.

620. Atrophy of the bones gives rise prematurely to changes similar to their diminution in old age.

In the Museum of the Faculty of Paris, there are long bones of

* Van Doeveren, *Observ. Osteol. varios naturæ lusus in ossibus. hum. corp. exhibent; in Obs. Acad. Specim.* Lugd. Bat. 1765.—Sandifort, *De Ossibus diverso modo a solitâ conformatione abludentibus, in Observ. Anat. Pathol.*, Lib. iii. and iv. Lugd. Bat. 1777-81.—Rosenmuller, *De Ossium varietatibus.* Lips. 1804.

† Lobstein, *Rapport sur les travaux exècutès a l'amphith. d'Anat.* de Strasbourg, 1805.

a young man, in which the walls of the medullary canal are as thin as paper. This canal has been enlarged by internal absorption, while no formation has taken place at the exterior. Phthisis, when very slow, sometimes produces this alteration in the bones. It is also produced by long inaction.

621. Inflammation of the bones is very imperfectly known.

The term *caries* is one of the vaguest words in pathology. The obscurity of the thing has been increased by comparing caries to the ulcer. What is most generally considered as caries, is a softening of the spongy substance of the bone, such that it can be cut with a bistoury without injuring its edge. This softening appears to be the effect of an inflammation, which generally terminates by suppuration, and also sometimes by necrosis.

Rachitis is another kind of softening which appears to depend upon the diminution of the earthy substance during the period of growth, whence results the bending of the bones under the weight of the body, and under the action of the muscles. In fact, if the bones of rachitic persons be examined at the period when they are soft,* it is found that the long bones have become spongy in their whole thickness, and that their tissue, which has become soft and red, may easily be cut with the scalpel. On the other hand, when the disease is terminated, and the bones have resumed their hardness and inflexibility, the compact substance is found much thicker on the concave side of the curvature than on the opposite side; and when the bone is bent at an angle, the place at which the flexure exists is entirely compact, and the medullary canal is obliterated in it.

In the adult state, the softening depending upon the same cause, may proceed to the same extent, and even farther: the bones may become soft and pliant *(Osteomalacia, seu Malacosteon)*; they may even acquire all the softness and flexibility of flesh *(Osteosarcosis)*. At this extreme degree of softness, of which the woman Supiot presented so remarkable an example, and in which the bones bend like soft wax, desiccation diminishes their weight and changes their form; decoction dissolves them; and their chemical composition is changed † to such a degree that they do not contain more than a few hundredth parts of earthy substance.

Lastly, it may happen, with, or without the preceding changes, that the animal substance of the bones loses its natural tenacity, and these organs, having become brittle, break under the slightest effort.

622. Morbid accidental productions are also sometimes met with in the bony tissue; tubercles, scirrhus, and the encephaloid production are not rare in them.

* Ed. Stanley, in Med. Chir. Trans. vol. vii.—Lond. 1816.

† Bostock, in Med. Chir. Trans. vol. iv. Lond. 1813.—J. Davy, in Monro's Outlines of Anatomy.

SECOND SECTION.

OF THE ARTICULATIONS.

623. The Articulations, *Articuli*, Ἄρθρα, are the joinings of the bones. The term comprehends the manner in which they meet, and are fitted to each other, and that in which they are mutually connected.

The long bones meet and are joined to each other by their extremities; the broad bones commonly by their edges; the short bones, by various points of their surface. The articular parts of the bones are most commonly prominences and depressions of different forms, and which are adapted to each other.

The means of union are cartilages, cartilaginiform ligaments, and fibrous ligaments. They are placed, either between surfaces which they connect, and thus render continuous, or around surfaces which remain in contact.

The articulations have for their common use, to connect the bones, and thus form them into a united whole, the skeleton.

Of the articulations some are moveable and others not so in a sensible degree, although none of them, strictly speaking, is incapable of motion.

According to the form of the articular parts, the mode of union of these parts, and their solidity and mobility variously combined, the articulations are divided into three genera, and into several species and varieties, which have been uselessly multiplied; the synarthrosis, or continuous and immoveable articulation; the diarthrosis, or contiguous and moveable articulation; and the amphiarthrosis, or mixed articulation, which is continuous like the first, and moveable like the second.

Each articulation has a proper name, composed of the names of the bones which occur united in it.

624. *Synarthrosis**, or the immoveable articulation, results from the union of all the bones of the skull and face, excepting the lower jaw, by edges more or less thick, and furnished with inequalities which fit into each other, often dovetailed, and always invested with a synarthrodial cartilage intimately united to the two articulated parts. The periosteum, in passing from the one to the other bone over the intervening cartilage, also unites these three parts, to which it intimately adheres. This kind of articulation, which is very solid, has no sensible motion. It favours the growth of the broad bones by their edges. It is often obliterated in old age. Its disunion requires efforts of the same kind and violence as those which fracture the bones.

* Duverney. *Lettre contenant Plusieurs Nouvelles Observations sur l'Osteologie.* Paris, 1689.—F. G. Hunauld. Rech. *Anat. sur les os du Crane de l'Homme.* Acad. des Sc. 1730.—E. G. Bose. *Program. de Suturar. Cranii Humani Fabricat. et usu.* Lips. 1763. Gibson on the Use of Sutures in the Skulls of Animals, in Mem. of the Soc. of Manchester, 2d Series, vol. i. 1805.

This kind of articulation, which has received the generic name of suture, presents several varieties.

625. The true suture is that in which the edges of the articulated bones present numerous and extensive eminences and depressions, which receive each other. Of this kind are the inter-parietal, occipito-parietal, and fronto-parietal articulations. This suture itself presents some differences. Thus, in the first, there are long tooth-like prolongations; in the second, they have the form of rounded tails; in the third, they resemble the teeth of a saw. These three varieties have received the names of dentate suture, *sutura dentata*, serrated suture, *sutura serrata*, and margined suture, *sutura limbosa*.

The harmonic articulation, is that in which the edges of the bone, which are more or less thick, present rugosities which are fitted to each other; the suture by which the nasal bones are joined to each other, is of this kind.

The squamous articulation is that in which the edges of the bones are sloped like a chissel, and fitted to each other like the edges of a bivalve shell. This disposition, which is very decidedly marked in the junction of the parietal and temporal bones, occurs combined with the suture or harmonic articulation in many other articulations of the skull and face. In many articulations, it is double and reciprocal, so that at one part, a bone overlaps the other, which in another part overlaps the first in its turn. Of this kind are the spheno-frontal sutures. This mortising is one of the most powerful means of ensuring the solidity of the synarthrodial articulations.

Schindylesis is a synarthrosis which results from the reception of the crest or ridge of a bone into the groove of another. Of this kind are the articulations of the sphenoid and ethmoid bones with the vomer, the lachrymal bone with the nasal process of the maxillar bone, &c.

Lastly, Gomphosis is a species of synarthrodial articulation, entirely different from the suture, which results from the reception of the roots of the teeth into the alveoli.

626. *Amphiarthrosis*,* or mixed articulation, partakes of the nature of synarthrosis in having the articular surfaces united by means of an intermediate substance, and of that of diarthrosis in having a considerable degree of mobility; this kind of articulation is confined to the body of the vertebræ, the pubis and the upper parts of the sternum.

The articular parts of the bones, are here flat and broad surfaces. The means of union are intermediate cartilaginiform ligaments, adhering very firmly to the two surfaces and accessary ligaments placed at the exterior of the articulation. This kind of articulation, which is often called symphysis, possesses a great degree of solidity, which is owing to the tenacity of the ligament. Its mobility is owing to the flexibility and elasticity of the same substance. The motion consists of the flexion or torsion of the ligament. This articu-

* A. Béclard. *Dictionnaire de Médicine*, vol. ii.

lation, which is very loose and mobile in childhood, becomes more and more firm in old age, at which period it sometimes ossifies. Sometimes the ossification is external to it, and only surrounds it more or less completely, as is especially observed at the fore part of the body of the vertebræ. It may be accidentally too loose or too close. It is not susceptible of a true luxation, but rather of a displacement, a drawing asunder, which always supposes the laceration or destruction of the intervening cartilaginous ligament.

After certain unconsolidated fractures, there are sometimes produced articulations of this kind; that is to say, the fragments are united by the intervention of a flexible and tenacious substance, which permits them to move upon each other. This mode of accidental articulations occurs after fractures of the patella, the neck of the femur, the olecranon, and also sometimes after those of the body of the long bones. Amphiarthroses also sometimes form in the place of some diarthroses of which the synovial membrane has contracted flexible adhesions.

627. *Diarthrosis* is a kind of articulation in which the articular surfaces of the bones are in contact, and move upon each other.

This kind of articulation exists among all the bones of the limbs, whether between each other, or between them and the trunk, between the lower jaw and the skull, between the skull and vertebral column, between the articular processes of the vertebræ, between the ribs and vertebræ, and between the costal cartilages and the sternum.

628. The articular parts of the bones, in this kind of articulation, are broad surfaces, whose configuration is reciprocal. These surfaces are in general, the one convex, the other concave. The convex surfaces, or articular eminences, are sometimes rounded like a large segment of a sphere, in which case they are called heads. Others are rounded, but elongated in one direction, and contracted in another: these have been named condyles. The heads and condyles are sometimes supported by a narrow part, which is called the neck. The articular depressions, or concave surfaces, bear the name of cotyloid cavities, when they have the form of a segment of a sphere and are deep; and that of glenoid cavities, when they are more superficial. Sometimes two condyles are brought near each other laterally, and leave between them a neck which enters into the articulation like themselves. This kind of surface is named a pully, *trochlea:* Lastly, many articular surfaces, which are nearly flat, presenting little convexity or concavity in their configuration, have received no particular name, but are designated, according to their extent, under the generic names of articular surfaces or facettes.

All these surfaces are covered with diarthrodial cartilages (554). These cartilages are themselves covered by synovial membranes (210), and moistened with synovia (216). There are, moreover, between certain of these surfaces, menisci or interarticular cartilaginous ligaments (531).

629. The means of union are fibrous ligaments, (512.) The muscles which surround the articulations, although they do not enter essentially into their composition, contribute powerfully to their solidity.

630. Firmness and mobility are variously combined in the diarthrodial articulations.

These articulations possess very diversified motions, as sliding, rotation, angular opposition and circumduction. The sliding motion exists in all the diarthrodial articulations. The other motions, on the contrary, occur only in a certain number of them. Rotation is peculiar to certain articulations. Sometimes it is exercised upon a single pivot, as around the odontoid process of the second vertebra. Sometimes there are two, as in the double articulation of the bones of the fore-arm with each other. Sometimes it is round an ideal axis that a bone turns, as is exemplified in the femur. The motion of opposition, or angular motion, is that in which the bones form more or less open angles with each other, according to the degree of motion. It is distinguished into opposition limited to two motions of flexion and extension, as at the elbow, the knee, &c. ; and into vague opposition, which may take place in four principal directions, and in all the intermediate directions, of which examples are offered by the arm, the thigh, the thumb, &c. Circumduction, which exists in all the articulations possessing vague opposition, is a motion by which the bone which moves describes a cone whose summit corresponds to the central extremity of the bone, and the base to its opposite extremity.

The firmness of these articulations, like that of the others, is in the inverse ratio of their mobility.

631. Several kinds of diarthrosis are distinguished, depending upon the configuration of the surfaces, the means of union ; and the motions of these articulations.

The close and planiform diarthrosis, *articulus adstrictus*, the amphiarthrosis of some, the *motus obscurus* of Columbus, is that in which the surfaces are superficial, the ligaments strong and tight, the motions obscure and confined to sliding, but capable of being performed in several directions. Of this kind are the articulations of the articular processes of the vertebræ, and those of the bones of the carpus and tarsus, whether with each other or with the metatarsus and metacarpus.

Arthrodia differs from the preceding articulation, in this respect, that the surfaces are less flat, the ligaments less tight, and the motions freer and more numerous. Of this kind is the articulation of the lower jaw with the temporal bone.

Enarthrosis consists in the reception of a head into a cavity. In this species the ligament is capsular, and the motions greatly diversified. The articulation of the femur with the coxal bone affords an example of it.

These three first kinds of diarthrosis are orbicular or vague. Their motions, which are more or less free, may take place in all, or in many directions. The following species, on the contrary, are called alternate, because the motions are performed in them only in two opposite directions.

The rotatory diarthrosis, *commissura trochoides* of Fallopius, is that which allows only motions of rotation; of which kind are the articulation of the atlas with the second vertebra, and that of the radius with the ulna. It is also called lateral ginglymus.

Ginglymus,* properly so called, or the hinge joint, also called angular ginglymus, is the articulation in which there are only two opposite motions, of which kind is the elbow joint. In this species of diarthrosis, one of the bones commonly presents a pulley, and the other a corresponding surface. There are generally two lateral ligaments. If the motion of extension is not to go beyond the line of direction of the bones, these ligaments, in order to limit the motion, are placed nearer the plane of flexion than the opposite plane.

632. Accidental diarthrodial articulations are produced under two different circumstances, after fractures of which the pieces have not united, and after luxations which have not been reduced. Both are very complex productions. The first kind may be called supernumerary, the other supplementary articulations.

633. The supernumerary articulations† have long been known. They occur after fractures in which the fragments have not been brought together, and those of which the fragments have been frequently moved on each other. Sometimes also the defect of union depends upon a constitutional affection. The ends of the bones, which have a different configuration, and have become compact and closed as after amputation, are covered with a thin layer of imperfect or fibrous cartilage. They are covered and enveloped by a synovial membrane, surrounded by a fibrous capsule, generally incomplete and with irregular ligamentous bands. This kind of articulation has been observed, with a great number of variations, in almost all the long bones of the limbs, and several times in the lower jaw and ribs.

634. The supplementary articulations have also been often observed. They follow unreduced luxations, and especially those of the femur and humerus. MM. Foville and Pinel Grandchamp sent me an anatomical preparation which represents an articulation of this kind that had been formed after an unreduced luxation of the bones of the fore-arm behind the humerus.

In the articulations of which we here speak, there occurs a depression in the point against which the head of the luxated bone has been placed. The circumference of this point is raised by an accidental ossification. Sometimes even there also occurs a circular fibro-cartilaginous rim in it. This newly formed cavity is covered with an imperfect or fibrous cartilage. The head of the luxated bone is commonly flattened. The interior of the articulation is lined by a very distinct synovial membrane and moistened

* I. F. Isenflamm and Schmidt. *De Ginglymo.*—Erlangæ, 1785.

† J. Salzmann. *De Articul. Analogis, quæ fracturis Ossium supervenient.* Argentor, 1718.—Langenbech. *Uber die Bildung wider naturlicher Gelenke nach Knochenbruchen, in der Neuen Bibl. fur die Chirurg.* Gotting. 1815.

by synovia. There is a fibrous capsule in it, formed by the remains of the old capsule, adhering to the luxated bone, by the surrounding cellular tissue, and by a new production. The old cavity contracts and becomes superficial, and the cartilage diminishes, or even entirely disappears. If it is in the haunch, the cotyloid cavity diminishes, and from being hemispherical becomes triangular ; a fact to be added to those which show that the form of organs depends, partly at least, upon their reciprocal action. It would appear that these changes were in part known so early as the time of Hippocrates.

635. M. Chaussier * has produced, in dogs, the formation of accidental articulations intermediate between the two kinds above described. Having by an incision made the head of the femur to come out of the cotyloid cavity, and having sawn it below the trochanter, he brought the flesh together, and left the animals to the care of nature. On examining the parts at periods more or less remote, he found that the muscles had drawn the extremity of the femur near a part of the ischium ; that the truncated bony extremity was rounded, and invested with a cartilaginiform substance ; that the point of the ischium against which it rested had also assumed a cartilaginous appearance, and sometimes presented an articular fossette of greater or less depth ; lastly, that the cellular tissue formed around this new articulation a kind of membranous capsule, in which was contained a serous fluid in greater or less quantity.

636. The diarthrodial articulations may be altered in their solidity and in their mobility ; they may be too loose or too tight, and they may also be luxated or anchylosed.

637. Luxation is the more or less complete cessation of the natural connexion between the contiguous surfaces of bones. When it takes place, the ligaments are violently stretched, drawn out, or even ruptured. The other articular and surrounding parts are more or less affected by these lesions. Motion is then very difficult. The most mobile articulations are the most susceptible of it. Thus the arthrodiæ and enarthroses are those which present the greatest number of examples of it, and the close diathroses those which present the fewest. Of the articulations of the same species, those which are the least close, those whose articular surfaces have the smallest extent, and those which take place between the longest bones, are those which are most frequently luxated. Thus, the shoulder-joint furnishes of itself more examples of luxations than all the others together.

638. Anchylosis,† or the uniting of the diarthrodial articulations, consists, when it is complete, of an intimate union, a real continuity between bones which were previously in contact. The

* *Bulletin des Sciences par la Soc. Philom.* Paris, an. viii.

† J. Th. Van du Wymperse. *De Ancylosi*, &c. Lugd. Bat. 1783. Idem. *De Ancyloseos Pathol. et Curat.* Lugd. Bat. 1783.—J. Cloquet, in *Dictionnaire de Médecine*, vol. ii.

spongy substance communicates from the one bone to the other. The compact plates, the diarthrodial cartilages, the synovial membrane and the synovia, which separated the spongy part of the two bones, have disappeared. Immobility continued for a great length of time, but especially a certain degree of inflammation, whether originally in the synovial membrane, or at first in the ligaments and the other surrounding parts, induce these changes. Sometimes they commence by an agglutination of the synovial membrane, and the formation between its surfaces of cellular tissue or fibrous bridles which may become ossified at a later period. Sometimes the articulation being laid open by a wound or the effect of an abscess, it is by suppurative granulations that the agglutination is established. In both cases, the diarthrodial cartilages are gradually absorbed before the osseous union takes place. All the diarthroses are susceptible of anchylosis, but the ginglymi more than the others.

Anchylosis sometimes affects several articulations. All the diarthroses and amphiarthroses have even been seen to be successively affected by it, and the skeleton has thus become a single inflexible mass. M. Percy has deposited in the Museum of the Faculty of Paris a skeleton which presents this general anchylosis of all the articulations.

639. At other times, the causes of alteration of which we speak determine the superficial necrosis or usure of the articular surfaces. It is in cases of this kind that excision of the articular extremities of the bones has been practised.* At other times, the adhesion of the articulation remains cellular or fibrous, with a little mobility. Sometimes the destroyed cartilage is reproduced. At other times it is replaced by the transformation of the subjacent bony plate into ivory or enamel. In cases of this kind spontaneous luxation of the bones sometimes occurs.

I have seen a singular displacement of the hip-joint, depending no doubt upon chronic inflammation. In this case the upper part of the articular cavity seems to have yielded to the pressure of the head of the femur, after having been softened. The cavity which has become oval, is greatly elongated and hollowed out at its upper part, where it lodges the head of the femur, while the lower part of the same cavity which lodged it before is contracted and superficial. I have observed this change sometimes on one side only, and sometimes symmetrically produced on both sides at once.

640. All the diseases of the diarthrodial articulations belong to each or to several of the parts of which they are formed, to their serous membranes, their cartilages, their ligaments, and to the articular parts of the bones.

* H. Park. Account of a New Method of Treating Diseases of the Knee and Elbow. London, 1783. Moreau, *De la Resection des Os*, &c. Paris, 1816. J. Jeffray. Cases of the Excision of Carious Joints by H. Park and P. F. Moreau, with Observations. Glasgow, 1806.—Wachter. *Diss. de Articul. Extirp.* Groningue, 1810.—Roux. *De la Resection*, &c. Paris, 1812.

THIRD SECTION.

OF THE SKELETON.

641. The skeleton is the aggregate of all the bones connected with each other by the articulations. It is called natural, when the bones are kept together by their proper ligaments, and artificial, when the bones are united by substances foreign to the organization.

It constitutes a symmetrical whole,* which has the form and dimensions of the entire body, which dimensions it in a great measure determines itself.

It is divided into the trunk and limbs. The trunk, the central and principal part, and which is formed in the median line by the vertebral column, presents two great cavities. The one, which is superior and posterior, and is formed by the skull and vertebral canal, lodges the nervous centre; the other, which is anterior and inferior, and is formed by the thorax, lodges the central organs of the nutritive functions. Other cavities (those of the face), receive the organs of sense, &c. The appendages or limbs which are furnished with numerous articulations, possessed of great mobility, are especially subservient to motion.

642. The uses of the skeleton are to form the solid and flexible axis of the body, furnish protecting envelopes to the nervous and vascular centres, and to the organs of sense, afford points of attachment to the muscles, and determine by its articulations the extent and direction of the motions.

The skeleton performs part of its functions through the hardness and rigidity of the bones, and the solidity of the articulations. The rest it performs through the mobility of the articulations.

643. In their motions, the bones articulated by diarthrosis act in the manner of levers.

The greater part are levers of the third kind, or that in which the power is interposed between the fulcrum and weight. The centre of motion or fulcrum is in the articular extremity of the bone, the resistance or weight at the other extremity, and the muscular power is applied in an intermediate point, which is commonly very near the fulcrum. Some of them are levers of the second kind, or that in which the weight is intermediate between the fulcrum and power. Some also are levers of the first kind, in which the fulcrum is interposed between the weight and the power.

644. As the bones are not all formed at the same time, and do not all grow in the same proportion, the form and proportions of

* Loschge. *De Sceleto Hum. Symmetrico*, &c. Erlang. 1795.

the skeleton, and not merely its dimensions, undergo great changes through age.*

The proportion of the head to the rest of the trunk and to the limbs is so much the greater, the younger the subject is, only within the twentieth year. At the second month after conception, it forms half the height of the body, nearly the fourth at birth, the fifth at the age of three years, and the eighth only when the growth is completed. The face in like manner is so much the smaller, compared with the skull; the pelvis, compared with the thorax; the limbs, compared with the trunk, &c. the younger the subject is. Many other differences of the same kind will be pointed out in the particular anatomy of the bones.

645. The skeleton presents pretty distinct differences in the two sexes.† In general the skeleton of the female is smaller and more delicate than that of the male; the thorax is shorter, and altogether smaller; it is also more mobile; the pelvis broader; the lumbar region more elongated, &c. The diarthrodial articulations are more mobile, the amphiarthroses more flexible, &c. All the regions of the body, and almost all the bones, present some particular differences.

646. The human races also present differences in their skeleton, the principal of which have reference to the dimensions and form of the skull, and its proportion to the face.‡ There are also some differences in the proportions of the limbs. In the negro race the upper limbs are longer in proportion to the trunk; the fore-arm and leg are longer proportionally to the arm and thigh.

647. Lastly, individual varieties are observed in the skeleton, both with respect to dimensions, and with reference to proportion, configuration, want of symmetry, &c.

The stature of the body, which is determined by the dimensions of the skeleton, is about five feet four inches in the adult man, and about five feet in the female;§ but this length, which varies somewhat in the different races, and even in still more restricted varieties of the human species, presents considerable differences in the individuals of the same race or nation. These differences, like those of the other species of animals, are confined within certain limits. Thus, dwarfs are seldom of less than half the mean stature, and giants are very seldom more than a half higher than the ordinary stature. What has been said of giants from seventeen to twenty-five feet high, must be referred to bones of animals mistaken for human bones.

* Boehmer, *op. cit.*—Cheselden, *op. cit.*—Eyson, *op. cit.*—Sue, *Sur les Proportions du Squelette de l'Homme, examiné depuis l'âge le plus tendre, jusqu'à celui de Vingt-cinq, Soixante ans et au-delà*; in *Mem. Pres.* vol. ii.—F. G. Danz, *Grundriss der Zergleiderungskunde des Ungebornen Kindes*, Francof, 1792.—Senff, *op. cit.*

† See J. F. Ackermann, *De Discrimine Sexûs Præter Genitalia*, Mogunt. 1788.—Compare also, Albinus, *Tabula Sceleti Hominis*, and Soemmering, *Tabula Sceleti Fœminei*, Francof. ad Mœnum, 1796.

‡ Blumenbach, *Decades Craniorum*, i.—vi.—Soemmering, *De Ossibus*.

§ The French measurements are somewhat longer than the English, which will account for the low average assigned for the adult male and female stature, the Paris royal foot being equal to 12.7977 English inches.—K.

The proportions which the limbs bear to the trunk and its different parts, or those of the limbs to each other, also present numerous individual varieties, determined by those of the bones. This is also the case with the general configuration and symmetry of the body, their variations being almost all determined by those of the skeleton.

648. The osseous system terminates those which have for their basis the mucous substance or the cellular tissue variously modified. The tissues which remain to be described are, on the contrary, essentially formed of globules united by the same substance.

CHAPTER IX.

OF THE MUSCULAR SYSTEM.

649. The Muscular System,* *Systema musculare*, comprehends all the organs formed of long, parallel fibres, reddish in the warm-blooded animals, soft, irritable, and contractile, which are named muscular. These organs produce all the great motions which take place in the living body.

The name muscle, *musculus*, *mus*, μῦς, from μύειν, *to contract*, indicates this property, the muscles in fact being the organs of motion.

650. It may perhaps appear surprising, but is nevertheless true that the first anatomists, Hippocrates and Aristotle, were unacquainted with the muscles, and especially with their uses. The anatomists of the Alexandrian school knew these organs, and have named some of them. Galen had a pretty correct general knowledge of them. He represents the muscle as formed by the nerve and by the ligament divided into fibrils, forming a tissue which he calls *stæbe*, filled up by the flesh. He supposes the muscles possessed of a tonic faculty, or contractile power, and in a state of elastic tension, inherent in their tissue, and independent of life. Motion would then depend upon the voluntary relaxation of the antagonist muscles. In his time there was also admitted a voluntary contraction quicker and more extensive than this contraction by elasticity. At the period of the renewal of science, myology was in the very imperfect state in which Galen had left it. It owed considerable improvements to Jacques Dubois (Sylvius). He gave names to most of the muscles, a thing which had been previously done only with reference to a very small number. Vesalius,

* W. G. Muys, *Investigatio Fabricæ, quæ in partibus Musculos componentibus extat*, diss. i.; *De Carnis Musculosæ Fibrarum Carnearum Structurâ*, &c. Lugd. Bat. 1741, 4to, clij. and 432 p.—Prochaska, *De Carne Musculari Tractatus Anat. Phys.* Viennæ, 1778; *et in Op. Min.* pars i. Viennæ, 1820.—F. Ribes, *Dictionn. des Sc. Med.* articles *Muscle*, *Musculaire*, and *Myologie*.

and the other anatomists of the Italian school, especially Eustachi, improved the particular knowledge of the muscles, and gave figures of them. The intimate texture of the muscles, their contractile action, the nervous influence upon this action, and the motions which result from it, have been much studied in the course of the two last centuries, and are still the subject of important investigations. *

651. In the most simple animals, the muscular fibre does not exist distinctly. The motions are produced in them by the cellular tissue. In the first of the series in which the muscular fibre appears, it only moves the tegumentary membranes to which it is attached, or of which it even forms part. In all those which have a heart, this fibre is its principal element. Lastly, in the vertebrate animals, a small number of muscles only are attached to the mucous membrane, the skin, the organs of sense, and the parts connected with them; whereas, on the contrary, a great mass is attached to the skeleton for moving it.

652. There are two classes of muscles in man. Some of them, which are internal, membraniform, and hollow, and belong to the mucous membrane and the heart, contract involuntarily, and are subservient to the functions of nutrition and generation, in a word, to the vegetative functions. Others, which are external, more or less thick and full, and belong to the skin, the organs of sense, the skeleton, and the larynx, contract voluntarily, and are subservient to the animal functions. Both present common characters, which it is necessary first to consider in a general manner.

FIRST SECTION.

OF THE MUSCULAR SYSTEM IN GENERAL.

653. The muscular system forms of itself alone a great part of the weight, and the greater part of the volume of the body.

654. Whatever be the diversity of their form and situation, the muscles, for the greater part, divide into bundles, and all are formed of primary or simple fibres, which are collected together into fasciculi.

The authors who have engaged in this point of the investigation of minute anatomy, have exposed it in a manner, in general, not very intelligible. Some of them merely say, that the flesh is composed of fibres; others, of fleshy striæ; others, of fibres and fibrils; others, of fibres themselves composed of *villi*. Muys divides the muscular flesh into fibres, fibrillæ, and filaments. He subdivides the fibres into three orders: larger, middle sized, and small, the

* MM. Prevost and Dumas are engaged in observations on the intimate texture and on the motion of the muscles. They have had the kindness to communicate to me their first results, which have not yet been published.

larger being composed of the middle sized fibres, and the latter of the small. So also with respect to the fibrillæ, of which the smallest compose the middle sized, and then the largest, these latter composing the smallest fibres. The smallest fibrillæ are in like manner composed of the filaments, which are themselves composed according to the general plan. According to this system, the muscles result from nine successive degrees of composition. Other anatomists, rejecting this entirely imaginary analysis, admit an indefinite divisibility. But it would appear, on the contrary, that in the muscles, as in all organic substance, we arrive by microscopic inspection at a finite and perfectly determinate degree of division.

655. The muscular bundles, *lacerti*, are not equally distinct, equally numerous, or of equal size in all the muscles. There are some whose bundles are so distinct and large that they might be considered as so many particular muscles. Such are the portions of the biceps and triceps muscles, the bundles of the deltoid muscle, masseter, gluteus maximus, &c. Of this kind also are the columnæ carneæ of the ventricles of the heart, the longitudinal bands of the colon, &c. On the other hand, there are many muscles which scarcely equal a small portion of a bundle of those abovementioned, and which are not formed of distinct bundles.

The muscular bundles are themselves formed of bundles of smaller size, and these of others still smaller, which may be distinguished in almost all the muscles.

656. All the muscles, besides, may be divided into fasciculi or fibres visible to the eye, *fasciculi seu fibræ secundariæ.* These fasciculi, which constitute the last degree of division perceptible by the naked eye, have nearly the same form and thickness in all the muscles. Like the preceding divisions, they may be perceived by a longitudinal section, but still better by a transverse section, and especially in a muscle that has been boiled or immersed in alcohol. They have a pentagonal or hexagonal prismatic form, and are never cylindrical. Their diameter varies little. Their length, according to Prochaska, equals the entire interval between their two insertions, even in the sartorius muscle. Haller, on the contrary, thinks, with Albinus, that the fibres or fasciculi have not the whole length of the muscles, and that the fasciculi of fibres terminate by becoming thinner in the intervals of other like parts. This, however, does not appear to be the case.

657. The muscular fibres, *fibræ musculares primariæ, seu fila carnea*, which are visible only with the aid of the microscope, form the last division which anatomical analysis determines in the muscles. For the best observations on this subject we are indebted to Hooke, Leuwenhoeck, Dehayde, Muys, Della Torre, Prochaska, the brothers Wenzell, Autenrieth, Sprengel, Sir Ev. Home, Bauer, * and to Messrs. Prevost and Dumas.† It is to be

* Croonian Lecture, in Phil. Trans. 1818.

† Examination of the Blood and of its action in the various phenomena of life, in *Ann. de Chimie et de Phys.* t. xxii.

remarked, however, that the first of these observers, having employed in their researches only glasses which did not magnify more than a hundred and fifty times, were unable to perceive the primary fibres, which, to be seen, require to be magnified about three hundred times. Their observations therefore refer to secondary fibres.

Hooke observed, that the muscles of various animals are composed of an innumerable quantity of minute threads, the volume of which he estimates at the hundredth part of a hair, and whose figure he compares to that of a string of pearls or coral beads. Leuwenhoeck, after perceiving the muscular fibres, which he named primary, conjectured that they were still compounded, going on the erroneous supposition, that the spermatic animalcules, which are of less diameter than the fibres, must be furnished with nerves and muscles. He gave several coarse figures of them. Those of Dehayde, although still coarse, are more accurate. Muys has given full and correct descriptions of them: he represents them as most commonly cylindrical, and but rarely nodulous. Della Torre said that they were reddish, which is not generally true. Prochaska's observations, which are much more accurate, have shown that these fibres are parallel, but not always straight, and that in boiled flesh they are always flexuous; that their form is not cylindrical, but flattened or prismatic; and that their substance is diaphanous, and appears solid. Their diameter, which varies little, appeared to him to be seven to eight times less than the greatest diameter of a red globule of the blood:—an observation which does not seem to be correct. These fibres appeared to him to form the limit of the division of the muscles, without his venturing to affirm, however, that they were elementary fibres. Microscopical observation made by the brothers Wenzell on a portion of muscle previously immersed for eight days in a mixture of alcohol and muriatic acid, showed them each fibre composed of excessively minute corpuscles of a round form. According to M. Autenrieth, the diameter of these fibres is the fifth of that of the globules of the blood. M. Sprengel, on the contrary, estimates the diameter of the muscular fibre at seven times that of the globules of the blood, (which is the three hundredth of a line) or about a fortieth of a line. He describes it as angular, striated and full. The microscopical observations of M. Bauer and Sir E. Home, published with very beautiful figures, represent the muscular fibre as identical with the particles of the blood deprived of their colouring matter, and of which the central globules are connected into filaments. MM. Prevost and Dumas have constantly obtained the same result, whatever animal was examined, and of whatever form or size its globules were. My own observations perfectly agree with theirs. In order that observation leave no doubts, it must be made on fresh muscular flesh that has not been any way prepared. In fact, as boiling and the action of alcohol produce globules by coagulating the albumen, their presence in the muscular fibre might be attributed to these two causes. These globules are connected by a medium which is invisible on account of its transparency and want of colour. It is a kind of jelly or mucus. If muscular flesh be macerated in water frequently renewed, putrefaction more rapidly altering the medium of connexion of the globules than the globules themselves, and the renewing of the water carrying off the product of putrefaction, the globules are obtained isolated and resembling those of the coloured particles of the blood. The fibres of all the muscles have the same form and size.

658. Wrinkles or flexuosities are often perceived upon the fasciculi of the muscles, especially when they are boiled. This appearance, which was noticed by Hooke, Leuwenhoeck, Dehayde, and Haller, and has been represented by Muys, much engaged the attention of Prochaska, who attributed it to the contraction of the cellular tissue, vessels, and nerves, and to their crispation by boiling. These apparent rugæ or striæ have also been attributed to several other imaginary causes, and have given rise to the idea that the fibres possess an articulated, tortuous, or spiral disposition. These wrinkles are, or appear to be, nothing else than flexuosities or undulations. They always exist in the muscles when contracted, whether in the state of life, or after death, or through the action of caloric. This flexuosity is also produced of itself when retraction of a muscle is favoured or produced by cutting its insertions or bringing them towards each other. They disappear entirely when the stiffening which follows death ceases.

659. Physiologists, deceived by inaccurate observations, or led away by hypothetical views, have admitted false or entirely arbitrary opinions respecting the intimate nature of the muscular fibre.* Thus many physiologists and mechanicians have admitted that the muscular fibre is hollow, and consists of a series of ovoidal vesicles, or rhomboidal cavities, elongated in the state of relaxation, and broadened and globular in the state of contraction of the muscles. Some have considered the muscular fibre as hollow and continuous with the nerves. Many others have regarded it as hollow, vascular, and capable of being injected, whether as formed solely of minute arteries, or as consisting of very delicate vessels, intermediate between the minute arteries and veins. Others have described these internal cavities, whether vesicles or canals, as spongy or cellular. Some have admitted transverse fibres, nervous or of a different nature, whether for retaining the blood in the fibre, or for contracting its dilated canal, and shortening it by this mechanism. Others again have imagined the fibre to exist in the form of a spiral tube around an inextensible filament; while others have supposed it twisted like flax or hempen threads.

There may be objected to all these assertions, that the muscular fibre, examined with good optical instruments, appears rather to

* Haller, *Elementa Physiol.* lib. xi. Sect. 1. and 3. t. iv.

result from a linear series of more opaque globules, connected by a paler medium, but that there is nothing whatever to indicate that these globules are vesicles; that during the contraction of the muscles wrinkles are seen to form, and these flexuosities are found to become obliterated during relaxation, but that no change whatever takes place in the figure of the globules; that in insects, which have no vessels, there are yet muscular fibres, which, therefore, cannot be a continuation of the vessels; that injection may, indeed, swell out the muscles by being infiltrated between the fibres, but that it does not penetrate them; that the alleged transverse fibres, torsions, spirals, &c. have never been seen, but only supposed, for the benefit of certain hypotheses respecting muscular action; lastly, that the muscular fibre, which differs essentially in its organic characters and vital phenomena, from the cellular tissue, the nervous tissue, and that of the vessels, cannot be likened to these tissues. Mascagni has renewed and modified one of these hypotheses, by considering the primary cylinders of the muscles as formed of absorbent vessels filled with contractile glutinous substance in the state of life, and continually renewed by the circulation. Nothing demonstrates this to be the case, or that the fibres are hollow. It is much more probable that they are solid.

660. The muscles are enveloped by the cellular tissue which forms membranes or sheaths for them. This is also the case with respect to their bundles and the divisions of these bundles; only, in proportion as the parts are enveloped are of less size, the cellular tissue forms thinner and softer envelopes. The fasciculi are enveloped and connected together by scarcely perceptible layers of this tissue. Lastly, the primary fibres are united together, in each fasciculus, by prolongations of its envelope, which are so thin and soft as entirely to elude observation. The cellular envelopes are perceived on separating the bundles and fasciculi from each other as well as on cutting a muscle across.

Adipose tissue also occurs around the muscles, in the intervals between their bundles, and even sometimes between the fasciculi.

661. The blood vessels of the muscles, which have been well described by Albinus and Haller, and figured by Prochaska and Mascagni, are very abundant, although less so than in the mucous membrane. Their quantity bears proportion to the size of the muscles. The internal muscles, however, are more vascular than the others, and some of them greatly more so. The veins, as in most of the parts, have a greater capacity than the arteries. Both communicate with the vessels of the tegumentary membranes, wherever the muscles are near them. Both, after dividing first in the cellular membrane, and there presenting numerous anastomoses, penetrate, under various angles, between the different bundles, and there divide again, to penetrate between the fasciculi and into the intervals of the fibres, always following the cellular envelopes, and continually presenting new divisions, and new anastomoses. In their whole course, these vessels accompany the di-

visions of the muscles by twigs running parallel to them, and cross their direction by other transverse twigs which surround them. On arriving at their last state of division, the arteries are continued into the veins, without its being possible to know how they contribute to the texture and nutrition of the muscular fibres.

It is not from the blood vessels of the muscles that the red colour of these organs is derived, for the internal muscles although highly vascular are whitish.

Lymphatic vessels are seen distinctly in the intervals of most of the muscles, and in the substance of some of them. The manner in which they originate in them is, however, unknown. Perhaps they are the continuation of the cellular tissue which exists between the fibres.

662. The nerves of the muscles are very large. Next to the skin and the organs of sense, the muscles are the parts most abundantly provided with nerves. In general, they are proportionate in number and size to the volume of the muscles. The internal muscles, however, have, in general, fewer nerves than the others, and of the latter, those of the skeleton fewer than those of the larynx and organs of sense. They generally accompany the blood vessels, and especially the arteries, and are loosely connected with them by cellular tissue. To see them well, it is necessary to macerate the muscles until putrefaction commences, which, in fact, destroys the muscles more quickly than the nerves. They penetrate by various points into the muscles, and divide in them in the manner of vessels; but they soon elude the sight, without our being able to perceive them by any artificial means; so that nothing can be affirmed with respect to their termination. It is conjectured, with some probability, that their divisions extend to the primary fibres. It would appear, that before disappearing, they become gradually softer, leaving off their proper envelope, so that their medullary substance is in immediate contact with the muscular fibre. Monro and Smith have thought that the nerves of the muscles are their spiral fibres.

According to MM. Prevost and Dumas,* the nerves of the vessels are better seen by the following means, than by any other. A piece of cow's muscle, which has been macerated in pure water, is examined in a dark place. On receiving upon the muscle alone a ray of strong light, the colour of the nerve is distinguished, as standing out from that of the muscle, and it may be followed to a great distance, by means of a good lens and a very small scalpel. The ramifications are then seen to terminate by being inserted between the muscular fibres, whose direction they intersect at right angles. To observe this arrangement in the whole mass of a muscle sufficiently thin to be transparent, the sterno-pubic muscle of the frog is placed upon a bit of glass, and is examined by transmitted light, by means of a weak lens, and the light of a candle.

* Unpublished Memoir.

The nerve and its branches are then perceived, the latter being distinguished from the muscular fibres by their direction. In fact, the trunk of the nerve runs in the substance of the muscle parallel to its length, and the branches all separate from it at right angles, to become engaged between the muscular fasciculi and fibre; and as they are all in the same plane, on account of the thinness of the muscle, they represent a kind of comb. If the muscle is contracted, the last visible transverse fibrils of the nerve are seen to correspond exactly to the summit of the angles, or flexuosities of the muscle.

The nerves, although numerous and of great size in the muscles, elude the sight long before their divisions are by any means sufficiently multiplied to be distributed to all the muscular fibres. Two hypotheses have been imagined to explain their action upon these fibres. Isenflamm and Mr. Carlisle suppose that the nerves, at their termination, dissolve into the cellular tissue of the muscles, and that this tissue thus participates of the conducting property of the nerves. Reil admits that the nerves have a sphere of activity extended beyond their termination, and which he calls the nervous atmosphere. These suppositions will be subsequently examined.

663. The greater number of the muscles have the extremities of their fibres attached to ligamentous tissue, through the intervention of which their action is transmitted to a greater or less distance. But these ligamentous parts are much more extensively distributed in the external muscles than in the others.

664. The colour of the muscles varies greatly. Those of the invertebrate animals, and of the cold-blooded vertebrate animals are white. The muscles of birds, mammifera, and man are, some of the reddish tint generally known by the name of flesh-colour, the rest of a greyish white. The shade varies greatly in both kinds. It also varies according to different circumstances, antecedent or subsequent to death. The colour is easily removed by washing and maceration. It appears to be so much the paler, the smaller the muscle, bundle or fasciculus is, and, on the contrary, so much the deeper, the greater the mass is. In their slices, muscular flesh is semitransparent.

The consistence of the muscles varies greatly, even in the dead body, and from causes which have acted before or after death, and which will be examined when we come to speak of their irritability. In general, the muscular fibre is soft, moist, possessed of little elasticity, and easily torn in the dead body.

665. The muscular flesh when exposed in thin slices to the action of a current of dry air, or to the heat of a stove, loses more than half of its weight, and becomes brown, more transparent, and very hard. On the other hand, when immersed in cold water frequently renewed, flesh loses its colour entirely, and acquires a straw-yellow tint. Maceration softens and swells it.

Alcohol, diluted acids, solution of corrosive sublimate, those of alum, common salt and nitrate of potassa, increase the consistence of the muscle, slightly contract it, favour its separation into fibres, and alter its colour in various ways. Alcohol renders it pale; alum turns it to brown and hardens it greatly; nitrate of potash and common salt redden it a little, and, after first hardening it, afterwards soften it, especially the former, while they at the same time retard its decomposition. According to the unpublished observation of M. Bretonneau, and those of M. Labarraque, the solution of chlorure of calcium, at a suitable degree of concentration, preserves the consistence, flexibility and other natural qualities of the muscles and other soft parts.

666. Muscular flesh treated by cold water, gives out to it colouring matter, differing a little from that of the blood, albumen, gelatine, and an extractive matter first observed by Thouvenel.

Submitted to the action of boiling water, flesh furnishes a greater quantity of these substances, and moreover fat. The muscle thus treated, and exhausted by the prolonged action of water, there remain colourless fibres, insoluble in water, and easily separable, which by desiccation are rendered brittle, and which possess all the properties of fibrine. Muscular flesh when calcined leaves about a twentieth part of its weight of saline matters.

It follows from these facts, which have been observed by Thouvenel, Fourcroy, M. Thenard and others, that the muscles are principally composed of fibrine, and also contain albumen, gelatine, extractive matter, osmazome of M. Thenard, phosphates of soda, ammonia and lime, and carbonate of lime.

These observations have been particularly made on cow's flesh; but as the chemical properties of muscles present differences, even in animals nearly allied to each other, they are not perhaps exactly applicable to man.

667. In the state of life, the muscles possess an active power or property, commonly designated under the names of muscular irritability, muscular force, or myotility.

668. Muscular action* has been the subject of numerous inves-

* See Fr. Glisson. *Anat. Hepatis.* Lond. 1654.—Swammerdam, *Biblia Nat.* T. II. Haller. *De Partibus Corp. Hum. Irritabilibus*; in *Comm. Gotting.* T. II. et in *Nov. Comm. Gotting.* T. IV.—*Memoires sur la Nature Sensible et Irritable des Parties du Corps Humain.* Laus. 1756-59.—Petrini *Sull' Insensib. e Irritab. Dissert. Transp. Romae*, 1754.—Fabri *Sull' Insensitiva e Irrit. Opuscol. Raccolti. Bonon.* 1757-59.—A. G. Weber. *De Initiis ac Progr. Doctr. Irritab.* &c. *Halae*, 1783.—J. L. Gautier (*Praes.* Reil), *de Irritabil. Notione*, &c. *Halæ*, 1793.—Croonian Lectures on Muscular Motion,* in Philos. Trans. 1738, 1745, 1747, 1751, 1788, 1795, 1805, 1810, 1818, &c. —J. Chr. A. Clarus. *Der Krampf. Lips.* 1822.—Lucae, *Grundlinien Einer Physiol. Der Irritabitat des Menschlichen Organismus* in Meckel's Archiv. B. III.—G. Blane, On Muscular Motion. Lond. 1788, and in Select Dissert, &c. Lond. 1822.—Barzelotti, *Esame di Alcune Moderne Theorie alla Causa Prossima della Contrazione Muscolare.* Sienna, 1796, and in Reil's *Archiv.* B. VI.—H. Mayo, Anat. and Physiol. Commentaries, No. 1. Lond. 1822.

* Dr. W. Croone, who died in 1684, left the plan of two lectures to be instituted, the one at the College of Physicians, on the nerves and brain; the other, which was to be annual, at the Royal Society of London, on the nature and laws of muscular motion. The latter is still continued, and has given rise to several excellent papers, both on the texture and action of the muscles. Several of these lectures are not consigned in the Philosophical Transactions.

tigations on the part of Haller, of several physiologists anterior to him, and of a great number of his contemporaries and successors.

The study of muscular action comprehends that; 1st, of the phenomena of that action; 2dly, of its conditions; 3dly, of its principle or cause; and, 4thly, of its effects.

669. The phenomena of muscular action which have been best determined are the following: The muscle in action shortens, swells and hardens; it is uncertain whether its volume changes; its colour does not vary; it presents wrinkles and folds at its surface; its fibres and fasciculi are often in a state of trembling or oscillation, which depends upon their alternate contraction and relaxation; it acquires a very great power and a manifest elasticity. These are the phenomena of *contraction;* and the most remarkable of these facts is in reality that of the shortening which takes place. When the action ceases, all these phenomena disappear, and the muscle is then relaxed.

Are the muscles also susceptible of an active *elongation?* Various facts have been cited in favour of this opinion, of which some prove nothing at all in its favour,* while the others, adduced by Bichat, M. Autenrieth, M. Sprengel and M. Meckel, still leave the question at least undecided.

There has also been admitted in the muscles a force of *fixed situation*,† or an action in which they are neither contracted nor elongated. The same remark applies to this phenomenon as to the preceding.

670. Contraction or shortening being the best determined fact in muscular action, we must examine it in detail, as well as its accompanying phenomena.

The muscle increasing in thickness at the same time that it shortens, the simultaneousness of these two phenomena has given rise to a question which has much occupied the attention of physiologists, and which has not yet been entirely solved: it is, whether the volume of the muscles changes during their contraction.

The experiments of Swammerdam, Glisson, Goddart and M. Erman, on the diminution of volume of the muscles during contraction, do not completely prove that this diminution takes place. The same may be said of the experiments and reasoning of Hamberger, Prochaska and Mr. Carlisle, in favour of their augmentation: they also leave the question undecided. It is very probable, that according to the observations and experiments of Sir G. Blane, M. Barzelotti, Mr. Mayo, and MM. Prevost and Dumas, and according to the opinion of M. Soemmering, M. Sprengel and M. Meckel, there is no change of volume; the shortening and swelling of the muscles compensating each other.

671. The shortening manifests itself by various effects, the swelling is evident to the most simple observation, and the hardening is sensible to the touch.

* See Barthez, *Nouv Elem. de la Science de l'homme,* T. I.
† Barthez. *Ibidem.*

672. The colour of the muscles does not change during contraction. The contrary has been supposed to have been observed, in examining the heart in action in young animals; but the apparent change of colour is merely owing to its transparency.

673. Many physiologists have attributed muscular action to the accumulation of the blood in the muscles, whether in their interior itself, or in the intervals between the fibres. Others have attributed it to similar causes, which all suppose are an increased activity of the circulation during muscular action. Haller made various objections to these hypotheses. There is no direct proof of the afflux of the blood into the muscles during their action. There results besides from the experiments of Barzelotti, that the contraction of the muscles of the frog, excited by galvanism, may take place after death: 1st, When the blood no longer circulates in the vessels; 2dly, even when the blood is congealed; and, 3dly, when the vessels are deprived of blood. Here indeed we have only contractions excited in the dead body by galvanism; but the facts also prove that the presence of blood in the vessels of the muscles is not necessary for their contraction. It is known, however, that when there is fluid blood in a muscle, contraction, even after death, puts the blood in motion, as by a kind of displacement.

674. The fibres which were straight during the state of relaxation, bend during contraction, forming very regular sinuosities. These sinuosities or folds, which have been already perceived by many observers, have been more particularly examined by MM. Prevost and Dumas, who have found that these zigzags are always produced in the same manner, and that the summits of the angles, which are the points of the fibre that approach each other during contraction, are also those in which the last transverse ramifications of the nerves terminate.

675. During the contraction of the muscles, a continual fibrillar agitation takes place in their substance; some of the fibres contracting, and others becoming relaxed.* It is to this cause that the rustling is to be referred which we hear when the finger is applied upon the orifice of the ear, as well as that which is perceived by the stethoscope when applied upon a muscle in a state of action. This phenomenon is especially, perhaps exclusively, perceptible in a muscle in a state of sustained action. It has not been observed, either by the sight, or by hearing, excepting in the external muscles and in the heart.

676. Certain muscles are capable of contracting partially. This at least is what is seen in experiments on living animals, and in some cases of convulsion of the subcutaneous muscles. Is this peculiar to the muscles which have several nerves?

677. The velocity and force of contraction are extremely great. The velocity is very great in the action of running, in that of

* Roger. *De Perpetua Fibr. Musc. Palpitatione.* Gott. 1760.—Wollaston, Croonian Lecture, in Phil. Trans. 1810.

speaking fast, in that of playing on stringed instruments, &c. This velocity, in some cases, may be carried to less than a third. The force of the muscles in a state of action is enormous, and is sometimes sufficient to break the tendons or bones, parts of the body which so powerfully resist rupture. It is always proportional to the number of the muscular fibres, each of them having its proper force, which is a fraction of the total force. The elasticity of the muscles when contracted is especially manifest in the production of the voice.

678. The extent of contraction is difficult to be determined. It has been attempted to determine it, according to hypothetical ideas respecting the form of the primary fibres, and it has then been estimated at a third of the length of the fibre. Direct observation shows that the shortening of the contracted fibre, in the external muscles, is a fourth of its length. MM. Prevost and Dumas have arrived at the same result, by measuring the angles which form during contraction. Be this as it may, the extent of the contraction is in fact proportional to the length of the muscular fibres. When nothing opposes itself to the contraction of a muscle, it may produce a very great degree of shortening, of which examples are seen in cases of fractures and of loss of substance of the bones of the limbs.

679. The conditions of muscular action are the life of the muscle and its communication with the circulating and nervous centres, its state of integrity, and the action of a stimulant.

In order that muscular action may take place, it is necessary that the muscle participate in the circulation. If the principal arteries or veins of a part of the body be tied, muscular action is greatly weakened in it. The muscles, in order to act, must also communicate by the nerves with the nervous centre. The interruption of this communication stops the muscular action more or less suddenly. It always arrests, and that instantly, the influence of the nervous centre; but the muscle remains possessed of irritability through causes which act upon it or upon the nerve to which it still holds.

680. The muscle must be in its entire state. Contusion of the muscles, inflammation of their cellular sheaths, the accumulation of fat in the interstices of the fasciculi, &c. are so many circumstances which more or less oppose muscular action. The extreme distention of the muscular fibres is sufficient to prevent their action. The same remark does not altogether apply to their contraction. An extreme degree of heat or cold, the direct application of opium to the muscles, and various other substances, diminish muscular irritability in general, although they exercise little influence upon galvanic susceptibility.

681. Lastly, in order that the muscle may enter into action, it must be excited by a stimulant. The stimulants of muscular action are: 1st, Volition, or the action of the will: it acts upon the muscles through the medium of the nerves, but it is a stimulant for certain muscles only, which for this reason are called voluntary

muscles; 2dly, Emotion or passion, which acts by the same means, but whose action extends to all the muscles; 3dly, Irritation of the encephalon, spinal cord and nerves, which, in the first case, also acts upon all the muscles, but with more or less energy; 4thly, The application of a stimulus to some determinate part, of the skin or mucous membrane, more or less remote from the muscles; 5thly, The stimulating of the membrane which immediately covers the muscles, as the internal membrane of the heart, the cellular sheath of the muscles, the serous membrane of the abdomen, &c.; 6thly, Direct irritation of the muscle itself: it remains doubtful in this case whether the stimulus acts directly on the muscular fibre or indirectly, that is, through the medium of the nerves. What renders the last supposition more probable is, that the irritation of a part of a muscle produces contraction of the whole muscle.

682. The cause of muscular action, like that of all the organic actions, is almost impossible to be determined. The phenomena and conditions are known; but beyond this we have nothing but mere hypotheses. This cause has been attributed to the action of the nerve, to that of the blood, to the reciprocal action of the nerve and blood in the muscle; and, according to the doctrines which have prevailed at different periods, these opinions have given rise to many different hypotheses. It is evident that during contraction there is a momentary increase of molecular attraction between the particles of the fibre. If we consider the folded form which the fibre assumes, and the relation of the nervous filaments to the folds, it will be conceived that the nervous influence must perform an important part in the phenomenon of contraction.

683. Is irritability a force inherent in the fibrinous substance of the muscles, and does not the nervous action act there as any other stimulus of contraction? In this hypothesis, the nerves would perform no other action in the voluntary muscles than that of irritating them; and with respect to the muscles which, like the heart, do not contract voluntarily, the nervous action would not manifest itself in ordinary circumstances. Or has irritability its source in the nervous system alone? In this other hypothesis, the nerves would perform, with reference to the voluntary muscles, the twofold office of rendering them irritable, and of making them contract; and with respect to the involuntary muscles, whose contraction is determined by local stimulants, it would only render them fit for this contraction. Or, lastly, have the muscles a proper force (*vis insita*), and a force derived from the nervous action (*vis nervea*)? It is almost impossible to solve these questions, or to give the preference, with any rational motive, to any one of these hypotheses.

684. The effects of muscular action, in the living body, are to produce or prevent the motion of the solid and fluid parts, or even of the entire body, according to circumstances.

The modes according to which the muscles exercise their action, may be reduced to two: 1st, The two extremities of the fibres in action may remain equally fixed, as in the action of the diaphragm, the muscles of the abdomen, the buccinator muscle, &c.; or they may be equally mobile, as in the sphincters, the annular fibres of the stomach, intestines, &c.; 2dly, One extremity of the fibres in action is more fixed than the other; so that the more mobile is drawn towards the other, as in most of the muscles of the limbs; as, in particular, in the muscles of the fingers and toes; or one extremity is absolutely fixed, and the other absolutely mobile, as in the muscles of the eye, the velum palati, &c.

685. The muscular actions which take place naturally in the body may be divided into two classes, voluntary and involuntary.

The voluntary actions are those of all the muscles subservient to standing and the motions of the skeleton, the motions of the larynx and those of the organs of sensation. All these muscles receive their nerves directly from the spinal marrow.

The involuntary actions may be subdivided into three orders. Some of them are produced by stimuli acting through a thin membrane which immediately covers the muscles. These are the motions of the alimentary canal, the urinary bladder, the heart, &c. Others are produced by stimuli of a similar kind, but which are propagated by means of association with many other muscles. Of this kind are the motions of deglutition, respiration, coughing, sneezing, fæcal excretion, emission of the spermatic fluid and urine, parturition, &c. The others are the motions of emotion or passion, as laughing, crying, &c.

Of the actions or motions of this second class some have been considered as semi-voluntary, or as constituting an intermediate class of mixed motions. It is, in fact, very difficult to establish a perfectly distinct line of demarcation between the voluntary motions, or those perfectly subjected to the will, and the involuntary motions; for, on the one hand, there are few functions over which the will, and especially the passions, have not some control, and, on the other hand, many voluntary motions become through habitude nearly involuntary; such, for example, are the motions of the limbs, which take place without consciousness and without the will during sleep; those of the eyelids, which take place without the will and even against it, when a foreign body is brought near the eye; such also, on the other hand, is the difficulty or impossibility of moving the upper and lower limbs simultaneously, or in moving the eyes in an opposite direction to that which they commonly follow. Accidental irritation of the muscles, nerves, or common centre, sometimes renders the contraction of the external muscles entirely involuntary. Other affections render them immoveable in spite of the will. As to the influence of the will upon the motions considered as involuntary, it is evident upon those of respiration, vomiting, and rumination. It would even appear that it may be sometimes extended to the motions of the heart, those of the uterus, iris, and skin. It is true that the influence of the passions upon the will itself must not be forgotten.

The motions which have been considered as mixed are especially those which, commonly taking place without consciousness and without the will, may be modified by the will. Such are the motions of the diaphragm. This name is not so generally given to those which, although habitually voluntary, are exercised by habit and association without being directed by the will, such as the balancing motions of the arms in walking.

It is to be remarked, that apoplexy and other cerebral affections most commonly paralyse the voluntary muscles alone.

686. In general, the varied muscular motions which take place in the living body, are either associated with each other to produce the same action, or opposed to each other to produce contrary actions. In the former case the muscles are called congenerous, in the other, antagonist. Antagonism is much more evident in the external muscles, as, for example, between the flexors and extensors, &c. It is less marked in the internal or automatic muscles, although it is not entirely foreign to them. There results, at the natural orifices, an opposition of the automatic muscles and of the voluntary muscles, as is seen between the excretory muscles, which are involuntary, and the retentor muscles or sphincters which are subject to the will. Antagonism in all cases presents this remarkable phenomenon, that the contraction of the one set of muscles is accompanied by the relaxation of the other. The congenerous or associated muscles present this important phenomenon, that their contraction is simultaneous, and that, when the exciting cause operates upon one muscle only, the others nevertheless enter into action. Thus when the gullet, the orifice of the larynx, the anterior angle of the bladder, &c. are stimulated, all the muscular powers of vomiting, cough, urinary expulsion, &c. enter into action by the law of the association of congenerous muscles, at the same time with, and conformably to, the law of antagonism. In the latter case, the sphincter and constrictor muscles of the neck of the bladder and the urethra relax.

687. The muscles continue to be irritable and contractile under various stimuli for some time after death, and after the cessation of the circulation. All the muscles do not retain their irritability the same length of time, nor do they all at once lose the susceptibility of contraction, but cease at first to be excitable by particular stimuli. The preceding state of the health, the kind of death, and the external circumstances before death, have great influence upon the duration of muscular irritability. Galen, Harvey, and Haller knew, that the heart is generally the *ultimum moriens*. Haller established an order of cessation of irritability in the different muscles, and also discovered different variations in this order. Zinn, Zimmermann, Oeder, Froriep, and especially Nysten, engaged in the examination of this subject. The variations which were observed by Haller depend greatly upon the nature of the stimulus. Thus the heart remains longer irritable by mechanical agents than any other muscle, and the muscles of the skeleton, on the contrary, remain longer excitable by galvanic irritation. The latter power

acts more efficaciously when the external muscles are not comprehended along with the nerve in the circuit. The contrary takes place with respect to the internal muscles.

The order established by Nysten for the successive extinction of irritability in the bodies of beheaded persons, is the following,—1st, The aortic ventricle of the heart; 2dly, The large intestine, the small intestine, and the stomach; 3dly, The urinary bladder; 4thly, The pulmonary ventricle; 5thly, The œsophagus; 6thly, The iris; 7thly, The external muscles; 8thly, The right auricle; and, lastly, the left.

Muscles, or portions of muscles, separated from the living body, retain their irritability for some time. They present variations in this respect similar to those which we have just pointed out. Contraction evidently takes place in these two circumstances without an afflux of blood.

688. When the irritability is nearly extinguished or exhausted in the muscle, irritation no longer determines general or extensive contraction of the entire muscles, their bundles or their fasciculi, but remain confined to the points that are irritated, which swell from the flexuosity of which they become the seat. This last kind of irritability which survives the nervous action, seems to me to be entirely of the same nature as that observed in the fibrine of the blood, it is there truly the *vis insita* of the muscular fibre.

689. The kind of death, the previous state, and the surrounding circumstances, exert an influence upon the irritability of the dead body. The state of paralysis, or hemiplegia, does not prevent the muscles from being irritable, in the dead body, by galvanism. Diseases influence the irritability of the dead body much more by their progress and duration than by their nature. Chronic diseases alter more this property than acute diseases, and most particularly the chronic diseases affecting the organs or function of nutrition. The most muscular subjects are not those in which muscular irritability continues longest after death. Its duration varies from one hour to about twenty-four hours.

690. At length, after all general or local irritability has ceased in the body deprived of life, the stiffness which follows death manifests itself. (124.) It is a constant phenomenon, whatever Haller and Bichat may have said of it, but it varies in its intensity and duration. This contraction, or stiffening, which has its seat in the muscular system, is independent of the nervous system; it only takes place when that system is no longer excitable by galvanism. Cutting of the nerves, the state of hemiplegia, or the removal of the brain, do not prevent it from being manifested. It is the last effort of muscular contractility. In the cold-blooded animals, in which the nervous excitability remains for a long time, the stiffening of the body is longer in coming on, and lasts but a short time. In the warm-blooded animals, on the contrary, in which the nervous excitability does not remain long, it manifests itself shortly after death, and continues long. The stiffening of the dead body seems analogous to the contraction of the fibrous coagulum of the blood,

and, like it, ceases only when putrefaction commences. It may be considered, together with the diminution of heat which always accompanies it, as a certain sign of death. If a muscle in the state of rigidity be immersed and kept in alcohol, this state persists indefinitely in it.

692. Other moving properties have also been attributed to the muscles. Galen recognised in them a tonic force independent of life. Elasticity has also been accorded to them. Haller accorded to them contractile force in general, and dead force; Simpson and Whytt attributed to them tonicity or tonic force; and Bichat, besides voluntary contractility and irritability or involuntary contractility, also accorded insensible organic contractility, that is to say, tonicity.

The muscles are extensible. They are also retractile, and are so independently of their contraction under irritation. In the state of sleep and rest, the muscles generally give to the parts intermediate attitudes, dependent upon their proportional length, and consequently upon their tension, their force, and the more or less efficacious manner in which that force is applied. The same thing takes place in paralysis determined artificially by cutting all the nerves of the limb. In paralysis of the brain, and in contraction of the limbs, the attitude is somewhat different, flexion being sometimes carried to a great extent. But a doubt remains here, which is, whether the cause of paralysis has equally affected all the nerves of the part, or even if this cause is not one of tonic contraction of some muscles. In the dead body the muscles remain contractile, and give a determinate attitude to all the parts of the body, until it is dissipated by the rigidity which ensues.

693. The muscles are possessed of sensibility, but only in a moderate degree. In the state of health they only suffer the feeling of fatigue during and after their action, when it has been prolonged. When this action has been very long and violent, it gives rise to a painful sensibility. It is the same in all cases of inflammation of their tissue or of their cellular sheaths. Cabanis and Dr. Yelloly have given cases of disease in which the muscles were insensible.

694. The circumstances which show a continual change of particles in the nutrition of the muscles are not very evident. The fact, however, is probable. It seems to be the globular part of the blood which supplies the materials for it. The effects of exercise upon the nutrition, enlargement, and colouring of the muscles, and the opposite effect of too long protracted rest, are well known. Paralysis produces a still more decided effect upon their diminution. The quantity and kind of food have a great influence upon the volume and strength of the muscles. Certain consumptive diseases, as phithisis, have a marked influence upon muscular atrophy. It is not known if, whether in this case, there is a diminution of volume only, or a disappearance of the fibres.

695. In the embryo, the muscular tissue is not distinct from the cellular tissue, but is confounded with it into a common gelatinous

mass. At a period not very remote from conception, the action of the heart already announces a pretty advanced degree of development in the muscular tissue of that organ. About two months after conception, the muscles of the skeleton have distinct fibres. They begin to perform some contraction towards the end of the fourth month. According to Bichat, the muscles of the fœtus have less irritability, or at least a less galvanic susceptibility, than those of individuals who have respired. Experiments made by Meckel, on some animals, have afforded results the opposite of those obtained by Bichat.

During childhood, the muscles remain of small size in proportion to the nerves and adipose tissue. At this age also, the muscular flesh is less red, and more gelatinous and fibrinous than in adult age; the motions are easy, quick, and weak.

The muscles, which are of a bright red colour in adult age, become pale, yellowish, red, and livid in old age. The contractions, at this period, become difficult, weak, and slow.

The irritability and actions of the muscles in the female compared with those of the male, present nearly the same differences as those of youth compared with adult age: a greater irritability or susceptibility of motions, and a less powerful and less sustained action.

There exist differences in the races of the human species with respect to muscular power, which, according to the observations made by Peron with the dynamometer, are to the advantage of the Europeans, whose health and strength result from an abundant and healthy food, and from constant occupation; while the natives of Timor, New Holland, and Van Dieman's Land, who are exposed to all kinds of privations, have less muscular power.

696. When the muscles are laid bare * by a wound of the skin, aponeuroses and cellular sheaths, and these parts are again exactly applied to each other, an effusion of organizable fluid takes place in the solution of continuity, which at first adheres but little to the muscle, but which at length re-establishes an organic union. The same thing happens when muscles divided across, in amputation for example, are covered over by pieces of skin; only the agglutinating matter is from the commencement very closely attached to the truncated extremity of the muscles. When muscles are divided across, and not covered by pieces of skin, suppurative granulations soon form at their extremity, and afterwards a cicatrix. These phenomena, and especially the latter, are longer in taking place when the muscles are only denuded laterally. In all these cases, whatever may be the period at which the wound affected with inflammation, whether adhesive or suppurative, is examined, the cellular sheaths of the muscles and their bundles are alone a]

* B. Fr. Schnell, *Præs. Autenrieth, De Natura reunionis musculorum vulnerator.* —Tubingæ, 1804.

tered; no change whatever is perceived in the muscular fibres themselves. It is not useless, however, to observe that these fibres are in this case deprived of the greater part of their irritability.

697. When a muscle is divided across, a considerable separation takes place between the edges of its division, and which is always greater than that of the wound of the skin. When the edges of the external wound have been brought together, and are united, the ends of the muscles, on the contrary, present a separation at first filled by an organizable fluid, which afterwards becomes vascular, soft, contracts a little, and slightly diminishes the separation which existed between the ends of the muscles, and at length becomes more or less firm and tenacious. This interposed substance, when its organization is completed, has sometimes the appearance of cellular tissue, most commonly that of ligamentary tissue, and sometimes that of a subcartilaginous coriaceous tissue, but never that of muscular tissue. At whatever period of its formation it is examined, it is always found that the muscular fibres and fasciculi are foreign to it, and that it is only the union of the cellular tissue that forms sheaths for them. As a muscle which has been reunited in this manner therefore presents a kind of aponeurotic or tendinous intersection; it is a kind of digastric muscle, of which the two bellies are living and irritable, while the interposed substance only performs the functions of a tendon which resists or yields to distention in a greater or less degree. This interposed substance is not capable of being irritated, either by mechanical stimulants or by galvanism. However, when irritability is still very manifest, and the galvanic action is powerful, irritation applied to one of the parts of the united muscle, is propagated through the cicatrix, which does not at all contract, to the other part of the muscle. It is not known whether in the living subject, and by the action of the will, the two parts of a muscle divided across and united again by a cicatrix, both contract. It is evident that the more widely separated the ends of the divided muscle remain while the mediate reunion is produced, the longer and more extensible also will be the interposed substance, and the more will the motions of the muscles have lost their extent and power. Even in the best cases, the motions are at first impossible, then weak and unsteady, until the interposed substance has acquired all its firmness.

All that has been above said respecting the uniting of muscles after being cut across, applies to their rupture by an effort.

When a transverse wound of the muscles and skin remains open and separated, there forms in its whole extent a layer of suppurating granulations, and afterwards a cicatrix of greater or less breadth, under which the two ends of the muscle remain separated.

In this latter case, as well as in the preceding, the intervening substance by which the separated parts of a muscle have been united, has been uncovered and cut out as being too long and extensible; after which, by keeping the ends as close to each other as possible, and during a sufficient length of time, a short and firm union has been obtained, and the motion which the parts had entirely or almost entirely lost has been restored to them.

698. The muscles are subject to variations and to vices of conformation. Certain monstrous fœtuses, acephalous and others,* have been seen destitute of all the muscles, or of all those of a limb at least, these organs being replaced by infiltrated cellular tissue.

Isolated muscles are those which are most commonly observed to be defective or wanting.

Not unfrequently there occur supernumerary muscles, or muscles divided into several distinct parts; muscles united which are commonly separated; others longer or shorter than usual, which changes their attachments and modifies their functions. All these varieties are original or primitive.

The diminution or augmentation of volume of the muscles are, on the contrary, generally owing to accidental causes. Rest and paralysis diminish their volume, while exercise increases it.

Ruptures of the muscles take place from two causes:† the action of antagonist muscles, or another power which distends a relaxed muscle, or by the action of the ruptured muscle itself; and in this latter case, the rupture commonly takes places at the union of the tendinous or aponeurotic parts with the fleshy fibres, of which a small number only are found broken. In the case of rupture, there take place a more or less extensive and deep separation accompanied with noise and pain, and a more or less abundant effusion of blood into the cavity formed by the solution of continuity, and into the surrounding cellular tissue. The internal muscles, and especially the heart, also sometimes burst by their contraction.

Displacement of the muscles,‡ which has been admitted by Ponteau, M. Portal, and other pathologists, can only happen when the enveloping aponeuroses are divided.

699. The muscles present various alterations of colour, consistence and cohesion.

In rheumatism, a gelatiniform fluid is sometimes found at the interior, and in the substance of the cellular sheaths of the muscles and of their bundles.

In cases of old paralysis, the muscles are wasted, white, and sometimes very fat. It has already been seen, (168) that the transformation of the muscles into fat is more apparent than real. It results from the paleness and wasting of the muscle, in conjunction with the accumulation of fat between the bundles of fibres.

Accidental productions, whether of similar tissues, or of morbid

* Béclard, *Mémoire sur les Fœtus Acèphales.*

† J. Sedillot, *Memoire sur la rupture musculaire*, in *Mem. et Prix de la Soc. de Med.* de Paris, 1817.

‡ J. Hausbrand, *Diss. Luxationis sic dictæ muscularis refutationem sistens*, Berol. 1814.

tissues, are rarely observed in the muscles. Accidental bones, however, sometimes occur in them. I once saw an osseous and cancerous compound production occupying the muscles of the calf. The leprous cysticercus (*Cysticercus Cellulosæ* of Rudolphi) sometimes occurs in the human muscles, and in those of the hog. The accidental production of the muscular tissue is of very rare occurrence, if, indeed, it ever takes place. Sarcoma, however, has been considered as approaching in its nature to muscular substance. Accidental muscular productions are also said to have been observed in the serous membranes, the bones, and ovaries; but it would seem that in this matter observers have allowed themselves to be deceived by appearances.

The development of the muscular texture in the uterus, during pregnancy, and the disappearance of that texture after parturition, make an approach to an accidental production.

700. The functions of the muscles present variations and alterations of which some have their seat and cause in the muscular tissue itself, and the others in the nervous system. These variations and alterations are for the most part different in the two kinds of muscles, and almost all are proper to the full, external, voluntary muscles, or those which belong to the animal functions.

SECOND SECTION.

OF THE INTERNAL MUSCLES.

701. The internal muscles, which are also named hollow muscles, involuntary muscles, and muscles of the vegetative or organic functions, have no proper names, each bearing the name of the organ which it contributes to form.

702. These muscles are: 1st, the heart; 2dly, those which envelope, in its whole extent, the mucous membrane of the alimentary passages; those which, uniting themselves to the urinary and genital prolongations of the same membrane, form the bladder, vesiculæ seminales, and uterus; and those of its pulmonary prolongation, which form the muscular fasciculi of the trachea and bronchi. The sphincters which are observed at the orifices of the alimentary canal, and urinary, and genital passages, may be considered as intermediate between the two classes of muscles. The muscles which are subservient to digestion, respiration, generation, and urinary excretion are all, in respect to their texture, and especially their functions, in the same predicament. There is, therefore, no very distinct demarcation between the two classes of muscles.

703. The muscles of which we here speak are placed at the interior, some situated beneath the internal tegument, another, the heart, situated in the most central part and at a distance from the two surfaces with which it has no connexion.

The volume of these muscles is very inconsiderable compared with that of the external muscles. All of them form walls of canals or reservoirs.

704. These muscles are disposed in layers or in bundles crossing each other.

In the whole extent of the alimentary canal, there are circular or annular fibres, and longitudinal fibres, forming each a distinct plane, more or less complete, and varying in thickness.

In the reservoirs, as well as in the heart, the fibres which are disposed in layers and bundles obliquely crossing each other, have the form of circles or rings fixed by their extremities to the sides of the aperture of the organ. The bundles of fibres in these organs cross between each other and unite in the manner of plexuses. This disposition is less marked in the alimentary canal, where the muscular layers cross at right angles.

The muscular fibre of the internal muscles is of a greyish white colour in the greater number of them, and red in the heart alone. This fibre does not otherwise differ from that of the external muscles. The uterus alone presents in this respect a decided difference, and characters which are entirely peculiar.

705. The cellular tissue of the internal muscles is less abundant and more compact than that of the other muscles. Fibrous or ligamentous tissue occurs only in the heart, where it forms rings at the orifices of the ventricles, cords or tendons in the columnæ carneæ of these cavities, aponeurotic expansions which constitute a great part of the tricuspid and bicuspid valves of the auriculo ventricular orifices, and cords in the edge of the semilunar valves of the arterial orifices. Bichat, who speaks only of the tendinous cords of the columnæ carneæ, had already indicated that there exist differences between them and the tendons.* In the other parts nothing similar to the ligamentous tissue is observed, excepting the submucous fibro-cellular tissue, to which the subjacent muscular fibres are attached.

The internal muscles appear to have more blood-vessels than the others. M. Ribes, however, asserts the contrary, the nerves of these muscles, which are not numerous, belong for the most part to the great sympathetic nerve. Several of them are supplied by the pneumo-gastric nerve and some by the other spinal nerves.

706. The irritability of the internal muscles presents the same phenomena as those of the other muscles, excepting fibrillar agitation, which has been observed only in the heart.

Irritability appears to be less dependent on the nervous influence in these than in the other muscles.

Mechanical irritation is much more effectual in determining contractions in them than the action of galvanism. The latter acts little upon them through the intervention of the nerves. The cardiac nerves and the heart, however, being included in a galvanic circle, the continued action of this agent determines motions in the organ.

* There seems however to be no difference in their chemical composition.—K.

The irritability or susceptibility of contraction of the internal muscles is especially remarkable in this respect, that it is naturally excited by local agents, which act upon the fibre through the medium of the membrane which covers it. At other times the cause acts in a sympathetic manner. Thus titillation of the gullet, the presence of a bougie in the urethra, or of a suppository in the anus, determine the action of the stomach, bladder, and intestine. The will has little control over the contractility of these muscles. The œsophagus, rectum, bladder, and even the stomach, however, are not altogether independent of it. It would even appear that the uterus, at least in birds, is also sometimes subject to the will. The small intestine, on the contrary, is altogether independent of it, as is the heart also. The case of an English captain, however, as related by Cheyne, and since repeated by all physiologists, and that of the late Dr. Bayle, related by M. Ribes, are adduced as instances in which the motions of the heart could be relaxed or suspended at will. But if the internal muscles are not subject to the ordinary influence of the will, strong affections of the mind and powerful emotions influence them in the most obvious manner.

Haller, in admitting that muscular power is inherent in the muscles, and that the nervous action is but its exciting cause, had been led to admit, and most of his successors had admitted still more positively than himself, that the internal muscles are independent of the nervous action, at least in their ordinary and regular motions. The experiments of Legallois afterwards led to the admission of a diametrically opposite opinion. The subsequent experiments of Mr. Clift * and Mr Wilson Philip† and the comparative observation of other animals, and of monstrous embryos and fœtuses, were calculated to modify both conclusions. The facts that are known show that the internal muscles, which are independent of the nervous medulla, in animals and in monstrous fœtuses which have none, as well as in embryos, in which it is not yet formed, and which is little under its influence in the young animals in which its power has not been long established, and in the animals of another inferior order, in which the nervous action has not a well determined centre, are, on the contrary, dependent upon that organ in the adult man, and are especially greatly influenced by injuries inflicted upon it, and still more so by sudden lesions than by slow alterations.

707. When the internal muscles enter into contraction, they sometimes draw into a simultaneous and associated action all the external muscles which contribute to the performance of their function. Thus in coughing, sneezing, vomiting, defecation, parturition, &c. a greater or less number of the muscles of the skeleton act in unison with the internal muscles.

* Philos. Trans. 1815.

† An Exper. Inquiry into the Laws of the Vital Functions, &c. London, 1818.

The internal muscles have not, like the others, true antagonists, all their fibres concurring toward a common and single object, the diminution of capacity of the cavity which they form. We may, however, consider as such,—1st, The foreign substances which keep the walls of the organs formed by these muscles separated; 2dly, The different parts of the same hollow organ; for example, the auricles with relation to the ventricles, the body of the uterus and bladder with relation to the neck or orifice of these organs; 3dly, The two muscular layers of the alimentary canal in the peristaltic motion, the contraction of the longitudinal fibres determining the elongation of the annular fibres, as they impel the contents onwards. Moreover, there happens here what takes place in all antagonism, the contraction of a muscle coincides with the relaxation of its antagonist, and *vice versa;* 4thly, The internal muscles find antagonists in the external muscles.

These muscles have no determinate fixed point. Those which are annular contract upon themselves; those which are longitudinal however, have as a kind of fixed point the orifices of the alimentary canal; those of the reservoirs, as the bladder and uterus, as well as those of the heart, have also a more decided fixed point in the orifice of these organs.

THIRD SECTION.

OF THE EXTERNAL MUSCLES.

708. These muscles are also named voluntary muscles, muscles of the animal functions, of the animal life, and muscles properly so called. It is of them that the greater part of the mass of the body is formed.

709. Their number is very great, amounting to between three and four hundred. Anatomists, however, are not agreed on this subject; some viewing as so many separate muscles what others regard as bundles of the same muscle.

710. Each muscle has its proper name, but the nomenclature has varied greatly. There is hardly a muscle that has not received more than one name, and some have received so many as a dozen.

The denomination of the muscles has been taken from various considerations. The numerical order has been adopted with respect to some of them. Thus, when several muscles belong to the same part, the same region, the same function, &c. they are distinguished by numerical names, as is the case with the radial muscles, the adductors, and interossei, which are distinguished into first, second, &c. Before the time of Jacobus Sylvius, almost all the muscles were thus designated by numerical names. Their situation, as being anterior, posterior, superior, inferior, superficial, deep, &c. has been employed as a means of distinction. They have also been designated by the name of the part which they move, or of the region which they occupy, as the palpebral, occular, labial, pectoral, dorsal, abdominal muscles, &c. Others are distinguished, with reference to their extent or volume, by the epithets *magnus*, *parvus*, *medius*, *gracilis*, *vastus*, *latus*, *longus*, *brevis*, *&c.* Others have been named *rhomboideus*, *quadratus*, *triangularis*, *scalenus*, &c., according to the figure to which they are likened ; *splenius*, from a comparison with the spleen or a compress ; *solearis*, on account of a resemblance to a sole or flounder. Certain muscles have been named, from their direction, *recti*, *obliqui*, *transversi*. From their texture and composition, they have been named *biceps*, *triceps*, *complexus*, *semi-tendinosus*, *perforans*, *perforatus*, *&c.* Other muscles have been named from their insertions, whether from one of them, as the *pterygoidei*, *peronei*, *zygomatici*, *&c.* ; or from two, as the *stylo-hyoideus*, *sterno-hyoideus* ; or from a greater number, as the *sterno-cleido-mastoideus*. Others have been named, from their uses, *flexores*, *extensores*, *levatores*, *depressores*, *pronatores*, *supinatores*, *&c.* Other circumstances also have been taken into consideration in naming the muscles.

Scarcely any of these considerations is altogether useless with respect to the knowledge of the functions of the muscles. At the same time, the most useful, without doubt, are the motion itself, the attachments, the region occupied by the muscles, its direction, &c. However numerous these bases may be, it would not matter much, did they always furnish proper names which should be distinct and short, even although they might not be very significant ; but almost all the names of the muscles are names compounded of several of the circumstances indicated. Thus in the nomenclature of the muscles we find the names : *obliquus externus abdominis*, *rectus anticus capitis longus*, *radialis*, *externus primus*, *rectus femoris anticus*, *interosseus dorsalis manûs primus*, *&c.* This inconvenience, joined to that which results from the multiplicity of different names given by different anatomists to the same muscle, have induced M. Chaussier* to propose a reform in the language of anatomy, and especially in that of myology. This reform in the names of the muscles consists in giving to each of them a name which expresses only and invariably the two opposite points of attachment, commonly designated by the names of origin and insertion. But it has been found impossible by the excellent author of this project to give names which were not at the same time, in considerable number at least, compounded of some other of the circumstances indicated above. M. Dumas† has attempted to modify M. Chaussier's nomenclature, by indicating in his nomenclature all

* *Exposition sommaire des muscles du corps humain.* Dijon, 1789. *Tableau des Muscles de l'Homme.* Paris, 1797.

† *Systeme Methodique de nomenclature et de classification des muscles du corps humain, &c.* Montpellier, 1797, 4to.

the points of attachment of the muscles. M. Dumeril * has also engaged in reforming the language of anatomy, by taking for the roots of that language the Greek or Latin names of the bones and viscera, and only varying the terminations of these names for the other organs and for the regions. The termination of the muscles is *ien*: thus, the name *occipito-frontien*, without adding the word muscle to it, designates in this nomenclature, the *occipito-frontalis* muscle. Vicq-d'Azyr also directed his attention to this subject, but did not put his project in execution. Dr. Barclay also engaged in it, and in particular laboured to give proper and precise names to the different regions of the body. M. Schréger † has collected most of the anatomical names hitherto employed into a voluminous Synonymetry, in which we find some organs having almost as many names as there are treatises on anatomy. The dread of contributing to the increase of a confusion which is augmented by almost every new work that appears, ought to induce anatomists to employ names already in use, selecting the best known, the most simple and the most significant.

711. According to their situation and their destination for the motion of some particular organ or part, the external muscles are distinguished into those of the skeleton or bones, those of the larynx, and those of the organs of sense and skin. Several external muscles also belong to the orifices of the digestive, respiratory, genital and urinary passages, and are there insensibly confounded with the internal muscles.

The muscles of the skeleton are situated on the trunk and limbs. In the limbs they form large masses, and are elongated. In the trunk they are broad, numerous on the back and abdomen, less so on the thorax, and much less so on the skull.

712. The muscles vary greatly in size: some are large or voluminous, others middle-sized, others small, and others very small.

713. All the muscles, excepting the diaphragm, the sphincters of the mouth and arms, the arytenoidæus, and frequently the levator uvulæ, are paired. All, excepting the diaphragm, are symmetrical, or similar on both sides of the body, although some slight difference is generally observed in this respect, those of the left side being smaller.

According to their form the muscles are further distinguished into broad, long and short.

The broad muscles belong to the trunk. Some of them extend from the trunk to the limbs, and are then elongated in this latter part of their extent.

The long muscles belong to the limbs, and are generally disposed in layers, the most external being the longest and straightest, the deepest having much less length and more obliquity. This arrangement it is of importance to know with reference to surgical

* *Magasin Encyclopedique.*

† *Synonymia Anatomica, Auct.* Chr. H. Th. Schreger, *Furthii*, 8vo. 380 pages.

operations, since muscles unequal as to length must contract unequally.

The short muscles are met with in the trunk and in the limbs, near the joints.

714. The direction of the muscles is that of a line stretching from the one to the other of their extremities, and passing through their centre. It is often very different from that of their fibres, and this latter is the most important to attend to. When all the fibres are straight and parallel to each other, the force of the muscle, which is equal to the sum of the forces of all the fibres, exercises itself parallel to the direction of these fibres. But if the fibres are oblique with respect to each other, the intensity and direction of the force are different.

715. There are generally distinguished in each muscle a body or belly, and two extremities, which are commonly designated by the names of insertion and origin. The body is the fleshy part, the extremities are commonly tendinous. The extremities are also pretty frequently distinguished with reference to their fixed point or origin, and their moveable point or insertion; but many muscles do not come under this description. Those to which it would best apply are certain muscles of the limbs, which are elongated, and swelled out at the middle by reason of the disposition of their fleshy fibres, and have a short tendon at their upper extremity, which is generally the more fixed, and a long tendon at the other extremity, which is generally the more mobile. But even in these muscles, the motion may be divided between the two points, and may even sometimes be entirely executed by the highest point.

716. Certain muscles form a single fleshy body between the two attachments; others, on the contrary, are formed of very distinct bundles, which might be taken for so many muscles. Of this latter kind are the masseter, the deltoid muscle, the infra-scapularis, the glutæus maximus, &c.

717. There are muscles which remain simple and distinct in their whole extent, and others which are divided into several parts, or confounded with others, at one of their extremities. Thus, some muscles, which are simple at their insertion, are at their origin separated into two or three portions. Of this kind are the biceps and triceps. Such also are the sterno-mastoideus and pectoralis major, which, for this reason, have been considered by some as composed of two muscles each. In like manner, the common extensor and flexor muscles of the fingers and toes, which are simple at their origin, are divided at their insertion into several parts. The serrati, transversi and other muscles which are attached to the ribs by digitations, are also much of the same nature. To this kind of muscles are allied those which have a common origin, as the muscles which are attached to the ischium, or a common insertion, as the latissimus dorsi and teres major.

718. There are other muscles whose composition is different. Such are several of the spinal or vertebral muscles, and particu-

larly the transversalis spinæ, longissimus dorsi and sacro-lumbalis. They result each from numerous muscular bundles, which are distinct at the extremities, and confounded together at the centre, so that each portion of muscle is single at one extremity, and at the other is continuous with two portions; and *vice versa*, each of the latter is connected with a double portion of the opposite extremity. These muscular bundles succeeding each other, and uniting laterally, there results from them a very long muscle, composed of short bundles, distinct at their extremities, and laterally united in their middle part. Each bundle, which is closely connected with the two bundles, cannot contract without the latter entering into action at the same time, so that the motion is always impressed at once upon several vertebrae or several ribs:—a disposition in perfect conformity to that of the bones, which always require to be moved several of them together.

719. The muscles of the skeleton, and they are the most numerous, have their two extremities attached to the periosteum and the surface of the bones, by tendons or aponeuroses. The muscles of the larynx are attached in the same manner to the cartilages and the perichondrium. The muscles which extend from the skeleton to the organs of sense, and are inserted into cartilages, are also provided with tendons at the two extremities. Those which are attached to the teguments, are, on the contrary, destitute of tendons at their insertion into the dermis.

Besides the tendons and aponeuroses of attachment which are observed at the extremities of most of the muscles, some of the latter also present tendons or aponeuroses of intersection, which occupy some point of their length, and divide them into several fleshy bodies. Of this kind are the maxillar digastric, and the cervical digastric muscles, which are divided into two very distinct bodies by tendons. Such are also the sterno-hyoideus, scapulo-hyoideus, rectus abdominis, &c. of which the fleshy body is divided by aponeuroses.

720. In many muscles the fibres are straight, and apparently parallel from one end to the other. In several muscles, the fleshy fibres, which are all parallel, extend obliquely between two aponeurotic tendons expanded on two opposite faces of the fleshy body; of which kind is the cruralis anticus. It was no doubt from having in his view muscles of this kind, that Gassendi compared the muscle to a mitten. Other muscles are radiated or fan-shaped, as the pectoralis major and latissimus dorsi, whose fibres are widely spread at their origin, and collect into a thick bundle towards their insertion. Such also are the glutæus medius, and glutæus minimus, whose fibres terminate successively upon an aponeurotic expansion. In others, the fibres extend obliquely in this manner from their origin from a bone to the side of a tendon. These muscles are called semipennate, of which kind are the peronæi. Others are pennated, the fibres passing obliquely to the two sides of a tendon. In some others, which are very similar to

these, the fibres form two planes, which are inserted upon the two faces of a middle aponeurosis; of which kind is the temporal muscle. Other muscles are more compound still, as the deltoid, masseter, &c. which result from the union of several penniform bundles.

721. The texture of the external muscles always results from more or less distinct bundles, which generally terminate at the two ends upon tendinous tissue. These bundles are composed of fasciculi or visible fibres, which themselves result from microscopic elementary fibres. The cellular tissue and the adipose tissue form envelopes and partitions for them, which are so much the more distinct, the more distinct and voluminous the bundles themselves are. The nerves of these muscles, which are very abundant, especially in those of the organs of sense, almost all come from the spinal marrow, few coming from the great sympathetic nerve, and those which are derived from this nerve, are never distributed to the muscles by themselves, but are accompanied by others.

722. Besides these parts which are essential to the muscles, these organs have appendages or parts attached to them. These are the *fasciæ* (519) or enveloping aponeuroses, which surround the muscles, keep them in their places, and furnish them with partitions by which they are separated, as well as points of attachment. Of this kind also are the sheaths and rings which inclose the tendons, and prevent their shifting, and the synovial membranes which facilitate their slidings.

723. The muscles are divided with reference to the motions which they produce, into congenerous and antagonist muscles, according as they contribute to produce the same motion, or produce different motions. The motions which take place in the human body, and which the muscles produce, are motions of flexion and extension, of lateral inclination, rotation in two opposite directions, which, in the fore-arm are distinguished into pronation and supination, motions of elevation and depression, of adduction, abduction, and diduction, of dilatation and constriction, of protraction and retraction, &c. From these motions, the muscles are named flexors, extensors, pronators, supinators, levators, &c.

The antagonist muscles present some differences. In almost every part of the body, the muscles which effect a motion are stronger than those which produce the opposite motion. Those of the two sides of the body which produce lateral inclination, and the rotation around the axis of the body, only present the slight difference which is generally observed between the two sides of the body. The others present much greater differences. The flexors and extensors are the only muscles that have engaged the attention of anatomists in this respect. Borelli thought that the flexors were shorter than the extensors, and that, by contracting with equal force, they necessarily pulled the bones along in flexion. M. Richerand also thinks, that the difference is to the advantage of the flexors. M. Meckel has adopted this opinion. These two physiologists think that it is established on the observation of the bent attitude which all the parts of the body assume in the state of rest, and that it has its cause in the force and length of the muscles, the size of their nerves, and the more favourable disposition of the flexors, with reference to the centre of motion, and the direction of the bones.

Ritter has added to these differences, that the flexors contract when the zinc pole of the galvanic pile communicates with the muscular extremity of the nerve, and the silver pole with the central extremity; and that the contrary takes place with respect to the extensor muscles. This difference is without doubt merely a difference of galvanic susceptibility,—a susceptibility sufficiently great in the strongest muscles to make them contract even in the least favourable circumstance of the galvanic action.

M. Roulin thinks, * like Borelli, that the principal cause of the antagonism of the flexors and extensors depends upon their relative length, and, consequently, upon their tension.

This question, perhaps, deserves to be viewed in a more general manner. The predominance ought to be looked for in the length and volume of the muscles, and more particularly in the number of the fleshy fibres which enter into their composition. It is also to be looked for in the disposition of the muscles with reference to the levers on which they act. It ought to be observed what is the attitude which the parts assume in their most ordinary action, and that which they assume in rest, in sleep, and in paralysis. Regard should also be had to that which they assume in general tonic spasm or tetanus. Now, in attending to these various considerations, it would seem that the preponderating muscles are, in the trunk, the extensor; in the jaw, the levators; in the upper limbs in general, the flexors; in the fore-arm, the pronators; in the lower limbs in general, the extensors; and in the foot, the adductors.

724. There are in the organization several circumstances unfavourable † to the action of the muscles, and which diminish their power of contraction, or effective force, to an efficacious force, in other words, to a much less result. These circumstances, which have been well known since the time of Borelli, are; 1st, The equal distribution of the muscular effort between its two attachments, while a single point in general is to be moved; 2dly, The unfavourable lever, that of the third kind, by which a great part of the power is lost; 3dly, The oblique insertion of the muscles into the bones, and of the fleshy fibres into the tendons; 4thly, The resistance of the antagonist muscles; 5thly, The friction of the tendons, and that of the joints.

There are also circumstances in the organization, which, by favouring muscular action, diminish the influence of the former.

* See his Inquiries respecting the Motions and Attitudes of Man, in the Journal de Physiologie, vol. i. and ii.

† J. Alph. Borelli, *De Motu Animalium. Opus posthumum.*

Such are the change of the angle which the muscle and the bone form, by means of certain anatomical dispositions, as the volume of the articular extremities of the bones, the existence of apophyses at the place where the muscles are attached, that of the sesamoid bones, &c. Such is also the diminution of friction by the synoviæ, &c.

In fine, the animal mechanism presents the same perfection as that which is everywhere to be admired in nature. What the muscle loses in force, motion gains in extent and in velocity, by the employment of the lever of the third kind, and by the obliquity of insertion. On the other hand, the obliquity of the muscular fibres upon the tendons, by diminishing the extent of motion, and even the force of the muscle, permits, under a small volume, the union of a very great number of fibres, which compensates, and much more than compensates, the loss of power; without speaking of the form and freedom of the limbs, which could not take place with any other insertion, or any other direction of the muscles with relation to the bones.

725. The muscle is the seat and the immediate organ of contraction, just as the teguments and the organs of sense, which form part of them, are the seat of impression. But just as sensation takes place only, in so far as the impression is propagated by the nerves to the nervous centre, so is it from the nervous centre that volition is propagated, by the nerves, to the muscle, for putting it in motion. In the one case, as in the other, there is, moreover, something that is entirely incomprehensible; which is, the manner in which the being acquires the knowledge of the sensation, and also the manner in which it determines the volition. This is not the proper place for examining the yet insolvable question of the reciprocal action of the organism and the mind.

Be this as it may, the volition proceeds from the nervous centre, is propagated by the nerves, and determines the contraction of the external muscles. If the nerve is cut or interrupted by a tight ligature, &c. the muscle, which still remains irritable, no longer contracts voluntarily. In the following chapter will be seen what is the precise, or, at least, probable, seat, in the nervous system, of the organic principle of the voluntary motions.

726. The effects of the contraction of the external muscles are to determine the attitudes and motions of the body, by acting upon the skeleton; to move the skin and organs of sense; to produce the voice, speech, and gesture; and, lastly, to subserve, in a more or less necessary, but always auxiliary, manner, the vegetative functions.

727. It has already been seen that the straight muscles, in contracting, draw one of their extremities, or both, nearer to the centre, according as one of the points of attachment only is moveable, or as they are both so; and that the circular muscles, in contracting, contract the orifices or canals which they form. The curved muscles become straight when they contract, if their attachments are

fixed; and, in tending to become so, they diminish the cavities of which they form the walls; as is the case with the abdominal muscles and diaphragm with respect to the abdomen; and they enlarge the cavity to which they correspond by their convex surface; as the diaphragm does with respect to the thorax. The reflected muscles, and they are very numerous, tend, like the curved muscles, to become straight during their contraction; but if any insurmountable obstacle comes in the way, the motion, the direction of which is changed, is transmitted to one or other extremity, or to both, according to their mobility.

728. When one of the parts to which a muscle is attached, is immoveable, the other capable of being moved, it draws the latter towards the former; as is the case with the muscles which extend from the bones to the soft parts, &c. When one of the two parts has little mobility, and the other is very mobile, as the trunk with reference to the limbs, the central extremities of the limbs with reference to the peripheric extremity, &c. the latter is in general the only one that moves. But it is to be observed, then, in this case, that the fixed point, and the moveable point of the muscles may change. Thus, in the most ordinary motions of the arm, the muscles which move that part have their fixed point in the trunk, and their moveable point in the limb. On the contrary, in the action of climbing up a tree, the fixed point, at the moment when the trunk rises towards the arm which was previously fixed, is in the arm, and the moveable point in the trunk. So also, in the action of going up a ladder, when the leg is carried forwards and upwards, the fixed point is in the trunk. When afterwards the trunk rises towards the leg of which the foot is supported, the fixed point is in the leg, and the moveable points of the muscles are in the thigh and trunk.

When the two parts to which the muscles are attached are nearly equally mobile, contraction tends to move them about equally. Thus when one is lying upon a horizontal plane, the contraction of the anterior muscles of the trunk tends nearly equally to bend the head upon the neck, and the pelvis upon the loins.

In this case and in the preceding, which are of extremely frequent occurrence in the animal mechanism,* the part which is to serve as a fixed point is retained by the contraction of other muscles which render it motionless. The motions apparently the most simple almost always require the simultaneous action of a greater number of other muscles than those which are destined to produce them immediately.

729. It is in efforts especially that we observe these muscular synergies.

An effort,† *nisus*, is any muscular action of extraordinary in-

* Winslow, *Mem. de l'Acad. des Sc.*, 1719-23-26-29-30-39-40, &c.

† Js. Bourdon, *Recherches sur le mecanisme de la respiration et de la circulation du sang*, Paris, 1820.—J. Cloquet, *De l'influence des efforts sur les organes renfermés dans la cavité thorachique*, Paris, 1820.—Magendie, *De l'influence des mouvemens de la poitrine, et des efforts, sur la circulation du sang.* Journal de Physiologie, vol. i.

ensity, destined to surmount an external resistance, or to perform a laborious function, whether accidentally or naturally. Thus, the action of raising or carrying a heavy body, parturition, difficulty of passing the urine, &c. require efforts before they can be executed.

In every effort, there is an extraordinary nervous influx upon the muscles. Sometimes this influx is voluntary, sometimes involuntary. In the latter case, it is irresistibly determined by the connexion already remarked between the involuntary internal muscles, and their external congeners. In every effort also, a great number of efforts, sometimes the whole apparatus of motion together, is in action. Lastly, in every effort, the lung is first filled with air by an inspiration; the glottis is closed and retracted, the muscles of expiration are contracted, and the walls of the thorax are thus rendered immoveable, in order to present fixed points of attachment to the muscles of the abdomen and limbs.

The effects of efforts are to retard or prevent the entrance of the venous blood into the thoracic trunks, whence its reflux and its stasis in the veins of the neck, the head, the abdomen, and even the limbs; to compress the thoracic and abdominal viscera, and even sometimes to produce their expulsion, especially that of the latter, through an opening in the walls. Efforts occasionally even go so far as to produce rupture of the muscles, tendons or bones, and to cause burstings of the blood-vessels, hemorrhages and effusions of blood.

730. The muscles which pass over several joints may move them all. Thus the flexors of the fingers, after having bent the third and second phalanges on the first, bend the latter on the metacarpus, and the hand on the fore-arm. One of the two even contributes to pronation. It is the same in the foot, where the common extensor of the toes bends the foot upon the leg, and where even the same disposition occurs. These muscles, which pass over several joints, have also other uses. They are auxiliaries or supplementary parts to shorter muscles, extending only to the two bones united by an articulation. Thus, the biceps, semi-tendinosus and semi-membranosus of the thigh, which pass over two articulations bending in opposite directions, may assist or supplant in their functions the extensor muscles of the pelvis upon the thigh, and the flexors of the thigh upon the leg. The muscles of this kind, which are so numerous in the limbs, especially the inferior ones, and which equally exist in the direction of extension and in that of flexion, appear also to have for use to render the act of standing secure, by applying the articular surfaces against each other, and preventing motion in all directions.

731. Muscular motion is simple when it is impressed by a single muscle or by several muscles which act in the same direction. It is compound, when it is produced by several muscles which act in different directions. Simple motion commonly takes place in the direction of the muscle itself or of the muscles which determine it. Thus the flexors of the fingers pull these parts in their own direc-

tion. In other cases, the muscle being reflected, the direction of the motion is determined by that of the portion of the muscle which extends from the place where it changes its direction to the mobile part. Thus the motion impressed by the obliquus oculi longus, by the circumflexus muscle of the palate, the lateral peronæi, &c., has a direction determined by that of the last portion of these muscles. The direction of the motion is frequently in a great measure determined by that of the articulations of the bones. Thus the bones articulated by ginglymus and by rotatory articulation, although most of them have oblique muscles, move in only two opposite directions. Thus, on the other hand, the same muscle, the biceps flexor, without changing its direction, produces by its contraction the supination and flexion of the fore-arm. Thus also, the pyramidales, gemelli, &c., which are rotators of the thigh outwards, when it is extended, become abductors when it is bent.

732. In many cases the muscular motions are compound; several muscles contracting simultaneously, impress upon a moveable part a motion different from that which results from the contraction of each of them in particular. Thus, if the rectus superior and rectus externus of the eye contract together and with equal force, the eye obeying these different forces, the pupil will be directed upwards and outwards. Thus, if the pectoralis major, which carries the arm inwards and forwards, contracts at the same time with the latissimus dorsi, which carries it inwards and backwards, the arm will be carried, by a compound motion, directly inwards. The motions of the shoulder are always compound. Many other parts are often so also; and were it not so, the motions, which are so varied, would be extremely limited.

733. The motions of the voluntary muscles are in fact most commonly combined. In this respect, the muscular actions may be distinguished into isolated motions, resulting from a single muscle in contraction; associated or combined motions, resulting from the action of several muscles, whether congenerous or antagonist, which are associated to produce determinate motions, as those of flexion, extension, &c., co-ordinated motions, as those which by their association produce standing, locomotion, &c., lastly, actions of the will, or muscular actions directed by volition. These variations in muscular action depend upon the nervous influence, according as it is voluntary, and according as, without the influence of the will, it is determined by irritation of the nervous centre, by that of the plexus of a limb, or only by that of an isolated nerve.

734. The contraction of the external muscles, through causes which act upon the muscular tissue, or upon the nerves, or upon the nervous centre, sometimes becomes feeble and uncertain (in trembling); impossible (in paralysis); permanent (in tonic spasm or contraction, tetanus); or involuntary and irregular (in convulsions, clonic spasm or contraction.)

CHAPTER X.

OF THE NERVOUS SYSTEM.

735. The Nervous System, *Systema nerveum*, comprehends cords (nerves), bulgings (ganglia), and a central mass (the brain in general,) formed of a white and greyish substance, which in the state of life, keeps up the irritability, are the conductors and receptacle of the sensations, the point of departure and the conductors of the volitions; in a word the organs of innervation.

The nervous centre is moreover the organ, in other words the material instrument of *intellect*.

736. The Asclepiadæ were not acquainted with either the nerves or the ganglia. One may easily be convinced, on reading the works of Hippocrates and Aristotle, that they have confounded under the name Νεῦρον, ligaments, tendons, nerves, and even the vessels. Praxagoras appears to have been the first who had any correct idea of difference among the white organs; but having placed the origin of the nerves at the termination of the arteries, he gave rise to an opinion respecting the hollow structure of the nerves, which has been continued up to the present times. Herophilus and Erasistratus knew the connexion of the nerves with the brain, but they continued to give the same name to the tendons and ligaments. Galen unravelled the confusion which still prevailed in his time with regard to this subject, by giving names to the ligaments and tendons. By discovering that the nerves are medullary in their interior, and membranous at the exterior, he clearly determined their connexion with the spinal marrow and brain. He remarked, in opposition to an opinion that had existed previously to him, that the spinal marrow is subordinate to the brain, which is therefore the nervous centre. He attempted to establish a distinction between the nerves of feeling and those of motion, and described and named the nervous ganglia. He had also made considerable progress in the knowledge of the nerves in particular. The anatomists of the Italian school having found neurology much in the state to which Galen had brought it, greatly improved its condition. G. Bartholin reproduced the opinion of Praxagoras and some others of the ancients, that the spinal marrow is the centre of the nervous system, and that the brain is only a continuation of it. From this period, the anatomy of the nervous system, whether in animals, or in the human species, has been continually enriched by new facts.

737. The most simple animals have no distinct nervous system. (28.)

The first in which it begins to make its appearance are the radiated animals, and in particular the asteriæ or sea-stars, in which it consists of soft threads and small enlargements disposed around the mouth, both white and destitute of cineritious matter.

In all the other invertebrate animals, the nervous system consists of two more or less approximated cords, brought together into a greater or less number of knots or ganglia, always united around the œsophagus or above the mouth by a nervous ring at least, and often by a ganglion, of which the volume is proportionate to the greater or less degree of complexity of the head, and which, in the mollusca, receives the name of brain.

In all these animals, the two teguments and their muscles, the organs of the vegetative functions and those of the animal functions receive similar nerves.

However there already occurs in the nervous ganglion of the cephalopoda, (50) an evident indication of a nervous centre peculiar to the organs of sensation and motion.

738. In the vertebrate animals,* the nervous system consists of a central mass peculiar to that class, and composed of a longitudinal cord, the spinal marrow, in which the ganglion figure is no longer apparent, and whose upper or cranial extremity, divided into the pair of cords, presents bulgings and developments, which together form the encephalon. These parts, viewed successively from behind forwards, are the cerebellum, the tubercula quadrigemina, the cerebrum or brain, properly so called, and the olfactory lobes. The spinal marrow gives attachment to a number of pairs of nerves corresponding to that of the vertebrae. Each of these nerves is furnished with a ganglion near its central extremity. The cranial portion of the spinal marrow (the medulla oblongata) furnishes nerves to the organs of sense and the other organs of the face, and to those of digestion and respiration. Moreover, there exists on each side, before the vertebral column, a knotted cord (the great sympathetic nerve) and nervous ganglia and cords for the heart and alimentary canal, a particular nervous system, which alone, or joined to the pneumo-gastric nerve, resembles in its distribution the first appearances of this system in the animal kingdom.

739. The spinal marrow, which is hollow in the oviparous animals, becomes full in the mammifera. In the former it occupies the whole length of the vertebral canal; in the mammifera it extends into the sacrum. Its volume is so much the greater compared with that of the brain, or the latter is so much the smaller compared with the spinal marrow, traced from the adult man to fishes. It is cylindrical, with slight bulgings at the places where the nerves of the limbs are attached to it. Its cranial portion also presents bulgings in proportion to the nerves there inserted.

The cerebellum, which is formed by the posterior or restiform cords of the spinal marrow, expanded, reflected and united above

* See M. Tiedemann's excellent work: *Anatomie und Bildungsgeschichte des gehirns*, &c. Nürnberg, 1816; translated into French by M. Jourdan. *Anatomie du cerveau, contenant l'histoire de son developpement dans le fœtus, avec une exposition comparative de sa structure dans les animaux.* Paris, 1823. Desmoulins. *Exposition succincte du développement et des fonctions du système cérébro-spinal.*

the fourth ventricle, is very simple in the osseous fishes, in many of the cartilaginous fishes, and in the greater number of reptiles. In the others, and especially in birds, it is more compound. In them there are already perceived laminæ and the commencement of lateral hemispheres; but in no oviparous animal are there yet seen the prolongations destined to form the annular protuberance, or that protuberance itself. In all the mammifera we find the lamellated structure of the cerebellum, lateral hemispheres, a ciliary body in the peduncles, and a protuberance. These parts are the more developed the higher we rise in the class of mammifera towards man. The prolongations of the cerebellum at the tubercula quadrigemina also exist in all the mammifera. The ventricle of the cerebellum is common to the four classes of vertebrate animals.

In some fishes there are observed encephalic lobes posterior to the cerebellum. Such are those which correspond to the origin of the nerves of the electric apparatus of the torpedo.

The tubercula quadrigemina, which are formed by the development of the lateral or olivary cords of the spinal marrow, appear to exist in all the vertebrate animals, although there has been much diversity of opinion with respect to their determination. In all they are the principal point of origin of the optic nerves. In all they form, by their union in the middle line, the upper wall of a cavity situated between the ventricle of the cerebellum and the third ventricle. They are so much the larger in proportion to the encephalon in general, the more simple it is. They are bigeminous only in the ovipara, and are quadrigeminous only in the mammifera. The anterior pair is larger than the posterior in the ruminantia, solipeda and glires. The reverse takes place in the carnivora. The two pairs are about equal in the quadrumana and in man.

The brain properly so called, which results from the expansion of the anterior or pyramidal cords of the spinal marrow, which cross each other in all the mammifera and in the birds of prey only, and not in the other animals, and are bulged out by the optic thalami and the corpora striata, presents many differences in its volume and complication, which are in general proportionate to the volume of these thalami and these corpora. The cartilaginous fishes have no brain. (Desmoulins.) In the osseous fishes it is formed by the optic thalamus alone, which is solid. (Desmoulins.) In reptiles and birds, it is formed by the same body, which is hollow, and bears some resemblance to the hemispheres of the mammifera; but these hemispheres do not cover the tubercula quadrigemina, and have as yet neither lobes, nor circumvolutions, nor corpus callosum. The brain of the mammifera, which is formed by a recurved medullary membrane, whose fibres come from the corpora pyramidalia, optic thalami and corpora striata, gradually approaches to that of man, presenting various degrees of organization. The glires and cheiroptera occupy the lowest rank in this respect. Their hemispheres do not entirely cover the tubercula. They have only a superficial fissura sylvii, a few slight grooves, and no circumvolutions. In the carnivora, the ruminantia, the hog and the horse, the hemispheres, which are much more voluminous and prominent, cover a part of the cerebellum. They have circumvolutions and anfractuosities, but are still destitute of posterior lobes. In the quadrumana, the hemispheres cover the cerebellum, but the posterior lobe is still destitute of circumvolutions.

The corpus callosum, which is formed by the reversion towards the median line of the peduncles spread out in the hemispheres, do not exist in the ovipara. In the mammifera its extent is proportional to that of the hemispheres. It is accordingly very small in the glires.

The lateral ventricles, which are formed by the replication of the nervous membrane of the hemispheres, are proportionate to the extent of the latter.

The fornix does not exist in fishes. We find the first traces of its pillars in reptiles, and still more distinctly in birds. In all the mammifera the pillars are united to form the fornix. In them there occur, moreover, the septum lucidum and its ventricle. These parts are proportionate to the extent of the hemispheres.

The cornu Ammonis exists only in the brain of the mammifera. The unciform eminence exists in none of the animals, excepting perhaps the quadrumana.

The pituitary gland exists in all the fishes. It is very large compared with the encephalon in all the inferior classes. The pineal gland appears to be wanting in the class of fishes.

The olfactory lobes terminate the encephalon anteriorly. According to M. Desmoulins they form what is called the brain in the cartilaginous fishes. They equal the brain in size in many osseous fishes and reptiles. They are very small in birds, greatly developed and hollow in many mammifera, and rudimentary in the human species.

The principal differences which the nervous centre presents in man, are, therefore, the volume of the cerebellum and cerebrum, compared with the spinal marrow, the tubercles and the olfactory lobes; the size of the lateral lobes of the cerebellum compared with the middle lobe; that of the cerebral hemispheres, and their being prolonged backwards; the existence of its posterior lobe and its appendages; the thickness of the nervous membrane which forms the hemispheres, the size of its central medullary mass, the number and depth of its grooves, the number and thickness of its convolutions, whence results a greater extent of its surface; and, lastly, the extent of the corpus callosum.

740. The ancients, commencing with Galen, and many moderns, regarding the nervous system as having a single centre in the encephalon, and prolongations (the spinal marrow and nerves.) It

has already been seen that G. Bartholin removed the nervous centre to the spinal marrow, which he did from the consideration that fishes have a very large spinal marrow, and a very small encephalon, and yet that these animals possess a great power of motion. Bichat, developing some ideas that had been vaguely emitted respecting the action of the ganglia, proposed two distinct nervous centres, the one (the cerebral, or encephalic and spinal) subservient to the sensations accompanied with consciousness, intellect, and voluntary motion; the other (the ganglionary) subservient to the functions which are performed without consciousness or the control of the will. In this latter he at the same time placed the seat of the passions. M. Cuvier considers the nervous system as a vast net-work embracing the whole animal, and furnished with numerous centres and communicating cords. Dr. Gall divides the nervous system of animal life into those of the spinal marrow, the organs of sense, and those of the brain and cerebellum. M. de Blainville considers the nervous system as divided into as many parts as there are great functions, and defines it masses or ganglia and filaments, some issuing forth and going into the organ which they are to animate, which forms the particular life; others entering, and all terminating in a central mass, establishing the general life, and giving rise to the sympathies and relations. The central part, according to this ingenious physiologist, is the spinal marrow; another part comprises the ganglia of the organs of sense and motion; a third those of the viscera, viz. the cardiac and semilunar or cœliac ganglion; the fourth and last comprehends the great sympathetic nerve, which forms a centre to the visceral ganglia, and which, by the intervention of the ganglia of sensation and motion, connects them with the central mass.

All these divisions, which may be justified by various considerations, are not yet so precise or distinct as their authors allege. In man, the encephalon or some one of its parts, the medulla oblongata, where it is embraced by the pons varolii, is certainly a centre to which the functions of all the other parts of the nervous system are more or less subject. In reality, in some of its functions, the spinal marrow may be considered as a centre having little dependence upon any other, which is also the case with the ganglia, and with the nerves themselves, for each part of the system is not reduced to the entirely passive office of a conductor. This independence of the nerves, the still greater independence of the ganglia, and the yet more decided independence of the spinal marrow, vary according as we consider them with reference to any particular function, in certain kinds of animals, and in man himself in the different stages of his development. These propositions, which may be considered as laws of innervation, will be developed as we proceed.

At present it is sufficient to remark that there is no point of absolute separation among the parts of the nervous system. We now proceed to consider it first in its aggregate, and then its principal parts, referring for the detail to particular neurology.

FIRST SECTION.

OF THE NERVOUS SYSTEM IN GENERAL.

741. The Nervous System* forms a continuous whole or a ramified and reticulated aggregate, of which all the parts are connected with each other.

742. This system consists of a central mass, nervous cords and ganglia.

The central nervous mass, which has not received any proper name, and which is designated by the name of brain in general, and sometimes by that of nervous axis, or cerebro-spinal organ, consists itself of several parts, which are distinguished by their situation into spinal marrow or rachidian cord (Ῥαχίτης μυελὸς) and encephalon (Ἐγκεφαλὸς); by their form and texture into nervous medulla and into cerebrum, cerebellum, and tubercula quadrigemina. The rudimentary olfactory lobes are considered as nerves.

The spinal marrow is a large single and median cord, divided by a double groove into two lateral portions, and by the insertion of the digitate ligaments into anterior and posterior bundles. This cord, which is principally contained in the vertebral canal, is prolonged into the skull, and there bears the name of medulla oblongata. In this latter part, besides the anterior and posterior bundles, it has on each side a lateral or middle bundle.

The middle bundles, augmented by the olivary eminences, are prolonged, for the most part, into the tubercula quadrigemina, and there terminate. The posterior bundles, after being reinforced in the festooned or rhomboidal body, expand in the brain and form it. Stretching beyond that part, they unite on the one hand in the median line, under the medulla oblongata, where they form the annular protuberance or pons varolii, and on the other hand unite with the tubercula quadrigemina. The anterior bundles, after crossing each other, united to a part of the lateral bundles, and strengthened by the optic thalami and corpora striata, expand in a radiating manner to form the hemispheres of the brain, and unite again in the median line in the corpus callosum.

* Th. Willis, *Cerebri Anatomia Nervorumque Descriptio et Usus*, Genevæ, 1676. R. Vieussens, *Neurographia Universalis*, Lugd. 1684. G. Prochaska, *De Structura nervorum Tract. Anat.* Ejusdem, *Commentatio de function. System. Nerv. in Op. Minor.* Vicq-d'Azyr, *Rech sur la structure du cerveau, du cervelet, de la moelle allongée, de la moelle épinière, et sur l'origine des nerfs, &c. in Mem. de l'Acad. des Sc. de Paris*, 1781 and 1783. A. Monro, Observ. on the Nervous System, Edinb. 1783. Ludwig, *Scriptores Neurologici minores selecti*, &c. Lipsiæ, 1791-95, 4to. F. G. Gall and Spurzheim, *Rech sur le Système Nerv. en général, et sur celui de cerveau en particulier*, Paris, 1809. Rolando, *Saggio sulla vera struttura del cevrello dell' uomo e degli animale, e sopra le funzioni del sistema nervoso, Sassari*, 1809. Carus, *Anat. und Physiol. des Nerven Systems.* Leipzig, 1814.

The nervous cords or nerves, to the number of forty and a few more pairs, are connected with the medulla by one extremity. They present a certain number of plexus in which they communicate together. Numerous ganglia are met with in their course. The cords terminate at their other extremity in the two teguments, the organs of sense, the muscles, and the walls of the vessels, especially the substance of the arteries.

743. The form of the nervous system is, in general symmetrical. Its symmetry is especially very decided in the central parts, and still more so in the spinal marrow than in the encephalon, where the surface of the lobes of the brain and cerebellum always present irregularities. The nerves which are directly connected with the spinal marrow are all symmetrical, excepting the pneumogastric, which is distributed to unsymmetrical organs. All of them, however, cease to be, in their last divisions, so strictly symmetrical as in their trunks. The ganglia and nerves which belong to the unsymmetrical organs of the vegetative functions partake beyond their central parts, but especially in their divisions, and at their peripheral extremities, of the irregularities of these organs,

744. The situation of the nervous system is internal and central in its masses, and still deep in the nervous cords. The extremities alone of these cords end at the surfaces of the body, the two teguments.

745. The nervous system is formed of two substances, distinguished by their colour and relative situation, into white or medullary, and grey or cortical.

746. The white nervous substance, also called medullary, *medullaris*, because it is generally enveloped by the other, presents several shades of white.

Its consistence varies a little in the different parts. It is in general less elastic than gelatine, but a little more glutinous, viscous or tenacious. A section of it presents a uniform colour and homogeneous appearance ; only there are perceived red dots upon it or streaks of blood. In fact, this substance is highly vascular ; and when it is torn, the broken vessels are seen to project at the uneven surface left.

The white nervous substance, immersed for some minutes in boiling oil, or for some days in alcohol, diluted nitric or muriatic acids, acidulated alcohol, or a solution of corrosive sublimate, increases in consistence ; and if it be then tried to stretch and break it in any direction, it is seen to present a fibrous appearance. White filaments, as fine as hairs, may be separated from it. The finest fibres that can be obtained are so delicate and so closely attached to each other, that it is very difficult to say any thing positively respecting their length and the diameter of the finest or primary fibrils. These fibrils, which are parallel or concentric, are united into bundles, which have different directions with respect to each other. It is not exactly known if this fibrous disposition exists in the whole nervous system ; only it has been found wherever it has been looked for, and it has always been found the same in the same parts.

This fibrous structure is visible in some parts of the nervous system without any preparation, nearly in all places where there is more difficulty in breaking this substance in one direction than in another, and precisely in the direction according to which the chemical preparations above mentioned show direction of the fibres to lie.

The white nervous substance when dried, acquires a yellowish colour and a horny appearance. When cut in thin slices, it becomes semi-transparent. When immersed in water, it resumes its colour and opacity.

747. The grey or cineritious substance,* *substantia cineria*, also called cortical because it in many places envelopes the preceding, presents like it, and even in a still greater degree, variations of tint: it varies from lead-grey to blackish brown. This substance is always softer than the white substance. The surface of its incision is uniform, and only presents red dots and streaks, which are still more numerous than in the medullary substance. This substance, in fact, is, in some points at least, much more vascular than the other. That which forms the crust of the brain and cerebellum contains so many vessels, that when it has been well injected and afterwards macerated, it appears to the microscope entirely composed of vessels. Albinus,† however affirms, and with truth, that in this case there evidently remains an uninjectable or extravascular part. The grey substance, on being submitted to the same chemical preparations as the white substance, does not present when torn precisely the same kind of fibrous appearance. When submitted to the action of water, the grey nervous substance becomes softer, swells a little, and loses a great part of its colour. Acids, alcohol, and especially corrosive sublimate, also whiten and harden it; and when afterwards dried, it becomes pulverulent. The colour, which varies a little in the different races, appears to be a product of the colouring matter of the blood.

748. The two nervous substances are variously intermingled with each other in the different parts of the nervous system. In the lobes or hemispheres of the brain and cerebellum, the grey substance forms an envelope or crust to the white. In the spinal marrow, the grey substance forms two internal cords, enveloped by the white substance. In the medulla oblongata and in the peduncles of the cerebrum and cerebellum, there occur masses or nuclei of grey substance, enveloped by white substance, alternating laminæ or layers of the two substances, and cords or fibres of both, which cross or pass through each other. In the ganglia, there is found a peculiar grey substance, traversed by white fibres, and lastly, in the nerves, there occur white fibres only.

* Ludwig, *de Cinerea cerebri substantia*.
† *Acad. annot.*, Lib. i. cap. 12.

The white substance alone forms a continuous whole. The grey substance, on the contrary, is met with only in certain places. It occurs wherever the central extremities of the nerves are inserted. It has even been supposed that it also exists at their peripheral extremity, and especially in the corpus mucosum of the skin. It is also met with wherever the white fibres acquire growth and seem to expand, as in the peduncles of the brain and cerebellum. It has even been thought that it exists in the ganglia, but this opinion is erroneous.

The fibrous texture of the nervous substance had been perceived in the white substance by Malpighi, but he considered the grey substance as glandular.

This opinion of Malpighi respecting the grey substance, was long admitted in conjunction with the hypothetical opinion that the nerves are hollow. For Malpighi's opinion respecting the grey substance, there were afterwards substituted, those of a point of origin (Gall,) a centre of action (Ludwig,) &c.

749. The nervous substance, whether medullary or cineritious, when examined with the microscope,* and magnified about three hundred diameters, appears in all its parts composed of semi-transparent globules, connected by a transparent and viscous substance. These globules appeared to Dellatorre different in volume in the brain, spinal marrow and nerves, the largest being in the brain, and the smallest in the nerves. They seemed to him heaped together without order in the central nervous mass, and arranged in linear series in the nerves. As to the fluid in which they are contained, it appeared to him to be but slightly viscous in the brain, more so in the spinal marrow, and still more so in the nerves. These globules and the fluid in which they are immersed, which are furnished and continually supplied by the influx of the arterial blood, proceed, according to him, from the brain, as a centre, to all the parts of the body, and *vice versa*. Their flux from the brain to the muscles determines motion, and their reflux from the organs of sense to the brain produces feeling. This absurd explanation ought to be separated from the pretty correct anatomical observation on which it rests.

Prochaska having examined with the microscope a slice of nervous substance thin enough to be transparent, found that it resembled a kind of pulp formed of innumerable globules or round particles. By the action of water this pulp separated into small flakes, and each flake was still composed of a certain number of globules. Maceration, even when prolonged during three months, is insufficient for separating the globules from each other. He concluded from this that the medium by which they are united is a delicate cellular tissue, formed in part by the blood-vessels, and

* J. M. Dellatorre. *Nuove Osserv. Micros*, in Napoli. 1776.—Prochaska. *De Struct. Nerv.*—J. and Ch. Wenzell. *De Penitiori Struct. cerebri.* Tubing, 1812. A. Barba. *Osserv. microsc. sul cervello e sulle parti adjacenti.* *Napoli.* 1807.—Home and Bauer. Phil. Trans. 1821.

partly by prolongations of the envelope of the nervous system. The globules appeared to him to differ in volume in the same part of the system. He estimates the volume of those of the brain and cerebellum at about one-eighth of that of the globules of the blood. As to the situation of the globules themselves, the most powerful microscopes afford no information on the subject.

Barba observed the globules, and found no difference between the substance which connects them in the different parts of the nervous system.

The brothers Wenzell have added some observations to the preceding. They found the nervous substance every where formed of globules, which they consider as vesicles filled with medullary or cineritious substance, according to the parts. The globules seem to be in contact or to adhere to each other, and nothing is perceived between them. This globular appearance remains unaltered by desiccation, or the action of alcohol, whether pure or acidulated.

Messrs. Home and Baur have published two different results of microscopical observations. According to their first researches, the brain when fresh is composed of fibres formed by the union of globules of a diameter about the same as those of pus. According to their new observations, the nervous substance is composed of semi-transparent white globules, of which some are of the size of those which form the nucleus of the coloured particles of the blood, the others smaller; of gelatinous substance, transparent and soluble in water, and of a fluid resembling the serum of the blood. The proportion of these three parts, the globules, the jelly, and the serum, as well as the volume of the globules, give rise to the principal differences which the nervous system presents. The grey substance presents few distinct uniglobular fibres, but is formed especially of very small globules. The gelatinous substance and serous fluid are very abundant in it. The medullary substance of the hemispheres of the brain and cerebellum contains more distinct and more abundant fibres, formed of linear series of distinct globules. The greater part of the globules of which they are composed are of a larger diameter. The gelatinous substance is more tenacious and in less proportion than in the grey substance. The corpus callosum and rachidian bulb especially have globules of a mean diameter; the gelatinous substance and the serum are more abundant than in the hemispheres, and the former is less tenacious. In the nerves there are found globules of all the diameters united into fibres, and these into bundles. The gelatinous matter in question occurs also in the blood, where it serves as a connecting medium to the particles of the colouring matter which surrounds the globules.

M. H. M. Edwards* is at this moment publishing microscopical observations according to which the nervous substance of the ence-

* *Mémoire sur la structure élémentaire des principaux tissus organiques des animaux. Thèse. Paris*, 30, *Juillet* 1823.

phalon, spinal marrow and nerves, in the four classes of vertebrate animals, is composed of microscopic globules of 1-300th of a millimetre united in linear series so as to form elementary fibres, of which the length is pretty considerable.

I have verified these observations, of which the importance is so much the greater that we find similar globules, but arranged somewhat differently, in all the tissues of animals.

According to M. Carus, the nervous globules are disposed in heaps in the central masses which act by irradiation, and in regular lines in the nerves which act only as conductors.

750. The cellular tissue which connects the nervous fibrils is soft and indistinct. This tissue is more condensed at the surface, where, together with the vessels, it forms a more or less dense and vascular membrane, which in the nerves is single, (neurilema), and around the nervous centre double, (pia mater and dura mater), with an interval having its walls in contact established by a serous membrane, (the arachnoid.)

751. The blood-vessels of the nervous system are very numerous. They first ramify greatly in the immediate envelope of this tissue, (the neurilema and pia mater), and then penetrate into the grey substance, where they are extremely abundant. Lastly, they penetrate into the white substance, where they are much smaller and less numerous. No lymphatic vessels have been observed in the nervous system.

752. The nervous substance has been examined in a chemical point of view by Thouret, Fourcroy, and M. Vauquelin.

The analysis of the brain, as made by M. Vauquelin, has yielded the following results: water 80.00; white fat matter, 4.53; reddish fat matter 0.70; albumen 7.00; osmazome 1.12; phosphorus 1.50; acids, salts, and sulphur 5.15.

According to the experiments of this able chemist, the spinal marrow and nerves have the same composition as the brain.

M. John has discovered that the grey substance does not contain phosphorus.

M. Chevreul has found in the blood a characteristic ingredient of the nervous substance, which is named cerebrine.

753. The vital properties of the nervous system essentially distinguish it from all the other kinds of organs. Besides the faculty of being nourished, which is common to all the parts of the living body, it possesses another active property, entirely peculiar, which is called the nervous force or nervous influence. It manifests itself by the functions of this system, which are collectively designated by the name of innervation.

754. Innervation,* which has been greatly too much limited by

* Rolando, *Op. Cit.* and *Journal de Physiologie*, T. III. Georget, *De la Physiolgie du système nervéux. &c. Paris*, 1821. Flourens' *Recherches physiques sur les proprietes et les fonctions du système nerveux, &c. in Archives generales de Medicine*, vol. ii. Fodeté, *Recher. Experiment. sur le Système Nerveux, in Journ. de Physiologie.* T. III.

those who confine it to sensation and volition, holds in subjection to it, in a more or less direct manner, all the phenomena of life. Modern physiologists, in establishing this pre-eminence of the nervous system, have even succeeded in establishing some of the laws of innervation, which they have elicited from the observations of comparative anatomy and physiology, those of embryogenesis, and from physiological and pathological observations. In general, the nervous system has more influence on the rest of the organism, the higher the animal is in the series and the more developed that system is in it. In the human species, the nervous system has more influence upon the functions, the more remote the individual is from the fœtal state and the more developed that system is in him. The influence of innervation over another function is so much the more decided, the more that function recedes from the object of the vegetative functions. The influence of the nervous system upon the rest of the system is so much the greater and the more necessary the more developed the centre is, the more voluminous in proportion to the rest of the system, and especially the more the different parts of the central mass are brought together towards a single point. It is in this latter respect especially that the nervous system of man differs from that of animals.

755. The highest mental operations exercise themselves upon the results, and are manifested through the medium of nervous action. It is therefore true that *man is an intellect served by organs.*

The actions of combination, intermediate between sensation and volition, which constitute an appearance of intellect, or the improved instinct of the vertebrate animals, also belongs to innervation.

The most limited instinct, which, in all animals, even the most imperfect, necessarily connect certain motions with certain sensations, is also a nervous action.

Sensation and volition, whatever may be the intermediate phenomena, are also actions of the same class.

The phenomena of irritation, that is to say, unfelt irritation and involuntary motion, are themselves more or less dependent upon the nervous action. In the intestinal canal, the heart, &c. impressions are not felt, and muscular contraction is not willed, but even here the nervous system intervenes; for if, in the regular order the impression does not go beyond the ganglia, and if the muscular contraction is the necessary result of it, this being the character of irritability, in certain cases of extraordinary impression sensation results from it; and, in like manner, when the will is disturbed by passions, the internal muscular motions are felt. In the vessels, and particularly in the minute arteries, the nervous action is very evident. In the cellular tissue, impression and contraction, being closely connected, and designated by the general name of tonicity, appear to have little dependence upon the nervous system, although they are not free of its influence, The nervous influence is not confined to the organ or solid parts alone; the blood also experiences its effects.*

756. The functions of formation and sustenance, in other words, the nutritive and genital functions, are also all more or less dependent upon innervation.

Digestion † is subject to innervation; and not the sensations and motions which take place at the entrance of the organs alone, but even the action of the stomach. It has long been known that when the nerves of the stomach are cut, that organ loses the faculties of digesting and of impelling the food into the intestines.

Nor is respiration less subject to the nervous influence. Section of the nerves of the lungs immediately causes asphyxia and death.

The circulation, especially the action of the heart and capillary arteries, is in like manner subject to the same influence.

Secretion is evidently so also. Direct experiments show that the section of the nerves of an organ suspends its secretion. Inhalation or absorption is equally modified by the nervous action. Nutrition or organic formation, without being a direct result of the nervous power, is not yet subjected to its influence. Animal heat is still more evidently dependent upon it. The physiological experiments of Messrs. Brodie and Chossat have clearly established this influence. The chemical and physiological experiments of Messrs. Dulong and Despretz have demonstrated that this heat could not depend entirely upon respiration.

So also in generation, the sensations and voluntary motions which accompany it, the motions of irritation, the phenomena of the secretion of the spermatic fluid and the formation of the ovula, those of the nutrition and growth of the fecundated egg, are all seen to be more or less directly subject to the nervous action.

757. Sympathy or the co-existence of two phenomena of formation, irritation, sensation or volition, in different parts, and by the action of a single agent, the most extraordinary phenomenon of the organism, is also an effect of the nervous action.

758. What connexion exists among the different parts of the nervous system with reference to its functions? Has it a single centre only, whether that centre be the spinal marrow, or the encephalon? Or are there two centres, viz. a cerebral centre and a ganglionary centre? Or are there as many distinct centres as there are principal organs or great functions?

In the adult man, the nervous system forms a single system of which all the parts contribute to the action of the whole, or to innervation, but besides this each has its proper functions. Thus, the brain and cerebellum, besides their particular functions, increase the energy of the spinal marrow, and the latter increases that of the nerves. In the adult man, the encephalon, and still more pre-

* G. A. Treviranus, Biologia. B. iv. p. 646. *Idem. Vermischte, &c. Schriften, &c.* B. i. p. 99.

† A. Brunn. *Experim. circa ligat. nervorum.*—Vavasseur. *De l'influence du système nerveux sur la digestion stomacale.* *Thèse. Paris.* 12 *Août* 1823.

cisely the mesocephalon, that is to say, the cranial extremity of the spinal marrow, the place from which the peduncles of the cerebellum and cerebrum arise, is truly the centre of action of the nervous system.

759. What relation exists between the two substances of the nervous system, and what is their particular use?

Dr. Gall considers the grey substance as the matrix of the nerves, a fertile bed in which the nerves are rooted, and upon which depend their nutrition and growth. If Dr. Gall meant by this that there is a true production or vegetation, he was deceived; for, on the one hand, no part is the product of another, all are deposited by the vessels, each in its place; and, on the other hand, the white substance appears before the grey, both in the animal kingdom in general, and in the embryo. If he only meant an implantation, he spoke truly. The grey substance must be considered, agreeably to the opinions of Ludwig, Dr. Gall, M. Carus and M. Tiedemann, as a centre of activity, and as strengthening the action of the white parts which are implanted into it, especially in so far as it produces this effect by the great quantity of arterial blood which passes through it. This substance abounds in the spinal marrow, wherever large nerves are connected with it. It also abounds in the rhomboidal body of the cerebellum, and in the optic bodies and corpora striata of the cerebrum, as well as at the surface of these two organs in man.

760. What is the particular function of each part of the nervous system?

The nerves (Sect. II.) conduct the impressions from the surfaces towards the centre, and the principle of the motions from the centre towards the muscles and vessels.

The ganglia, (Sect. III.) by reason of the quantity of blood which is distributed to them, and by reason of their peculiar texture, modify the nervous action.

The central nervous mass performs the most important parts of the function of innervation. It is the instrument of intellect.

The actions of combination, which are intermediate between the sensation and volitions, are also functions of the encephalon.

Instinct, which is in like manner intermediate between these two orders of phenomena, if it is connected with any particular portion of the nervous system, probably has its seat in the upper part of the spinal marrow.

It has often been tried to determine the organic seat of sensation and volition, by observation and experiment.

M. Rolando considers the hemispheres of the brain as the seat of these two actions, and the cerebellum as the organ which sends the moving principle to the muscles under the direction of the brain.

According to M. Flourens, the spinal marrow, at the place where it is surmounted by the tubercula quadrigemina, is the common point at which the sensations arrive, and that from which the nervous influence of the muscular motions departs. The cerebellum, according to that physiologist, is the balancer or arranger of the motions. According to him, the removal of the cerebellum renders the animal incapable of acting in a regular and co-ordinated manner for producing standing and locomotion.

M. Magendie thinks that sensibility is inherent in the spinal marrow, an opinion which he founds upon the experiments of Lorry and Legallois, together with his own. This excellent physiologist is of opinion that the will or the faculty of determining muscular motions resides in the highest part of the cranial medulla, extending as far as the optic tubercles and the peduncles of the brain; that the optic tubercles are necessary to the lateral motions; that the cerebral hemispheres are necessary for the production of motion forwards, and the cerebellum for the contrary motion. Removal of one or other of these organs suppresses its action, and determines the irresistible action of the other. Removal of an optic thalamus induces a turning motion.

MM. Foville and Pinel Grandchamps have been led by observations in morbid anatomy, to which they added experiments on animals, to establish the seat of sensibility in the cerebellum, and that of voluntary motion in the medullary substance of the hemispheres; the anterior part and the corpus striatum for the abdominal limb, the optic thalamus and the posterior part of the hemisphere for the upper limb.

M. Dugés,* by an ingenious collection of physiological and pathological facts, also places the seat of sensibility in the cerebellum, and that of voluntary motion in the hemisphere of the brain, admitting that sensation is transmitted directly to the side of the cerebellum corresponding to the impression. On the contrary, as has long been known, volition is transmitted from one side of the brain to the opposite side of the body.

These different opinions, which contradict each other in some points, all rest upon facts that have been more or less correctly observed. New facts, however, are necessary to dissipate the uncertainties which still remain on this subject.

The transmission of feeling takes place by means of the posterior part of the spinal marrow, and that of motion by means of its anterior part. As will subsequently be seen, there are particular nerves for each of these functions.

The spinal marrow, which in these functions only performs the part of a conductor, is the seat or origin of the principle of irritability. If the spinal marrow be divided at its middle part in a living animal, the posterior parts of the body remain destitute of sensibility or motion. If the skin of this part of the body be irritated, the irritation, which is not felt, causes involuntary motions in the muscles of this part. If the spinal marrow is removed, and the central connexion of the nerves thereby destroyed, motions can no longer be determined by irritating the skin.

* Unpublished Memoir.

The circulation is under the influence of the entire spinal marrow, and of all the nerves of motion which are connected with it. The particular action of the heart also is under it, but not directly, and is directly under the influence of the sympathetic nerve. Respiration is under the direction of the upper and lateral part of the spinal marrow; digestion, under the combined influence of the par vagum and sympathetic nerve.

Secretion, absorption, vital heat and nutrition, are under the influence of all the parts of the nervous system.

761. Nothing is known respecting the manner in which the nervous system produces innervation. This fact eluding observation, a multitude of hypotheses have been proposed with respect to it. These hypotheses have varied with the doctrines which have predominated at different periods.

It has been attempted to explain the nervous action by mechanical hypotheses, whether by supposing that the fibres may vibrate in the manner of cords, or by only admitting such vibrations in their elementary fibres, or in the spiral fibres which are supposed to exist in them; or lastly, by a concussion among the elastic globules which have been imagined to occur in them.

Other explanations have been founded upon the supposition of a nervous fluid, whether coarse and visible, or more generally an incoercible fluid; and in this latter supposition, it has sometimes been called ether, sometimes phlogistic or magnetic, luminous, electric, and latterly galvanic, according to the objects which have at different periods engaged the attention of philosophers.

Reil has proposed a hypothesis on this subject, which consists in deriving the nervous action from a chemico-vital process. He attributes in general the action of the organic parts to their form and composition. The form and composition of the organic parts being changed, their action is always changed; and whenever the action is changed, there are observable changes in the parts; so that as a general rule, the change of action is the consequence of a change of composition of the part. The nervous action, therefore, supposes a change in the nervous substance. What appears especially favourable to this hypothesis, is the great quantity of arterial blood which is distributed to the nervous system, and especially to the grey substance, the volume of which is always proportionate to the nervous activity. (759.)

762. Independently of all hypothesis, the nervous action may be considered as a general fact, and its phenomena and conditions may be observed. The phenomena of innervation are not sensible in the nerve, as those of muscular contraction are in the muscle. Nothing is seen in it. Some facts, however, seem to indicate that a motion of some kind takes place in the nervous substance when in action in order to produce sensation. The sensation resulting from the impression made by the light of the sun upon the eye is not instantaneous. Shaking or pressure of the eye in darkness gives rise to the sensation of light, &c. Many other facts collected by Darwin would seem to indicate that in sensation there

is a molecular motion of the nervous substance which is not instantaneous. On the other hand many facts seem to indicate that the nervous system is the forming and conducting organ of an imponderable agent analogous to the electric or galvanic agent. This agent of innervation, whose existence has been proved by Reil, and admitted by M. Humboldt and by Aldini, allows us easily to explain all the phenomena of innervation, and especially the relation which exists between the torpifying nervous action of electric fishes and the galvanic phenomena on the one hand, and the ordinary nervous action on the other, the possibility of producing galvanic phenomena with nerves and muscles only, the possibility of determining muscular contractions, the chymifying action of the stomach, the respiratory action of the lungs, &c. by substituting galvanic action for the nervous influence ; the existence of a nervous atmosphere, acting at a distance around nerves and muscles, and across the solution of continuity of divided nerves ; the plication which is produced in the muscular fibre when in a state of contraction, and the connexion of the last transverse nervous fibrils with the angles of these folds, a phenomenon of innervation which recalls certain phenomena of electro-magnetism, &c.

These opinions have appeared so probable to M. Rolando, that he has sought for the source of the nervous agent of contraction in the cerebellum, which, on account of its laminæ, has appeared to him necessarily to act in the manner of a voltaic pile, and has admitted a molecular motion of the pulp in sensation.

Be this as it may, the nervous power becomes weakened and is exhausted by the operation of the intellect, by exercise of the organs of sense, of the muscles and encephalon, and still more by pain, and is restored by rest, food and sleep. Its energy, generally and particularly, is proportional to the entire mass of the nervous system and to that of its parts, and especially to the mass of the grey substance, which is the most vascular. It is also proportional to the extent of the surfaces. It sometimes continues long after death in the nerves and muscles.

This power seems to result from the action of a subtile fluid, formed by the organic action of the nervous substance bedewed with arterial blood. It appears that this fluid is formed in all parts of the system, but more especially in those parts where the grey and vascular nervous substance is accumulated. This subtile fluid seems to traverse the interior and the surface of the nerves, to form an atmosphere for them, and, beyond their extremities, to penetrate into or impregnate all the organs and the humours themselves. The blood in particular appears to be penetrated by the same fluid, and to owe to it the essential properties by which it is distinguished during life.

The arterial blood, however, furnishes the nervous system with the matter of its action ; and, accordingly, the influx of the arterial blood is one of the conditions of that action.

Asphyxia, the cause of which has so long been sought for in the interruption of the passage of the blood through the lungs, (Haller,) in the arrival of blood remaining venous in the left ventricle, (Godwin,) in the penetration of this blood into the muscular substance of the heart, (Bichat,) results much more probably from the penetration of the venous blood into the nervous substance. In like manner, syncope depends upon the interruption of the innervation of the heart. Life being essentially connected with the reciprocal action of the blood upon the nervous substance, and of the nervous substance upon the blood.

Does the nervous agent result directly and solely from the reciprocal action of the blood and the nervous substance? Is it derived from without? Can it pass from one individual into another? Does it result from the opposition of the white and grey substances? from the action of the nervous fibre upon the muscular fibre? Would the nervous action be then comparable to an electric discharge?

763. The nervous action is excited or put into play by external or internal stimulants.

764. The first moments of that formation and development of the nervous system cannot be apprehended by observation. Does this system exist from the commencement, and does not generation result from the union of the cellulo-vascular system furnished by the mother, and the nervous system furnished by the male (Rolando)? Does the nervous system commence by the formation of the cardiac ganglion, and is it successively developed by the great sympathetic nerve and the rest of the system (Ackermann *)?

What we have learned from observation is that the spinal nerves and ganglia are formed before the spinal marrow, and the latter before the encephalon, that is to say, before the cerebellum, the tubercles and the brain.

The spinal marrow, which is at first open behind like a gutter, then hollowed like a pipe, by the edges coming together, finally becomes solid. It at first occupies the whole length of the vertebral canal. The white substance which forms its exterior is deposited first. The grey substance is afterwards deposited at its interior, and fills up the cavity.

The cerebellum, tubercles and cerebrum, which at first only constitute broader parts of the gutter of the spinal marrow, turns back, meet each other, and unite in the median line, presenting in the various phases of their development the most correct resemblance to the same parts of fishes, reptiles, birds and mammifera, ascending from the glires towards the quadrumana (739.)

In the brain, as in the rest of the encephalon, and as in the spinal marrow, the growth in thickness takes place simultaneously at the exterior and interior. It is by this circumstance that we are, with M. Desmoulins, to account for the existence of a cavity which is found, in the fœtal state, in the substance of the centrum ovale of Vieussens, between the inner layer and the outer layer of the vault of the lateral ventricles.

* Ackermann. *De Systematis nervei primordiis. Heidelb.* 1813. Tiedemann.

In the encephalon as in the spinal marrow, the grey substance forms only after the white, and even only after the fibres of the latter are united by commissures in the median line.

After birth, the growth of the nervous system, which up to this period has been so rapid, now slackens greatly. Next to the internal ear and the eye, it is the part which then grows most slowly.

In old age, the nervous system undergoes a sensible diminution of volume, which manifests itself in the encephalon by the contraction of the cranium,* and which may also be determined by measuring the spinal marrow.

765. The nervous system is subject to numerous vices of conformation.† There is a case known of the total absence of the nervous system: it was observed in an acephalous fœtus reduced to a small shapeless mass. There is a considerable number of cases of absence of the encephalon and head. There are numerous examples of total privations of the nervous centre, the spinal nerves and ganglia existing. We have a still greater number of cases of absence of the encephalon, the spinal marrow existing, as well as the nerves of the face and neck. The spinal marrow may have remained open, or hollow, or extended to the whole canal. In certain cases the cerebellum and tubercles exist, as well as the crura cerebri, thalami nervorum opticorum, and corpora striata, and the hemispheres alone are wanting. In some cases the hemispheres are incomplete; the middle or posterior lobes are destitute of grooves and circumvolutions. Sometimes the corpus callosum alone is wanting;‡ or there remains a cavity in the substance of the hemisphere, or in the septum, &c. The cerebellum may present similar deficiencies, especially in the number of its laminæ.|| All these cases are imperfections or defects of development.

There may exist defects of symmetry or defects of proportion among the different parts of the system.

766. The consistence of the nervous system is sometimes changed. The softening § is a very frequent alteration of a part of the central nervous mass. The softened nervous substance is sometimes at the point of being liquid. Its colour is sometimes milk-white; at other times it is yellowish, pink, red or brown. This alteration is met with in the optic thalami, the corpora striata, the hemispheres of the brain in the cerebellum, and even in the spinal marrow. It gives rise, according to its seat, to various derangements of the sensations, voluntary motions, and other functions of

* Tenon, *Recherches sur le Crâne Humain. Mem. de l'Inst. Nervous, &c. Phys. et Math.* T. I.

† A. Beclard. Memoire sur les Fœtus Acephales. Paris, 1815. Geoffroy Saint-Hilaire. *Philos. Anatom.* vol. ii. Breschet. *Dictionn. de Med.* Art. *Acephale* and *Anencephale.* C. P. Ollivier, of Angers. *Essai sur l'Anatomie et les Vices de Conformation de la Moelle Epinière. Paris,* 1823.—*Idem. Traité de la Moelle Epinière et de ses Maladies,* 8vo.—Laroche, *Essai d'Anat. Pathol. sur les Monstruosities de la Face.* Paris, 1823.

‡ Reil. *Archiv. für die physiologie.* Tom. xi.

|| Malacarne. *Neuro-Encephalotomia.* Pavia, 1791.

§ Rostan. *Recherches sur l' ramollissement du Cerveau,* 2d ed. Paris, 1823.

the nervous system. It is often the result of an inflammation. In some cases, however, it appears to be independent of inflammation.

The induration* of the nervous system has been observed by M. Esquirol and M. S. Pinel, who has given an excellent description of it. The hardened nervous tissue presents a compact mass, of an organic appearance. It resembles in colour, consistence and density, the white of an egg greatly hardened by boiling. No blood-vessels are perceived in it, and it appears shrunk upon itself. The hardening appears to affect the white substance particularly. It has been observed in the bodies of idiots, in the brain, the cerebellum and the spinal marrow, where it renders the fibrous disposition of the white nervous substance very manifest.

767. The nervous system is subject to numerous affections,† the principal of which are, in the central mass, sanguineous congestion with or without effusion; inflammation and its various degrees; the various products of chronic affections, as encysted abscesses, the production of tubercles, schirri, cancers, fibrous tumours, osseus tumours, hydatids, and foreign bodies. The membranes which envelope the central nervous mass are equally the frequent seat of sudden congestions with bloody or serous exhalation, of acute inflammation in different degrees, and of chronic inflammation. Acute and chronic hydrocephalus have been observed in it. The affections of the nervous substance and those of its membranes may be complicated together.

The affections of the spinal marrow are not so common in man as those of the encephalon. The reverse is the case in animals.

These different alterations, according as they are acute in chronic, according as they act by irritating, destroying or compressing, and according to their seat, induce various more or less dangerous derangement in the functions of the nervous system.

768. The nervous tissue is not produced accidentally. The affinity supposed by M. Maunoir to exist between this tissue and the cerebriform production, rests on insufficient semblances.

The nervous tissue when wounded cicatrizes when the wound is of such a nature as not to destroy the individual.

Wounds of the encephalon and spinal marrow, when not mortal, unite like those of the other parts. Wounds of the encephalon, with loss of substance of it's envelopes heal by the formation of an external cicatrix. This fact has been observed, by M. Dumeril, in salamanders, and by many surgeons in the human species. Wounds, with loss of substance of the brain, the skull remaining entire, heal by the formation of a new substance, which is soft, in some degree resembling mucus, and is not entirely similar to that of the organ, and by the widening of the corresponding ventricle of the brain. Lacerations of the encephalon, produced by bloody effusion, present, when the individual survives, remarkable pheno-

* Pinel the Younger. *Recherches sur l'Endurcissement du Systeme Nerveux.* Paris, 1822.

† Lallemant. *Recherches Anat. Path. sur l'Encephale et ses Dépendances.*

mena. The blood is presently surrounded by a layer of organizable lymph. This layer becomes vascular, and unites with the nervous substance. The blood is gradually absorbed, whether first the fibrinous and cruoric parts, and then there remains serosity,* or first the serosity, and there then remains a fibrinous coagulum,† with which the cyst unites. At length, the whole of the blood being absorbed, the cyst, which gradually shrinks upon itself, contracts adhesions, and becomes a yellow cicatrix which perhaps ultimately disappears.‡

The cicatrices and other alterations of the nerves will be afterwards examined.

769. The nervous system, which performs so important a part in the regular exercise of the functions, performs an equally important part in the production of diseases.§ It is it that receives and propagates the impression of morbific causes, determines the irregular motions of the muscles, the heart and the arteries, and produces morbid sympathies; and as its action extends to the cellular tissue which forms the basis of the organs, and to the blood which penetrates into them and moistens them, it will be easily conceived that there is no morbid action in which it does not perform a part, and that it is the principal agent of a great number of them.

The diseases called general, essential or dynamic, most probably have their seat in the nervous and vascular systems, which are the centres of the animal and vegetable functions, and in the blood and the nervous agent by which they are traversed, and which are in mutual, intimate, and necessary connexion.

It is in the regular relation of these two great apparatuses and their function, that life and health consist; and it is from the derangement of their harmony that disease and death result.

SECOND SECTION.

OF THE NERVES IN GENERAL.

770. The nerves,‖ *Nervi*, are white cords formed of medullary filaments, attached by one extremity to the nervous centre, and by the other to the teguments, the organs of sense, the muscles and the vessels.

771. The anatomists of the Italian school were pretty accurate-

* Riobé. *Observations propres à resoudre cette question; l'Apoplexie, &c. est-elle susceptible de guerison.* Paris, 1814.

† Rochoux. *Recherches sur l'Apoplexie.* Paris, 1814.

‡ Nothing can exceed the accuracy of these remarks, as I have often had opportunities of observing. And I may further observe, that no other, so far as I know, surpasses M. Beclard in such descriptions. They must have been carefully recorded at the time of the actual inspection of the diseased structure.—K.

§ Georget. *Op. Cit.* Lobstein. *Discours sur la preeminence du Systeme Nerveux.* Strasbourg, 1821.

‖ J. C. Reil. *Exercitationes Anat. de Structura Nervorum.* Halæ, 1779. Folio.

ly acquainted with all the pairs of nerves which are known at the present day; but did not classify, number or name them as is now done.

Willis gave them numerical names and proper names, by which they have generally been known since his time, viz.

1st, The olfactory nerves; 2d, The optic or visual nerves; 3dly, The motory nerves of the eyes; 4thly, The pathetic nerves of the eyes; 5thly, The fifth pair; 6thly, The sixth pair; 7thly, The seventh pair, composed of a hard part and a soft or auditory part. 8thly, The eighth, or the par vagum, with its spinal or accessory nerve. 9thly, The ninth pair, or the motory nerves of the tongue. 10thly, The tenth pair, or the sub-occipital nerve. The nerves of the spinal marrow; and the intercostal or sympathetic nerve.

M. Soemmering has modified Willis's division. He proposes forty-three pairs of nerves, of which twelve pairs belong to the brain; by dividing the seventh pair of Willis into the seventh or facial, and the eighth or auditory; his eighth into the ninth or glossopharyngeal, the tenth or nervus vagus, and the eleventh or accessory nerve, the twelfth being the hypoglossal; and by placing the sub-occipital among the spinal nerves, which are then thirty pairs, the great sympathetic nerve forming the forty-third pair. These modifications have been generally adopted.

Bichat has distinguished the encephalic or cranial nerves, into those of the brain, those of the protuberance, and those of the medulla oblongata. This division is not founded upon accurate observations.

The nerves may be accurately distinguished,* 1st, into nerves having a double root, the one attached to the anterior column, the other to the posterior column of the spinal marrow: They are the spinal nerves, the infra-occipital nerve and the trifacial or fifth pair of cranial nerves. These nerves are at the same time subservient to sensibility and muscular motion. 2dly, Into nerves having a single root. These are the first pair, the second, and the eighth,† or the olfactory, optic and auditory nerves; and the third, the fourth and the sixth, or the motory nerves of the eye; and the twelfth, or the motory nerves of the tongue. These nerves are exclusively subservient, some to sensibility, the others to muscular motion. 3dly, Into respiratory nerves, and nerves of the voice

* The division proposed here by the distinguished author is not only anatomically inexact, but contrary to the most common observation; the eighth pair being not only a nerve provided with a double root, and ganglion, but the most important of all the double-rooted nerves. I should be inclined to call it a respiratory nerve, if I could imagine any good to result from this name. It seems to me a retrograding in physiology, to substitute the term respiratory, as applied to this nerve, for that of pneumo-gastric, in as much as the function of the nerve is not exclusively respiratory. I had thought also, that every comparative anatomist had been aware of the fact, that the respiratory branch of this nerve is so delicate in some animals, (reptiles,) that its existence had been called in question, and yet the gastric branches in these same animals are by no means deficient. In fishes the respiratory or branchial and gastric branches are equally powerfully developed. To reason then about this nerve, as exclusively respiratory, must lead to error.—K.

† The learned author no doubt means the *seventh*.

and expression. They are attached to the lateral bundle of the upper part of the spinal marrow. They are, according to Mr. Charles Bell,* to whom we are indebted for a correct knowledge of them, the par vagum, which is the centre of the system, the facial nerve, the glosso-pharyngeal nerve, the spinal or accessory nerve, the diaphragmatic nerve, and the external thoracic nerve. 4thly, Into circulatory nerves. They are connected with all the spinal nerves, and are the great sympathetic nerves. These latter and the nervus vagus belong moreover to the internal tegument, and to the internal glands and muscles in general. The sympathetic nerve will be described separately in the following section.†

772. The form of the nerves is in general cylindrical. Their twigs, like those of the vessels, are collectively larger than the trunks which furnish them. The nerves consequently enlarge from their origin to their termination. They are also slightly enlarged at their origin. Their surface presents transverse wrinkles, or striæ, which depend upon the elongation which they undergo in the different motions. These striæ are very distinctly seen with a lens, especially in the nerves of the limbs.

There are three things to be considered in the nerves: 1st, Their origin; 2dly, their course; 3dly, their termination.

773. By the *origin* of the nerves there must not be understood a point from which they spring, and on which they vegetate, so to speak; this origin is merely the central extremity of the nerve, or that by which they are connected with the nervous centre. The origin of all the nerves is in the spinal marrow and medulla oblongata; none of them rises from the lobes of the brain or from the cerebellum. Even the olfactory nerve itself forms no exception to this rule; it is attached to a prolongation of the spinal marrow, which, in animals, constitute the olfactory bulb. There sometimes occur fœtuses destitute of brain, and in which the olfactory nerves yet exist, together with the spinal marrow and the peduncles of the brain, as I have very lately had occasion to observe. Bichat, while he stated generally that all the nerves come from the spinal marrow, made an exception with reference to the optic and olfactory nerves, which is not correct.

The origin of the nerves is often situated more deeply than it at first sight appears to be; so that the point from which they are detached is often not their true root. The fifth pair, for example, does not come from the pons varolii, from which it seems to be detached, for this part does not exist in the oviparous animals, in which the nerve in question, nevertheless, takes its origin at the same place as in the mammifera. We must not, however, seek to follow the origin of the nerves beyond the reach of the senses, and imagine them to proceed from the cerebrum or cerebellum, as has been done for the purpose of supporting hypothetic explanations.

It is asked if the nerves cross each other at the origin; and the

* Phil. Trans.

† Of all the divisions of the nerves I have read or heard of this is the worst.—K.

question has readily been answered in the affirmative, for the purpose of explaining pathological phenomena, in which the cause and the effect, both seated in the nervous system, presented a kind of crossing. The following is what we learn on this subject from inspection. There is no perceptible crossing in the nerves of the spinal marrow. It is the same with those which come from the medulla oblongata, excepting perhaps the optic nerves, in which a partial crossing at least appears to exist. Authors, in fact, are not agreed respecting the mode of union of these nerves. Their crossing, which has been admitted by some and denied by others, is evident in fishes, but in man, although in most cases, atrophy of one of these nerves is continued on the opposite side, observers worthy of credit assert their having seen it continued on the same side. Nor does dissection show that the crossing takes place in all the fibres, so that the opinion of those who think it to be only partial is the most probable. But, setting this exception aside, the crossing of the nerves has by no means been demonstrated. We may say as much respecting that of the two sides of the brain and cerebellum, which has been admitted. The anterior pyramids alone show this disposition, which accounts for the circumstance that, in injuries of the brain, the symptoms show themselves on the opposite side of the spinal marrow. When the latter also is divided below the place where the intercrossing of the pyramids exist, the symptoms appear on the same side.

Another question which has engaged the attention of anatomists is, whether the nerves unite in the median line by commissures like those which occur between the corresponding sides of the cerebrum and cerebellum. This union is evident only in the pathetic nerves. The auditory nerves are also sometimes united, at their origin, by white striæ, which line the bottom of the fourth ventricle, but these striæ are far from being constant, and are generally wanting in youth.

The nerves arise almost all deeply from the grey substance, and not from the white, which covers the grey, and under which they merely sink. In the spinal marrow the nerves when pulled off leave a depression which shows that they were not merely attached to the surface; and when the spinal marrow is hardened, we can follow the roots of the nerves and see them traversing the longitudinal fibres of that organ, to be inserted into the grey substance. Within the skull this disposition is equally evident with respect to most of the nerves. The auditory nerves alone have their origin at the surface of the medulla oblongata, but there is a grey substance at the place whence they rise, only it is superficially placed; it forms the grey band.

The nerves of the spinal marrow arise by two roots, an anterior and a posterior, as has already been said. The comparative volume of these two roots respecting which there has been much diversity of opinion, and which Dr. Gall has said to be greater in the posterior root, is in reality so only in the brachial nerves, the contrary being the case in the crural nerves. These roots unite in the intervertebral foramina, where the posterior presents an enlargement or ganglion, to which the anterior is simply attached. The anterior root does not contribute to the formation of this ganglion, as it is said to do in most anatomical works, although this circumstance was long ago pointed out by Haase, Monro, and Scarpa, to the latter of whom the discovery has even been attributed; only Dr. Gall remarks with truth, that at the neck the anterior roots of the spinal nerves are soft, pulpy, and reddish, which may have deceived anatomists in examining that region. In the skull the roots of the nerves are not so distinct. At the place where the nerves come off from the medulla oblongata, the neurilema deserts them or becomes softened, and is confounded with the pia mater, and the medullary substance alone is continuous with that of the encephalon. The internal filaments of the nerve are sooner left by the neurilema than the external filaments. There results from this that when the nerve is pulled out, it tears farther externally than internally, and there remains a prominence which has erroneously been compared to an apophysis on which the nerve is inserted.

774. In their course the nerves divide so as to retain nearly the same volume in the interval between their divisions. The divisions merely consist of a separation of the filaments of which the nerves are composed, and do not resemble those of the vessels. The divisions of the nerves are in general accompanied by those of the vessels, although they do not exactly correspond to them. The nerves communicate together in three ways; 1st, By anastomoses; 2dly, By plexus; 3dly, By the ganglia.

775. By anastomosis is meant the union of two nerves together. This union was so named by the ancients, because they considered the nerves as vessels in which the nervous fluid circulated, and compared them in this respect to the arteries. This expression, which has been censured, is proper enough, for there is not merely an application of the nervous filaments in the anastomoses, but a true communication of these filaments, an interosculation of their canal, which in truth contains a substance that is resident in it, and not a circulating fluid, as was formerly supposed. The anastomoses take place sometimes between the branches of the same nerve, sometimes between the different nerves, and rarely between the nerves of one side and those of the opposite side.

It is more especially in the nervous arches that the inosculation of the filaments is most evident. The most remarkable of these arches is that which results from the union of the nervus vagus of the right side and the solar plexus, which Wrisberg has described under the name of *ansa communicans memorabilis*.

The plexuses are nothing else than multiplied anastomoses. Scarpa* has given a very good description of them; but he has erroneously likened them to the ganglia. The manner in which the last four cervical pairs unite with each other and with the first dorsal,

* *Anat. Annot. De gangliis et plexubus.*

to form the brachial plexus, furnishes a very remarkable example of them. The cervical, lumbar and sciatic plexuses are also examples. These plexuses are so disposed that the nerves which issue from them derive their origin at the same time, for the most part at least, from a certain number of nerves of which they are constituted.

Bichat admits that there is nothing else in the plexus than merely an intimate intermixture of the nerves. Monro says, that they contain grey substance, and may be considered as a new origin of the nerves which issue from them ; but this has by no means been demonstrated.

The ganglia consist of enlargements which contain, besides the nervous filaments, a substance which is foreign to them. The nervous filaments are much finer. They consequently present a greater complication than the other two modes of communication. They will be examined after the nerves, from which they differ in several respects.

776. The termination of the nerves takes place after they have passed through anastomoses, plexuses or ganglia, or directly, without their having been interrupted from their origin. The mode in which the nerves terminate is little known. They are only seen to lose their neurilema towards their extremity, and to become in consequence very soft ; so that it is then very difficult to trace them. They generally enlarge as they approach their termination ; they become flattened, and are then lost sight of, although they seem as if they ought to be continued further. There are two hypotheses respecting the termination of the nerves, both of which are perhaps alike destitute of foundation. According to one of these hypotheses, the nerves lose themselves as it were in the organs, and become identified with their substance, which is soaked full of it, if one may so speak. In the other hypothesis, which belongs to Reil, the nerve, as it cannot be spread out in the whole organ at once, is surrounded by a nervous atmosphere in which it extends its action, much in the same way as that exhibited by electrical phenomena. What has given rise to these hypotheses is the circumstance that the nerves are expanded in parts whose extent is much greater than their own, even after they are divided as far as the eye, aided by the microscope, can follow them, as is seen in the muscles, the skin, the organs of sense, and yet each point of these parts, however minute it may be, presents, when pricked, the same phenomena as if the nerve itself were pricked.

777. The different parts do not receive an equal number of nerves. The organs of sense are those which contain most : the eye and the ear present membranous expansions entirely formed of nervous substance. The skin, particularly on the hands and lips ; the mucous membranes, whether at the exterior or at the interior ; the glans penis, the different parts of the vulva, which are placed at the line of junction of these membranes with the skin, are the parts which receive the greatest quantity of nerves, next to the four principal organs of sense. Next come the external muscles,

then the internal muscles, and the blood vessels, of which the arteries receive more than the veins, or lymphatic vessels, in which latter their existence is not very certain. The existence of nerves is doubtful in other parts, or in those which have the cellular fibre for their basis, if we except the vessels, as the cellular tissue, the serous and synovial membranes, the cartilages, the bones, &c. These parts, in fact, do not appear to receive any nerves. Lastly, the horny and epidermic parts are assuredly destitute of them. It is possible, however, that there may be nerves in the above tissues, although their softness and extreme tenuity may prevent their being visible; and the sensibility which these tissues exhibit in diseases gives some countenance to the idea. It is true that the hypothesis according to which the nerves act by means of an imponderable fluid, susceptible of extending its influence beyond their apparent termination, may, to a certain degree, account for this phenomenon. According to that hypothesis, the nervous action is transmitted beyond the nerves and across the organic substance, as nutrition takes place beyond the termination of the arteries, by a kind of imbibition.

It is worthy of remark, that, in some circumstances in which there exists paralysis of feeling, and not of motion, the inflammations which are developed are not accompanied with pains; which would lead to the belief that the same cords are the seat of the general feeling and of the feeling of pain peculiar to inflammation, and that the nerves of the blood-vessels are not the only ones which cause the latter to be experienced.

778. The parts in which the extremities of the nerves terminate in the most evident manner, are therefore the tegumentary membranes and the organs of sense, which form part of them, the muscles and the arteries.

The organs of sense* are those by which external bodies are perceived. They are more or less complicated, and possess a structure calculated so as to enable them to receive a determinate impression. They are connected with the nervous centre by nerves of great size. These organs are those of tact, or touch, taste, smell, hearing, and sight.

The muscles are connected with the nervous centre by numerous nerves, which are greatly branched (662.) The arteries receive a very great number of nerves; but they do not all exhibit the same circumstances. 1st, Some only accompany and surround them, as ivy twines about trees, without penetrating into their tissue, unless perhaps after having accompanied them to a greater or less distance. Of this kind are the nerves which accompany the vertebral, internal carotid, and facial arteries. 2d, Others, adhering closely to the outer membrane of the artery, penetrate along with it into the organs, becoming soft and pulpy. After ramifying greatly, they disappear, and seem to dissolve in the external

* See Blainville, *Principes d'Anat. Comparee*, T. i. Paris, 1822.

membrane. 3d, Lastly, notwithstanding Behrends's negation, nervous ramuscules are seen passing through the outer membrane of the arteries, and terminating in their middle membrane. The nerves of the arteries belong either to the sympathetic nerves, or to the spinal and trigeminal nerves.

779. The nerves have been examined in their structure by various anatomists. Della Torre found in them the fibres and globules common to the whole nervous system. Prochaska and Reil have since still more fully described their internal disposition. According to their researches, the nerves are composed of cords, and these of filaments or very fine threads, whose tenuity is equal to that of the threads of the silk-worm, and which, in the optic nerve only, are of the size of a coarse hair. These filaments, which are of the same nature as the medullary fibre, or filaments of the brain and spinal marrow, differ from them only in being more distinct, and more separated from each other, which arises from their being surrounded by a proper membrane. This membrane or envelope, which is called *neurilema* or *neurhymen*, which means the membrane of the nerves. Galen had employed this expression, but Reil was the first who made precise application of it. The neurilema forms a general envelope to the nerves, and furnishes partial envelopes to the nervous cords, as well as to the filaments of which they are composed. It is very tenacious. When it is emptied, it represents an assemblage of small tubes. These tubes unite with each other, or inosculate, at intervals. It is not, therefore, correct to say that the nerves are composed of filaments, which are distinct in their whole length; for the communication of these filaments with each other render them no longer the same. When examined at the upper part and at the lower part of the nerve, the nervous cords are not simply adherent there either, but send filaments to each other. There is the same disposition as in the plexus, where there is an intimate communication between all the nerves, by means of the cords and filaments which they send out. What the plexus presents on the large scale is seen in the small scale in each nerve; and the cords themselves are nothing but plexuses of nervous filaments. Towards the origin or central extremity of the nerves, the neurilema is continuous with the pia mater, but only in the portion of it which constitutes the general envelope of the nerve. The internal sheaths of the nervous filaments become softened, and are insensibly lost, so that the filaments are left bare in the centre of the nerve. The nerves are, in like manner seen to lose their neurilema at their termination, wherever they can be traced so far. The neurilematous tubes do not present, internally, a smooth and polished surface, like the internal surface of the vessels. They send off a multitude of prolongations, which traverse the medulla of the nerve and sustain it. The medulla is not free and moveable in the nerve, which is in part owing to its consistence, but also in part to this disposition. There exists cellular tissue around the general sheath, and between the partial

sheaths of the nerve, as is observed with respect to the muscular bundles and the fibres of which they are composed. In neuralgiæ, this tissue is sometimes the seat of an œdema or infiltration, which renders it in certain cases compact and condensed. At other times it is the seat of a congestion of blood, or of a very intense redness, as Cotugno and others have observed; which would lead to the inference that these painful affections depend upon its inflammation. Fat may also accumulate in this tissue. The medullary fibres contained in the tubes of neurilema are of the same nature as those of the brain and spinal marrow.

780. The blood-vessels of the nerves penetrate between the cords of which they are composed, and divide, for the most part, into two twigs, the one direct, the other retrograde. Their number is great, and in fortunate injections the whole neurilema is covered with them. They are seen by means of a lens to extend over the neurilema of the nervous filaments, which is itself formed of fibrous cellular tissue and blood-vessels, no lymphatics have been discovered in the nerves.

781. The structure of the nerves is not precisely the same in all. In the greater number of the researches that have been instituted on this subject, the optic nerve has been selected, because the filaments are larger in it, and because it is easy to fill the neurilematous tubes in it. Now, this nerve differs from the others in this respect, that its tubes are separated by common septa, which come off from the interior of the general sheath. The structure of the nerves has however also been observed in other nerves, and especially in those of the muscles, in which the filaments are more distinct than in the nerves of the organs of sense and skin.

782. Reil, to whom we owe almost all that is known respecting the structure of the nerves, has pointed out the means by which it may be observed. By washing a nerve with water and nitric acid, the neurilema is, after a certain time, entirely destroyed, and there remain the medullary filaments, which may be seen crossing each other nearly in the same manner in which the optic nerves cross at their commissure. On the other hand, by immersing the nerve in soap-boiler's lees, which may be considered as an alkaline solution of subcarbonate of soda, the medullary substance is destroyed, and the sheaths of neurilema are obtained. To prevent their collapsing, air is blown into them, which is very easily done, by impelling that fluid into one of them, as they all communicate together. The nerve is then tied at its two ends. When dried in this state, it presents, on being cut, a multitude of minute tubes, opening into each other, which gives it the internal appearance of a reed. These observations, which have since been frequently repeated, demonstrate the two different substances of which the nerve is composed.

The observations of Sir Everard Home on the optic nerve have shown that the medullary filaments, of which it is composed, augment in number and diminish in volume, from the origin to the termination.

783. The nerves possess little or no elasticity. They present no sensible motion, whether of oscillation, or of vibration, when they are irritated in the living animal. The irritation of a nerve produces excruciating pains, and excites convulsive contractions in the muscles.

784. The nerves are conductors of feeling and motion. They transmit the volitions, with incalculable velocity, from the nervous centre to the muscles, and conduct to the centre the sensations produced by the impression of external agents. Section and ligature of the nerves interrupt their functions, and render the parts situated beneath, incapable of feeling and motion. Irritation made above the interruption causes sensation of pain, similar to those which irritation of the extremities of the nerve would produce. Irritation applied below the interruption produces contraction, like those which would result from irritation of the origin of the nerve.

785. Since the time of Herophilus and Galen, endeavours have been made to discover whether there be particular nerves for feeling and others for motion. It was, in fact, soon found that there are sensorial nerves, as the first, the second pair, and the auditory nerve; nerves of motion, as the third, fourth, and sixth pairs, and hypoglossal nerve, &c.; and mixed nerves, as all the spinal nerves, which are in fact distributed to the skin and to the muscles of the trunk and members, and as the infra-occipital and trigeminal nerves. But paralyses and anesthesiæ, which are sometimes observed united, and sometimes separated in the parts of the body to which the nerves that have double roots are distributed, led to the belief that these nerves were composed of distinct sensorial filaments and moving filaments. The experiments of Mr. Ch. Bell, those of M. Magendie, and my own, have clearly demonstrated that the posterior root of the spinal nerve is sensorial, and the anterior root motory.

786. The nerves are not entirely limited to the office of conductors; they possess a proper activity, which manifests itself when they are separated from the nervous centre; but this activity is much increased by that of the spinal marrow, as that of the spinal marrow is, by the influence of the encephalon; so that removal of the encephalon greatly diminishes the activity of the spinal marrow, removal of the spinal marrow greatly restricts that of the nerves, and the nearer to a muscle the nerve is removed, the more is the influence of the nervous power over its contraction diminished.

787. Have the nerves a power of formation or of regeneration such, that when cut across, their union possesses the texture and performs the functions of nerves; and even such that after being divided with loss of substance, they are capable of being reproduced? These questions have much occupied the attention of physiologists, and especially of Fontana, Monro, Michaelis, Arne-

mann, Cruickshank, Haighton, Meyer, &c. Most of these experimenters have resolved affirmatively the questions that relate to the reproduction of the nervous substance. Arnemann alone, proceeding like the others upon the results of a series of experiments, has adopted a contrary opinion.

Assisted by one of my pupils,* I have made a great number of experiments for the purpose of solving this question. There result from our observations: 1st, That the division of a nerve, produced by a ligature, is always followed by an exact union of the two ends of the nerve, and the prompt re-establishment of its functions.

2dly, That incomplete section or pricking, to which fatal results have been attributed in man, do not produce accidents in animals, and that reunion and re-establishment of the functions very speedily take place.

3dly, That the complete section of a nerve in a part possessed of little mobility, as for example along one of the two bones of the fore-arm of the dog, in the neck, in the same animal, along one of the bones of the fore-arm in man, &c. is commonly pretty speedily followed by an exact reunion, and the complete re-establishment of the functions.

4thly, That in parts which possess great mobility, as in the vicinity of a joint, when a nerve is divided, there takes place, besides the original separation which constantly follows, an accidental separation which varies in extent according to the motions of the part. In this case the union is long in taking place, and if it ensues at all is imperfect. The re-establishment of the functions is also imperfect, or does not take place at all. It is to this that we must refer the results of some of Meyer's experiments, and the permanent paralysis which is said to result from the section of the radial nerve at the lower part of the arm.

5thly, That when there is considerable loss of substance of a nerve, whether by excision, or in a contused wound with destruction, there remains a wide separation between the two ends of the nerve, and the functions are never restored, whatever may be the nerve that has been affected; which is sufficient to prove that the anastomoses go for nothing, when the re-establishment of the functions takes place.

It may therefore be concluded from all that has been stated above, that the nerves unite after being cut across; and that when union does not take place, this depends solely upon the great separation of the extremities, caused by the motions of the part, or by a loss of substance.

788. When a nerve has been divided, an exudation of organizable matter takes place in the first days, around the extremities, at their surface, and in the interval between them. The surrounding cellular tissue is penetrated in the same manner, and has lost its

* L. J. Descot. *Dissertation inaug. sur les affections locale des nerf.* Paris, 1822.

per ncability. In this state, the ends of the nerve are simply agglutinated to each other and to the neighbouring parts; the functions are still suspended as they were immediately after the separation; the two ends of the nerve, which are swollen, and especially the upper, the surrounding cellular tissue, and the organizable matter, acquire more consistence, and become highly vascular. In this state, which lasts some time, the two ends of the nerve are united by a vascular organizable substance; but there is as yet no communication of nervous action between the two ends. In time the surrounding cellular tissue ceases to be compact and vascular; the intervening substance, which varies in length, according to the kind of wound and the concomitant circumstances, gradually diminishes in volume, consistence, and redness, assumes the appearance and texture of the nerve, (as proved by the application made by Meyer of nitric acid to the nervous cicatrix) proceeding from the extremities towards the middle of their interval, and ultimately performs the functions, with so much the more precision and quickness, the less the separation of the extremities has been, as in cases of ligature, where there has been no separation, or when it has been inconsiderable, as in the case of simple section, or where there has been a very small portion cut out in a part possessed of little mobility. On the contrary, when the separation is great, no union takes place, or it only takes place by means of cellular tissue, which at a certain distance from the extremity does not acquire the structure and properties of the nerve. The time necessary for the complete re-establishment of the structure and functions is not exactly known. It has certainly been exaggerated by those who have asserted that it must be several years; it may be stated at about six weeks or two months.

789. Section of the united pneumo-gastric and trisplanchnic nerves, in which state they present themselves in the dog, always produces death, when performed on both sides at the same time. It is upon these nerves especially that the reparation of the tissue and the re-establishment of the functions may be simultaneously examined, as they have been determined by the experiments of Cruickshank and Haighton, and my own.

The following are the phenomena which we have observed on cutting these nerves at various intervals.

Having on the same day cut the two pneumo-gastric nerves in two different dogs, one of them died thirty hours after the operation, the other at more than sixty-six hours after this double section. Another animal, after an interval of nine days between the two sections, died in the night between the fourteenth and fifteenth days. In a fourth, the second section having been made at the end of twenty-one days, death did not supervene until the twentieth day after this second section. Lastly, in another animal, the second cutting was performed thirty-two days after the first, and the animal survived a whole month. At this epoch, that is to say, two months after the first division, we found the first nerve divided completely united. This dog died of an empyema which formed in the left cavity of the thorax. Lastly, Haighton cut the second pneumogastric nerve six weeks after the first, and the animal survived nineteen months, after which time it was killed. It has been asserted that the nervous action, like galvanic action, might be established through another substance than the nervous tissue, as a liquid or moist cellular tissue. It has also been alleged that the nervous action can be exercised at a distance, and overleap the interval which exists between the ends of the nerve. Lastly, it has been asserted that the re-establishment of the functions may take place by means of anastomotic branches. If it were by either of the first two causes that the nervous action was continued, this action would not be a single moment suspended, and the animals would not have died in any one of the abovementioned experiments. As to the re-establishment of the nervous functions by means of anastomoses, it is contradicted by a great number of cases, in which the nerve having been cut across in certain subjects, and in others cut out or destroyed by cautery, the functions have been re-established in the first case, and not in the second. The re-establishment by anastomoses is especially contradicted by an experiment which consists in cutting again the same day, in the place where they have re-united, the pneumogastric nerves which have cicatrized after the previous division of these two nerves, at a suitable interval. The animal, which had survived until this moment, dies in the space of one or two days.

It is not, therefore, by the interposition of a merely humid substance between the two ends of the divided nerve, nor by the distant action of the nervous system, nor, lastly, by anastomoses, that the nervous functions are re-established, but by a true nervous cicatrix. In fact, we see the functions, which are at first entirely destroyed, becoming gradually re-established, and in their restoration following the progress of the organic union. It cannot be denied, however, that the nervous action is propagated in a certain degree from one part to the other of a nerve that has been simply divided. This is proved by experiments made by Mr. Wilson Philip, and repeated in France.*

790. The nerves are subject to other alterations besides those which result from physical injuries, such as inflammation or neuritis, and tumours or neuromata, of which some consist of a hard and very painful graniform or pisiform subcutaneous tumour; others of a scirrhous tissue of greater or less quantity. Local neuralgiæ and insensibilities, and partial paralyses and convulsions, are the ordinary result of local affections of the nerves. Besides, these local affections are sometimes propagated to the nervous centre, and thus give rise to general neuroses.

* Vavasseur. *De l'influence du système nerveaux sur la digestion stomacale.* Paris, 1823.

THIRD SECTION.

OF THE GANGLIA AND SYMPATHETIC NERVE.

791. The *Nervous Ganglia* are round or oblong bodies, formed of medullary nervous filaments and a peculiar substance, situated in the course of the nerves, and especially of the nerves of the vegetative functions.

792. The name ganglion, γαγγλιον, was employed by Hippocrates to designate the tumours of the sheaths of the tendons. Galen first applied it to the nodosities of the nerves, by comparing them with the morbid ganglia. J. Riolan the younger and Vieussens made use of the same name. Others have employed that of gangliform plexus. The term ganglion, however, is now universally adopted.

MM. Gall, Reil, Walther, de Blainville, &c. have extended the sense of the word ganglion, and have applied it to grey substance which exists in the interior of the spinal marrow, to the masses of grey substance which are met with in the medulla oblongata, and in the peduncles of the cerebrum and cerebellum, as the olivary eminences, the rhomboidal body of the cerebellum, the optic thalami and corpora striata. It has even been extended to the olfactory lobes, the hemispheres of the brain, the tubercles and the cerebellum. Lastly, the ganglia have been confounded with the plexuses and with the sensorial nervous expansions. These are forced assimilations which have been already combated by the elder Walther, Reimar, and Soemmering. It is not in this sense that the word ganglion is here employed.

793. The ganglia have been particularly examined and described by Meckel,* Johnstone,† Haase,‡ Scarpa,|| Bichat,§ Weber,¶ and especially Wutzer.** The opinions which anatomists and physiologists have formed respecting the texture and function of the ganglia, may be referred to two principal ones; some considering them merely as condensed plexuses, and regarding the nerves which proceed from them only as remote divisions of the spinal and cranial nerves; others considering the ganglia as particular nervous centres, and regarding the nerves which emanate from them as independent of the nervous system. It will be seen that these two opposite opinions must be combined and modify each other.

794. The inferior animals, that is to say, the radiaria, mollusca,

* *Hist. de l'Acad*, de Berlin, 1749 and 1753.
† Essays on the Use of the Ganglions, &c. 1771.—Medical Essays, &c. 1795.
‡ *De Gangliis Nervorum*, Lipsiæ, 1762.
|| *De Nervorum Gangliis et Plexubus*, Mutinæ, 1779.
§ *Anatomie Generale.*
¶ *De Systemate Nerveo Organ.* Lipsiæ, 1817.
** *De Corporis Humani Gangliorum Fabricâ atque usu*, Berolini, 1817.

and articulata, have nervous enlargements which have been assimilated to the ganglia of the vertebrate animals. But in the invertebrate animals the same nerves belong to all the kinds of organs and functions, while in the vertebrate, the great sympathetic nerves (and, to a certain degree, the pneumo-gastric nerves) belong especially to the organs of the vegetative functions. M. Weber has compared the spinal ganglia of the vertebrate animals to the ganglia of the inferior animals.

In the vertebrate animals, the only animals that possess true nervous ganglia comparable to those of man, these ganglia are seen to enlarge, especially those of the sympathetic nerve, and the pneumo-gastric nerve to diminish, in proportion as the encephalon is developed; so that the lowest of them, the class of fishes, have the smallest sympathetic nerve and the largest pneumo-gastric nerve, while the reverse takes place in the highest, which are the mammifera;—as if the vegetative functions were more withdrawn from the influence of the encephalon, the less that organ is subjected to instinct.

795. The ganglia have been divided into several classes by those who have described them with most accuracy. Scarpa divides them into simple or spinal, and into compound. M. Weber divides them into ganglia of *strengthening:* those of the spinal nerves and some of those of the cranial nerves; and ganglia of origin; those of the sympathetic nerve, with which he associates the orbitar and maxillary ganglia. M. Ribes * divides the ganglia into three series. In the first he arranges the rachidian or spinal nerve; in the second, those which occur in the course of the trisplanchnic nerve; and in the third, all those which are situated more internally. M. Wutzer classes them into ganglia of the cerebral system, ganglia of the spinal system, and ganglia of the vegetative or sympathetic system. I divide them into two kinds: 1st, the ganglia of the encephalo-rachidian nerves, of which some, the more numerous and regular, belong to the nerves which have double roots, and others occur in the course of the nerves which have only one root: 2d, The ganglia of the two sympathetic nerves, some of which form a double longitudinal series, and others are placed near the median line.

796. The number of the ganglia is very great as will be seen. They are all situated in the trunk; and Lancisi has erred in alleging their existence in the limbs. Their size varies from that of an olive to that of a millet seed. Their form is round, amygdaloidal, lenticular, &c.

797. The ganglia are composed of two internal substances; the first medullary and white; the second, pulpy and of a reddish grey. The medullary substance is collected into cords and threads, as in the nerves of sensation and motion. These internal medullary

* *Exposé sommaire de quelques Recherches Anat. Phys. et Pathol. in Mem. de la Soc. Med. d'Emulation*, vol. viii.

fibres are visibly the continuation of the nerves connected with the ganglia. The cœliac ganglion is the only one in which this continuation is not very manifest. These filaments are still recognised by their colour and form. The action of alkalies and acids upon them, characterizes them in the very heart of the ganglia, as medullary nervous filaments.

These filaments, as they penetrate into the ganglia, leave off their neurilema, which intimately unites with the external membrane of the ganglion; their surface appears looser, and as if blended or intimately united with the adjacent substances. These medullary filaments have a considerable tenacity.

798. The second substance of the ganglia determines not only the difference between the nerves and ganglia, but also between the ganglia and plexuses. This substance has been much neglected by anatomists, who, considering the ganglia as more condensed plexuses, have only regarded it as destined to separate or unite the nervous filaments (Scarpa,) or to perform the functions of cellular tissue (Haase.) The matter which surrounds the medullary filaments of the ganglia is a peculiar cellular tissue, whose interstices are filled with a mucilaginous or gelatinous pulp, of a reddish ashy colour, and in some ganglia yellowish. This colour, like that of the other organs, does not depend solely upon the quantity of the blood which they receive.

This secondary substance is not equally abundant, and is not entirely united to the medullary substance in the same manner, in all the ganglia.

799. Scarpa says that this pulpy matter is of a fatty nature in very fat bodies. M. Meckel appears to be of the same opinion. Bichat, on the contrary, thinks that the ganglia are never transformed into fat. The observations of M. Wutzer, and my own, are in perfect accordance with those of Bichat. In very full subjects, fat accumulates beneath the membrane of the ganglia, and when in large quantities, not only surrounds the ganglion, but compresses it and diminishes its volume, but this is never itself converted into fat.

800. The ganglia are enveloped by a cellular or fibrous membrane, which differs in the various kinds of ganglia.

801. The blood-vessels of the ganglia are very numerous. The arteries come from the neighbouring trunks. They ramify first in the membrane, where they form a network. Minute twigs penetrate into the filamentous and pulpy tissue of the ganglion. Sometimes arterial twigs penetrate into the ganglion along with nervous filaments, and accompany them. The veins present a similar distribution. Nothing is known respecting the lymphatic vessels of these organs.

802. The medullary filaments present no interruption in the ganglia. They establish a continuity or an uninterrupted connexion between the nervous cords, in the course of which the ganglia are placed. These medullary filaments contract connexions in the interior of the ganglia, and traverse them in all directions, so as to

unite together all the cords which are attached to them. Whence results the irregular figure and internal complication of the lateral and median sympathetic ganglia, which are placed at the middle of many nervous cords, and the regular ovoidal form, as well as the simply longitudinal direction of the filaments of the spinal ganglia.

803. Bichat made some chemical trials on the ganglia, which apprised him, that there is nothing common between their substance and that of the brain. Some anatomists, however, having continued to confound with the ganglia the bulgings of the central nervous mass, composed of white substance and grey substance, M. Wutzer undertook a series of comparative chemical experiments on the ganglia, and on mixtures of white and grey substance of the cerebrum and cerebellum. The results of these experiments are: That they differ essentially; that the ganglia differ from the nerves in having a larger proportion of gelatine, and still more from the brain in an excess of gelatine, in a larger quantity of albumen, and in a less proportion of fat. M. Lassaigne,* has analysed the guttural ganglia of the horse, and has found them composed: 1st, of fibrine for the greater part, 2dly, concrete albumen in small quantity, 3dly, soluble albumen, 4thly, traces of fat matter, 5thly, phosphate and carbonate of lime. M. Lobstein has observed that, although they resist putrefaction more than the nerves, they become readily converted into fat by immersion in water.

804. The ganglia of the first kind are those which are met with in the course of the nerves of the spinal marrow, and not far from their origin. There are on each side thirty, which are named spinal; one upon the trigeminal nerve, which is called the ganglion of Gasser, one or two upon the nervus vagus, and one upon the glosso-pharyngeal nerve. The spinal ganglia, which were first observed by Volcher-Coïter, which are thirty on each side, have an oval or amygdaloidal form. They belong to the posterior root only of the spinal nerves, the anterior being united to the ganglion only by loose cellular tissue. Haase was the first who made this observation, which has since been confirmed by Prochaska and Scarpa. The anatomists who preceded them thought, that the two roots of the nerve contributed to the formation of the ganglion.

The membrane of the spinal ganglia, which is supplied by the dura mater, appears firmer, denser, and more solid than that of the other ganglia. The ganglion itself is so closely enveloped by it as to appear very hard. The pulpy substance envelopes the medullary filaments more loosely than in the others, and is more distinct and more easily separable.

The medullary fasciculi which enter by the posterior or inner extremity of the ganglion, divide into three, four, or five white filaments. They first separate from each other, and then approach

* Lassaigne, in *Journal de Physiologie*, Vol. i.

towards the anterior extremity. These filaments unite and intermingle with each other, so that each filament, as it issues from the ganglion, is formed of filaments which probably come from several of the cords which enter it. The number, tenuity and blending of the filaments, however, are not very great. The spinal ganglia have a simple texture compared with the other.

The nervous fasciculi which are collected together at their egress from the ganglion, intimately unite, after a course of hardly a few lines, with those of the anterior root, to form the common trunk of the spinal nerves; and this trunk itself has only a length of one or two lines when it divides into two branches, the anterior and posterior.

The common trunk of each spinal nerve, at a short distance from the ganglion, furnishes a single, frequently double, and rarely triple branch, which directs itself towards the neighbouring ganglion of the trunk of the sympathetic nerve, and joins it in such a manner, as to establish the most intimate connexion between the nerves of the spinal marrow, the spinal marrow itself, and the great sympathetic nerve. It has been a subject of much discussion among anatomists, and especially among physiologists, whether the communicating branch comes from the one or the other root. I have seen, as Scarpa and M. Wutzer have also seen, that the single or double root comes from the inextricable common trunk, and that when it can be followed, it is found to come from both roots. This communicating branch, which in its origin resembles the spinal nerves, on arriving at the distance of about a line from the ganglia of the sympathetic nerve, becomes red, and gradually assumes the character of that nerve.

The ganglion of the fifth pair of nerves, or the ganglion of Gasser, evidently belongs to the series of spinal ganglia, from which it differs only in form. The white nervous fasciculi which pass beneath it, without forming part of it, and which Paletta has proposed to consider as particular nerves, entirely resemble the anterior root of the spinal nerves.

The ganglia of the nervus vagus and glosso-pharyngeal nerve also resemble the spinal ganglia in form and texture.

The trunk itself of the nervus vagus has an entirely peculiar texture, differing from the other nerves, without however resulting from a linear series of ganglia, as Reil asserts. It greatly resembles the trunk of the sympathetic nerve.

805. The second kind of ganglia comprehends the series of the three cervical ganglia, the twelve thoracic ganglia, the five lumbar, and the four sacral ganglia, belonging on each side to the trunk of the sympathetic nerve. The ophthalmic, spheno-palatine and maxillary ganglia are also of the same kind. To these are to be added the cardiac ganglion, which is often replaced by a plexus, the semilunar or cœliac ganglia, and many others, situated in the solar plexus and its divisions; the small coccygeal ganglion, which is sometimes met with at the union of the two sympathetic nerves,

opposite the tip of the sacrum; and the small palatine ganglion, which sometimes exists in the anterior palatal canal. Lastly, there are also joined to these some variable ganglia, which are sometimes met with on the walls of the arteries, where they replace plexuses, as the ganglion of the anterior communicating artery, that of the cavernous sinus, that of the deep temporal artery, &c.

All these ganglia have, in general, an irregular and variable figure. They generally have connexions with several nervous trunks or branches. The direction of the medullary filaments which pass through them is very complicated, and it is seldom that these filaments pass through from one side to the other. The pulpy substance of these ganglia is so intimately united to the medullary filaments, that it is very difficult to separate them. This substance, besides, appears to differ from that of the other ganglia, being harder, denser, and more tenacious. This is especially remarkable in the cœliac ganglia, and in those of their plexuses. The membrane of the ganglia of this series is cellular and firm, but does not possess the fibrous solidity of that of the spinal ganglia.

806. The nervous cords and branches, the nerves, in short, which unite these ganglia, differ remarkably from those which are directly attached to the spinal marrow. In place of diminishing, as they do, in proportion as they recede from their origin or central extremity, they furnish successive divisions, and are seen to diminish or increase indifferently, or not to undergo any change of volume, as they recede from the ganglia. The ganglionary nerves possess a less power of cohesion, and are more fragile, than the others. The external envelope of the ganglia is continued upon the nerves to a certain distance. Beyond the point at which this continuation ceases to be apparent, the neurilema appears thinner and more intimately united to the medullary substance than in the other nerves. Their internal substance, like that of the ganglia, results from medullary filaments, and filaments of a reddish grey pulpy substance, which can hardly be separated from them. The filaments, or the twigs united to form a cord, are themselves hardly separable. Lastly, the ganglionary nerves seem formed of the same substances as the ganglia, the latter being only elongated into cords. However, the nerves of the ganglia are not absolutely alike. Those which connect the spinal ganglia with the ganglia of the sympathetic nerve, and the splanchnic nerves, which go from the thoracic ganglia of the sympathetic nerve to the cœliac ganglia, seem intermediate, by their white colour, cylindrical form, fibrillar composition, firmness and tenacity, between the nerves of the spinal marrow and the reddish grey, flattened, irregular, pulpy, soft, and fragile nerves of the sympathetic nerve. Scarpa asserts, that the sympathetic nerves can be anatomically analysed, and reduced to filaments like the other nerves. This, however, I believe to be impossible, especially in the nerves which form the mesenteric or intestinal plexuses.

807. The *Sympathetic Nerve*,* called also the intercostal or trisplanchnic, is a nervous and ganglionary cord, extended from the head to the pelvis, connected by anastomosing twigs or roots with all the spinal nerves, and the trigeminal nerve, and furnishing twigs to the organs of the splanchnic cavities of the trunk.

The cephalic extremity of this nerve penetrates into the cranium by the carotid canal and cavernous sinus, in which it forms a plexus and frequently a ganglion upon the carotid artery. From thence it sends anastomotic filaments to the nerve of the sixth pair, and communicates with the inferior twig of the vidian nerve. It sends off secondary plexuses over the branches of the internal carotid artery, and can be traced as far as a small single ganglion situated upon the anterior communicating artery of the brain.

It afterwards consists of three cervical ganglia, twelve thoracic, five lumbar and four sacral, and of their communicating cords, placed on each side of the anterior face of the vertebral column.

In the whole length of the nerve, each ganglion presents external anastomotic filaments or roots, and internal filaments or branches.

In this respect the sympathetic nerve may be compared to a subcutaneous stem or an articulated rhizoma, which, at each knot, presents on one side roots, and on the other branches, both which separate at a right angle or at one approaching it.

The branches of the great sympathetic nerve are distributed to the organs situated in the face, the neck, the thorax, the abdomen properly so called, and the pelvis.

The pelvic extremity of the sympathetic nerve consists of a small ganglion or arch, in which the two nerves unite, and which furnishes some slender filaments to the parts about the anus.

Some of the internal twigs of the sympathetic nerves proceed directly to arteries, and form plexuses for them; others, in much greater number, gain the median line, and there, uniting with those of the opposite side, form median ganglia or plexuses (the cardiac and cœliac,) which communicate with twigs of the pneumogastric nerve, which furnish secondary plexuses and ganglia, and terminate in the heart, the aorta, the digestive canal, the urinary and genital organs, but especially in the arteries of these organs.

808. Rare, and perhaps incorrectly observed, interruptions in the trunk of the sympathetic nerve, have led some anatomists to consider the existence of this trunk as a circumstance of little importance. This opinion is exaggerated. However its roots are certainly in the spinal nerves, and not in the vidian nerve and the sixth pair.

The branches of the sympathetic nerve not only differ from those of the other nerves, but also differ greatly from each other.

* Walter, *Tabulæ nervorum thoracis et abdominis.* Berol. 1783.—H. A. Wrisberg. *De Nervis arterias venasque comitantibus.—De Nervis pharyngæis —De Ganglio plexuque semilunari.—De Nervis viscerum abdominalium, &c. in Comment. Gotting.*—Chaussier, *Table synoptique du nerf trisplanchnique,*—Lobstein, *De Nervi sympathetici humani fabricâ, usu et morbis.* Paris, 1823, 4to. *cum tabulis.*

Each ganglion and especially each plexus of twigs has a character peculiar to itself.

The sympathetic nerve has been considered, by Soemmering especially, as the nerve of the arteries. In reality, the arteries receive numerous twigs from it; but the muscular tissue of the heart, that of the digestive canal, the mucous membrane of that canal, and of the urinary and genital passages, the ligaments, and even the bones of the vertebral column, receive filaments from it. It is remarkable that the veins and the lymphatic vessels and glands, as well as the serous membranes, receive none. Filaments from it, on the contrary, are met with in the longi-colli muscles, the intercostal muscles and the diaphragm.

809. The spinal ganglia, with their nerves, are the first parts of the nervous system that make their appearance.

The nervous ganglia and trunk of the trisplanchnic nerve are apparent in the fœtus at the third month. The cœliac ganglia, and the splanchnic nerves, which are in a manner their roots, are developed nearly as soon as the cervical ganglia and the cardiac nerves. In old age, the ganglia and their nerves are paler and drier than in adult age.

The ganglia and cords of the sympathetic nerves are met with in fœtuses destitute of brain, and in those which are deprived of brain and spinal marrow.

810. The vertebrate animals are the only ones which have a particular nervous system for the organs of the vegetative functions.

In fishes, the sympathetic nerve consists of a very slender filament, with or without ganglia.

In reptiles it is more distinct. It connects with each other the intervertebral nerves, and penetrates into the cranium united with the nervous vagus.

In birds, it penetrates into the cranium along with the nervus vagus and the glosso-pharyngeal nerve. It communicates with the fifth and sixth pairs, and presents a very apparent interruption in the neck, depending upon the circumstance that it is there contained within the vertebral canal. It is very distinct and ganglionated in the thorax, and is prolonged as far as the caudal vertebræ.

In the mammifera, the sympathetic nerve does not differ much from that of man.

811. MM. Meckel and Weber have remarked that the sympathetic nerve is so much the smaller, compared with the body, the more remote the animal is from man. A second general observation is, that the sympathetic nerve and par vagum exist in an inverse state of development; so that they supplant each other in the vegetative life to which they both belong. It is also to be remarked, that the sympathetic nerve is developed in all animals, in proportion to their circulatory apparatus, to which they, in a great measure, belong.

812. The ganglionary nervous system, which exists in all animals, which in the vertebrate animals, forms a separate system in

connexion with the nervous centre, whose development it precedes; which retains a part of the state of dispersion presented by the nervous system of the invertebrate animals, and which also forms some principal centres, as the cardiac plexus, and especially the ganglia, and the cœliac or solar plexus, which has been termed an abdominal or epigastric brain, must necessarily possess a great importance in the organism. But before exposing the functions of the sympathetic nerve, we must examine those of the ganglia.

813. Willis had an idea respecting the ganglia and sympathetic nerve, pretty similar to that which is generally entertained at the present day; he considered the ganglia as diverticula of the spirits, and the sympathetic nerve as placed between the cerebral conceptions and the precordial affections, between the actions and passions, in such a manner as to establish a consent or sympathy between the parts.

Vieussens also considered the intercostal nerve as a medium of sympathy placed between the brain and the viscera of the other two cavities; and placed in the ganglia, which he named plexus, a centre of muscular and fermentative action. Lancisi also regarded the ganglia as centres of impulsion which he compared to the heart.

Winslow, who first employed the name of sympathetic nerve, considered the ganglia as centres of origin, or small brains.

Meckel attributed to the ganglia the uses; 1st, of dividing the nervous twigs into ramuscules, and the latter into filaments; 2dly, of making twigs arrive at remote places by different directions; 3dly, of uniting several twigs into a single cord.

Zinn maintained the same opinion, adding, that the twigs brought together from different points in a ganglion, are more intimately mingled than in the plexus.

Johnstone considered the ganglia as brains capable of developing and communicating the nervous power, as the origin of the involuntary nerves, and as calculated to interrupt the influence of the will upon the organs having involuntary motion, such as the heart.

Haase, who unites the ganglia and plexuses, combats Johnstone's opinion by the arguments, that voluntary muscles receive nerves from the spinal ganglia, and that involuntary organs, as the stomach, receive nerves from the par vagum.

Scarpa adopts an opinion similar to that of Meckel and Zinn. According to him, the use of the ganglia is to separate, mingle, and unite again the nervous filaments. The nerves of the viscera emanate directly from the spinal nerves, and the fifth and sixth pairs, and are only collected in the ganglia.

All these opinions, as will be seen, may be reduced to two. Some anatomists, as Meckel, Zinn, Haase, Scarpa, and more recently, Legallois, have seen in the ganglia nothing else than a particular arrangement, an anatomical disposition of the nervous filaments; while others, as Winslow, Johnstone, Lecat, Petit, Metzger, &c.

have considered the ganglia as points of origin, and especially as centres of nervous action, no one has defended the latter idea with more vigour and talent than Bichat. Reil, Autenrieth, Wutzer, Broussais, and many others, have added new arguments to those of our celebrated countryman, whose opinion they have embraced with some slight modifications.

814. Bichat considers the organic nervous system as essentially resulting from numerous centres or ganglia, connected together by filaments, and the sympathetic nervous trunk itself as a series of anastomosed ganglia and filaments. Bichat has perhaps attributed too great an importance to the ganglia; but he certainly has not accorded to their collective mass all the importance that it merits.

According to Reil, the sympathetic nerve constitutes a system of its own, which he calls the ganglionary system. He also calls it the vegetative nervous system. In the vertebrate animals it is united to the cerebral, or animal system, but does not emanate from it. His system, in place of having a single centre into which the roots are implanted, has several foci of action:—1st, It consists of two plexuses or net-works placed around the arteries. Of these there are reckoned about a dozen. One of the principal of them, the epigastric plexus, which is furnished with ganglia, and forms secondary plexuses, is a kind of centre or brain. 2dly, These plexuses are connected with the cerebro-spinal system by conducting twigs and plexuses. The two trunks united below, before the coccyx, and above by the fifth and sixth pairs, and by the brain, constitute an elliptical periphery which embraces the whole system of ganglia and plexuses, and into which penetrate several cerebral nerves, especially the eighth pair. 3dly, The conducting twigs or plexuses would transmit sensations and volitions, were they perfect conductors; but they may be considered as semi-conductors, and the ganglia as isolating bodies.

There result from this two nervous systems, and two spheres of nervous activity:—1st, The animal sphere, in which the impressions are felt, and in which the volitions determine the motions; 2dly, The vegetative sphere, in which the nervous activity is distributed slowly, constantly and obscurely. In this system, the impressions, without being propagated to the animal centre, determine motions. In the diseased state, however, the communicating cords and plexus become conductors, the ganglia cease to isolate, the impressions are felt, and the motions are influenced by the animal centre.

Farther, according to Reil, in magnetic sleep, *i. e.* somnambulism, the separation of the two nervous systems disappears, and the epigastric nervous centre, the centre of the vegetative sphere, becomes a distinct sense.

M. Autenrieth considers the symphathetic nerve as arising from the brain and spinal marrow, but becoming more and more independent, in proportion as it is separated by plexus and ganglia, the reddish and greyish substance of the sympathetic nerves, conducting with more difficulty than the white the impressions and irritations.

M. Weber has brought together numerous anatomical and physiological arguments to demonstrate that the sympathetic nerve constitutes a particular system, which is independent of the brain, and has its centre in itself.

M. Wutzer has observed, as Bichat and others have also done, that mechanical irritation of the sympathetic nerve produces no applicable effect, while a more powerful irritant, as the galvanic agent, causes pains and convulsions.

M. Broussais also considers the intercostal nerves as a system by itself, a particular centre of sensation, which transmits impressions to the animal sensorium, and consequently determinations to the voluntary muscles. In the fœtus it alone acts, it directs the secreting and nutritive organs, excites the energy of the heart, extends its action to the animal centre, and determines the automatic motions. In anencephalous fœtuses, and such as want the spinal marrow, it excites the muscular motion by its action upon the spinal nerves. After birth it acts upon the nervous centre, transmitting to it the internal sensations, and thus establishes between the brain and the viscera of the other two cavities a connexion which gives rise to numerous phenomena. At all periods it regulates the action of the capillary vessels, and directs the nutrition through the medium of the formative or plastic force, which this ingenious writer calls the chemistry of living bodies.

815. Nearly all these opinions, which consist in considering the system of ganglia as an independent system, err in being too absolute, just as those do who see nothing in the ganglia but a mere anatomical arrangement. The system of ganglia must be considered at one and the same time as a separate or united, an independent or dependent system, according to various circumstances which have already for the most part been pointed out.

The functions of the ganglia appear to be to *diminish* or *arrest* the influence of the nervous centre upon the ganglionary nerves, and to *diminish* or *prevent* the transmission of impressions to the centre, so that, by the action of the ganglia, the vegetative nervous system is *separated* from the animal system.

The ganglia, moreover, appear destined to *collect* and *concentrate* the nervous power, which they derive from the spinal marrow, and to develope it of themselves, for the purpose of communicating it suitably to the nerves and organs in which they terminate.

The ganglia exercise *different* functions, according to the *diversity* of their texture.

These differences consist in, 1st, The more or less intimate mixture of the medullary filaments; 2dly, The diversity of the secondary substance; 3dly, The differences in the external membrane, according as it is more or less dense, or more or less tense. Now it is in the ganglia of the sympathetic nerve that we observe the greatest blending and intermixture of the medullary filaments, the most intimate adhesion and union of the secondary substance, together with a pretty firm capsule, adhering strongly to the internal substance. In the spinal ganglia, on the contrary, the medullary filaments are straight and do not intermingle, and the secondary substance is coarse, loose, and very distinct from the filaments. Accordingly, these ganglia are considered as less perfect than the others, and Pfeffinger thought that they ought to be excluded from this class of organs. The function of these ganglia is also very doubtful. It does not, in fact, appear that they diminish the nervous communication, nor can they be considered as the common origins of the nerves of motion and sensation, for the anterior root of the spinal nerves is unconnected with them.

816. The uses of the ganglionary nervous cords are to conduct the nervous influence, but they are somewhat different conductors from the other nerves, from which they differ in greatly resembling the ganglia. They are imperfect conductors. Mechanical or chemical irritations do not pass along them, but galvanic irritation is conducted by them, and determines sensations and contractions. It is the same with morbid irritations, as intestinal ureteric irritations, which are felt.

The functions of the sympathetic nerve are to direct nutrition and the secretions; to distribute the nervous agent to the heart, the digestive canal and the urinary and genital organs, and to establish a sympathetic connexion among all the principal organs. It performs these different functions without the influence of the will, and without the consciousness of impressions, the ganglia performing at once the office of ligatures, which moderate the transmission of the nervous influence, and particular centres of activity, which augment and modify its distribution.

The sympathetic nerve thus forms a particular system in the general system. It has a sphere of action of its own contained in the general sphere. The two nervous systems are intimately connected, and exert a reciprocal action, especially in the state of disease.

817. M. Lobstein has collected several curious facts respecting the morbid alterations of the sympathetic ganglia and nerves. He has observed inflammation of the semilunar or cœliac ganglia in cases of chronic abdominal affections of the nerves, hooping-cough, and tetanus. He also observed it in various cases of inflammation of the cardiac and pulmonary nerves. M. Autenrieth has also observed inflammation of the par vagum, sympathetic and cardiac nerves in hooping cough. Dr. Duncan has seen the abdominal portion of the sympathetic nerves enlarged to three or four times its natural size in a case of diabetes. The sympathetic nerves, like the others, are enlarged in hypertrophiæ, and, on the contrary, diminished in simple atrophies, as well as in those, which result from an infiltrated accidental production in the tissue of an organ.

Many abdominal and thoracic diseases seem moreover to depend upon an irregular action of the sympathetic nerve, and others, also very numerous, upon the abnormal action of that nerve upon the cerebral nervous centre.

CHAPTER XI.

OF ACCIDENTAL PRODUCTIONS.

818. The productions which are accidentally met with in the human organization are humours, concretions, tissues, and living animals.

These objects do not form part of the healthy or regular organization, and belong only to morbid anatomy. Their description, or at least their general indication, we, however, place here, as forming a supplement to what has been said, under each tissue in particular, respecting the alterations and productions which are peculiar to them. The productions treated of in this chapter are common to several parts, or to the whole of the organization.

The knowledge of alterations and accidental productions is of great importance to the medical practitioner; for, on the one hand, this knowledge is the basis of pathology, and, on the other, anatomy being seldom studied on sound subjects, but most commonly on bodies of diseased individuals, the anatomist, in his researches, meets every moment with alterations of the organization and accidental productions.

FIRST SECTION.

OF ACCIDENTAL HUMOURS.

819. The natural humours may be altered in their quantity or in their quality. Some of these alterations have already been pointed out. There sometimes, moreover, occur humours entirely different from the former. Of these pus is the only one sufficiently known to be described.

820. Pus* is an accidental humour resulting from a morbid secretion, which is named suppuration. It is composed of microscopic globules similar to those of the blood, and discovered by Home, swimming in a fluid which is coagulble by the solution of muriate of ammonia.

It is of a white or yellowish colour, opaque and of the consistence of cream. Its consistence and colour depend upon the proportion

* C. Darwin, Experiments Establishing a Criterion between Mucus and Purulent Matter, Lightfield, 1780.—Brugmans, *Dissertatio de Pyogenia*, Groningæ, 1785.—E. Home On the Properties of Pus, London, 1789.—Grasmeyer, *Abhandlung Von dem eiter*, &c., Gotting. 1790.—Schwilgué, unpublished Memoir on Pus, analysed in Nosogr. Philos. vol. ii.—G. Pearson On Expectorated Matter, in Phil. Trans. 1809.—Idem, Observ. and Exper. on Pus, ibid, 1810.—Rizetti, *De Phthisi Pulmonali Specim. Chim. Med.* in *Turin Mem.* vol. ii. and iii.—Rossi and Michelotti, *Analyse premierè du Pus*, *ibid.* vol. iii.—E. Home on the Conversion of Pus into Granulations or New Flesh, in Phil. Trans. 1819.

of the globules to the fluid part. Its specific gravity is greater than that of water. It has a constant slightly saline taste, and a peculiar faint smell, which varies a little.

Pus sinks in water, while mucus floats. By agitation, pus mixes with water, giving it a uniform white colour; mucus, on the contrary, remains in distinct flakes. Pus is coagulated by heat, acids and alcohol. Alkalies render it viscid and ropy, and dissolve it. According to Schwilgué, it is composed of albumen in a particular state, of extractive matter, a fat matter, soda, muriate of soda, phosphate of lime and other salts. It greatly resembles the serum of the blood, from which it appears to differ only in the state of the albumen and extractive matter. Mucus mixes with water, and dissolves by the addition of sulphuric acid, which is not the case with pus. A solution of caustic alkali dissolves both pus and mucus, and by the addition of water pus alone is precipitated. These chemical characters, and others of the same kind, are not so certain as the action of water alone, and especially as microscopic inspection.

Pus does not always present exactly the same physical qualities, and the same chemical properties. It may be distinguished into creamy, homogeneous, vulgarly healthy pus; serous or sanious pus, or purulent serosity; glairy pus or puriform mucus; cheesy or curdled pus; and concrete pus. Moreover, pus may be mixed with blood, serosity, excrementitious matter, putrid matter, accidental tissues, calculi, virulent matter, &c.

In all cases, it is composed, according to Mr. Pearson, of a white opaque animal oxide, having little solubility, of a limpid fluid resembling the serum of the blood, which holds the animal oxide in suspension, but does not dissolve it; and an innumerable quantity of microscopic globules. The differences which it presents depend upon the different proportions in which these essential materials, as well as the substances, which may occur accidentally in it, exist.

821. Pus may form in most of the organs.

The tissue in which suppuration is the most frequent and seems to be produced most easily, is the mucous membrane. Some hours after the application of an irritating cause, the physical and chemical properties of mucus gradually change into those of pus. When the irritation diminishes and ceases, the reverse takes place, and the properties of pus gradually change into those of mucus. The suppuration of the mucus membrane is accompanied by a slight degree of redness and swelling, and very rarely with ulceration.

The skin easily suppurates after it has been irritated, and the epidermis removed. This may continue indefinitely, if the irritation is kept up, or frequently renewed. The skin then assumes the appearance of an inflamed mucous membrane.

The cellular tissue being exposed by the removal of the skin, the hemorrhage stops; there then flows serosity, which gradually assumes the character of pus. At the same time the vulnerated surface becomes covered with a layer of organizable matter, which becomes vascular and is covered with granulations.

The cellular tissue when irritated by a foreign body, or by an unknown cause, *(Spina Helmontii,)* inflames, and pus forms in the centre of the phlegmon. This pus is contained in a membrane of new formation, which is more or less distinct, and more or less vascular, according to its age. The surrounding cellular tissue, which is inflamed and highly vascular, has lost its permeability through the interstitial deposition of organizable matter.

The serous membranes, when they suppurate, present similar changes. They become very vascular, and at length assume the appearance of mucous membranes.

822. Boerhaave attributed the origin of pus to the melting of organs under inflammation; Pringle and Gaber, to a change in the serum of the blood. These two opinions, variously modified and combined, were long and generally adopted.

The idea that pus is formed in the vessels, and issues from them by a secreting action of these organs, was first emitted by Dr. Sympson, then by Dehaen; and afterwards by Dr. Morgan of Philadelphia. Hunter and Brugmans embraced and developed this doctrine, which is now generally adopted.

Suppuration is a morbid secretion. This secretion is always preceded and determined by inflammation; but the inflammation is more or less evident. Dehaen himself, who expressly admits suppuration without previous inflammation, evidently speaks only of inflammation with ulceration. In fact, what was then announced is now well known, that suppuration may take place on surfaces without ulceration. He takes notice in the cases of suppuration without inflammation, of plastic productions and adhesions, which, as is well known, depend upon inflammation.

In the scrofulous constitution suppuration is often preceded only by a chronic and latent inflammation, but which does not the less exist, although it may be obscure.

823. Suppuration, when it has long existed, and takes place over a large surface, becomes, through its connexion with the functions, an important secretion, and for this reason a suppuration ought not to be lightly induced or suppressed.

Pus is sometimes the vehicle of virus introduced into the organism. It is also, in some cases, considered as the causal vehicle of diseases eliminated by the organism.

According to Sir Everard Home, pus has for one of its uses that of furnishing, by its coagulation at the surface of suppurating wounds, the materials of the cicatrix, in other words, the organizable matter of that new tegument.

SECTION SECOND.

OF STONY CONCRETIONS.

824. Concretions or Calculi* are solid bodies, more or less hard, which form in the humours contained in the cavities, the reservoirs, and the canals lined by the mucous membrane. This formation is always accompanied by a more or less evident change of composition of the fluids in which it takes place.

825. Intestinal calculi are of rare occurrence in the human species. These calculi, which vary in size and number, are of a round or ovoidal form, and of a yellow or brown colour. Their specific gravity is 1.4. They have for their nucleus a ciliary calculus, indurated feces, or a foreign body. They are formed of layers, and composed of earthy matter, especially phosphate of lime, and a little animal substance.

The mucous and sebaceous follicles sometimes contain indurated or more or less concrete bodies.

Some cases are mentioned of small calculi of phosphate of lime and animal matter, in the caruncula lachrymalis, the tonsils and prostate gland.

There have also sometimes been found stony concretions of the same nature in the lachrymal sac and duct, in the salivary glands and their ducts, and in the pancreas.

826. The biliary passages† are frequently the seat of calculi, *cholelithi*. They occur most commonly in the gall-bladder; sometimes in the cystic, hepatic, or choledochous ducts; or in the intestinal canal, and rarely in the roots of the hepatic ducts in the liver. The number and size of these calculi vary extremely. There have been found from one to several thousands in the same gall-bladder, and from the size of a hen's egg to that of a grain of millet seed. Their colour varies from white to yellow, brown and black. Their surface is rounded or furnished with facettes, polished or rough. Their consistence varies greatly. Their specific gravity is from 0.20 to 0.35. They are divided, since Walter's time, into three kinds or genera. The striated or radiated *striata*, the lamellar, *lamellati*; and those provided with a cortex, *corticati*. In the human species these calculi are formed of cholesterine, yellow matter of the bile, and sometimes a little picromel.

827. The urinary calculi,‡ *urolithi*, occur in the pelvis of the kidney, in the ureter, the mouth of that canal, the bladder, the urethra, the prepuce, in cells of the bladder, in the ducts of the prostate gland, and in accidental urinary cavities and passages.

* Walter. *De concrementis terrestribus.* Berol. 1775. Vicq. d'Azyr. *Acad. Roy. de Medicine.* 1779. Mosovius, *Dissert. de calculorum animalium, eorumque imprimis biliariorum, origine et naturâ.* Berolini, 1812.

† Soemmering. *De concrementis biliariis corp. human. Traject. ad Mœn.* 1795. Thenard, *Mem. de la Soc. d'Arcueil*, vol. i.

‡ Fourcroy and Vauquelin. *Mem. de l'Inst. Nat.* t. iv. Wollaston. Phil. Trans. 1797. &c.

The calculi of the pelvis and calyces of the kidney, adopt the form of these cavities, when they grow there, and become branched like coral.

Calculi of the bladder are the most common. Sometimes, and this is the ordinary case, there is only one in the bladder; sometimes there are several, and they have been found in all numbers, up to more than a hundred. Their volume and weight vary from the size of a grain of wheat, to that of the head of a full-grown fœtus, and as much as six pounds in weight. Their form is round, ovoidal, tetrahedral, cuneiform, cubical, &c.

Their surface is smooth, rough, or mamillated. They vary greatly in colour and consistence. They have always a nucleus, formed either of a particle of gravel that has descended from the pelvis of the kidney, or by a clot of blood, a flake of mucus, or a foreign body.

They are sometimes homogeneous, pretty frequently formed of superimposed layers, similar to each other or different, at other times mixed or heterogeneous, and without layers.

Calculi of the bladder are composed of the following substances; 1st, Uric acid; 2d, cystic oxide; 3d, phosphate of lime; 4th, urate of ammonia; 5th, ammoniaco-magnesiano phosphate; 6th, oxalate of lime; 7th, silica; 8th, carbonate of lime; 9th, xanthic oxide; 10th, fibrinous matter; 11th, mucus; and 12th, phosphate of iron, magnesia, carbonate of iron and urate of soda. These substances occur in calculi, either isolated, or combined by two, three, four or five. The most common of all is the uric acid calculus; then the fusible calculus, composed of ammoniaco-magnesian and calcareous phosphates; then the mural calculus, composed of oxalate of lime; then the calculus formed of distinct layers of uric acid and oxalate of lime, &c. Silica and cystic oxide, and still more the xanthic oxide and fibrine, are the rarest substances in urinary calculi.

828. Pisiform calculous concretions are said to have sometimes been found in the vesiculæ seminales and the spermatic ducts.

Small concretions of a similar nature also sometimes occur in the uterine tubes. As to the concretions of the uterus, they are most commonly ossified fibrous bodies. However, concretions of phosphate of lime having a foreign body for their nucleus, have been found in that organ.

Calculous concretions are said to have been found in the excretory ducts of the mamma.

THIRD SECTION.

OF ACCIDENTAL TISSUES.

829. Accidental tissues* are new organs developed in the living body.

* Laennec. *Cours. oral de Medicine, au College de France.* 1822-1823.

These tissues may be divided into two kinds: 1st, Those which are similar to those of the healthy organization; 2dly, Those which are unlike any that occur in the healthy organization. For the sake of brevity these tissues may be designated, the former by the name of analogous tissues, the latter by that of heterologous.

There are also some accidental tissues, which are in a manner intermediate between the two kinds, and have analogies, not in the human organization, but at least in other animals.

830. These different kinds of tissues are sometimes isolated, sometimes, and frequently, united together or combined. They are even frequently combined with accidental humours, living animals, altered humours or tissues, &c.

831. Of anatomists and pathologists, some (MM. Dupuytren, Cruveilher, &c.) consider the accidental tissues as the result of transformations that have been undergone by the natural tissues. They call the analogous accidental tissues, transformations properly so called, and the heterologous tissues, degenerations. Others (J. Hunter, MM. Abernethy, Laennec, &c.) consider them as new or epigenetic productions. This is a question of very difficult solution; the latter opinion, however, we think more accordant with observation.

832. The real transformations are of very rare occurrence, and only take place between tissues which are not very different from each other. Thus the cartilages of the larynx change into bone; the mucous membrane when exposed to the air by reversion changes into skin, again the skin, when drawn into the interior by a cicatrix, becomes mucous, &c. In the same manner we see in trees the roots converted into branches, and the branches in their turn into roots. But most of the alleged transformations are nothing else than productions. Thus, a cicatrix is an entirely new membrane, and not the result of the transformation of the denuded tissues. In like manner, cancer of the neck of the uterus is the result of a matter of new formation infiltrated into its tissue, and which has distended, compressed and wasted it, and not the result of the degeneration of that tissue.

ARTICLE I.

OF THE ANALOGOUS ACCIDENTAL TISSUES.

833. These tissues resemble the tissues of the human body in a state of soundness.

They are alterable like the natural tissues, and even in a still greater degree.

These tissues are of two kinds: 1st, Some of them are the result of the adhesion of the lips of a solution of continuity, or of regeneration after a loss of substance; 2dly, Others are the result of an entirely accidental production. Both kinds have already been described in speaking of the different tissues, (Chap. I. to X.)

834. Semi-analogous tissues are: 1st, Some of the above tissues, which do not attain a perfect degree of organization; of which kind are especially cicatrices or accidental cutaneous productions, the production of compact and feeble white tissue, semi-cartilaginous productions, earthy and stony ossifications, imperfect horny productions, &c.; 2dly, the mother of pearl production, resembling the air-bladder of fishes, observed in the walls of cysts, the production of lamellar fungus, &c.

ARTICLE II.

OF THE HETEROLOGOUS ACCIDENTAL TISSUES.

835. The heterologous accidental or morbid tissues, which are different from any that occur in the organization in its sound and healthy state, are pretty numerous. The most common and best characterized are the tubercle, schirrus, the cerebriform tissue and melanosis. Some others of rarer occurrence will be mentioned as we proceed.

836. These tissues probably commence with the fluid state; but from the moment when they can first be perceived, they are solid. They continue a longer or shorter time in this state, which is named crudity or organization; a state in which they may be compared to zoophytes, in which they for the most part present vessels, and in which they are indolent and injure only mechanically. They afterwards soften, decompose and become fluid. In this state, which Bayle compares to an anticipated death, they cause more or less acute pains, sometimes none at all, irritate and inflame the neighbouring parts, exercise a deleterious action upon the whole organism, and particularly upon the nutrition, and even upon that of the bones, and then extend and multiply more or less rapidly in the organization.

The origin and cause of these tissues are unknown. They have been considered as innate or hereditary; as resulting from an aberration of the formative action; as organized beings developing themselves, and dying prematurely in the midst of the organization; as products or results of inflammation and irritation, &c. These are merely hypotheses, however, which are more or less ingenious.

These tissues exist under the form of isolated masses, of enveloped masses, of infiltrations in the tissue of the organs, &c.

Sometimes they exist singly, and sometimes are combined with each other, and with other accidental productions, as well as with altered tissues and humours.

I.—Of the tubercle.

837. The tubercle, or tubercles, for they generally occur many together, constitute the most common morbid tissue. They are

also called scrofulous tubercles, because they make their appearance in most cases of scrofula.

This tissue exists under the form of isolated or enveloped masses, and under that of infiltration.

It commences with the gelatinous state; but this state is perceivable only when the tuberculous substance is infiltrated.

It afterwards exists in a greyish, transparent, and as it were semicartilaginous state. This is the first distinct period of the isolated tubercles. They then constitute the miliary granulations of Bayle.

These grains, as they enlarge, often unite into a mass, and become opaque, yellowish and friable, commencing at the centre. The same change of colour and consistence takes place in the state of infiltration. Thus far they are in the state of crudity.

They then soften and become fluid. At this period, or even in the previous periods, there is commonly produced much new substance, whether in mass, or in the form of infiltration.

The tuberculous matter, more or less completely liquified, and converted into homogeneous or cheesy pus, is evacuated by an opening made in the skin or mucous membrane. It is also perhaps sometimes absorbed. Sometimes the nucleus remains inflamed and ulcerates; sometimes it shrinks and is obliterated; sometimes the new membrane which lines it acquires a semi-mucous or semi-cartilaginous texture, and constitutes a dry permanent fistula; lastly, there sometimes is found only a friable matter, probably the residuum of absorption, the tubercle not having suppurated.

Vessels never occur in tuberculous masses. In the case of tuberculous infiltration the vessels are compressed and obliterated, and quickly disappear. The masses, which are slowly developed, have a soft or glutinous cellular, cartilaginous, and even sometimes osseous envelope.

The tubercular tissue is met with in all the organs, and especially in the lungs, in the natural and accidental tissue, at the surface of the serous membranes, but especially in their false membranes, at the free surface of the mucous membrane, and especially that of the intestine, in the lymphatic ganglia, in the glands, the spleen, the bones, the muscular tissue, the tissue of the heart, the encephalon and spinal marrow, and in compound tumours.

This morbid tissue has been observed in all the vertebrate animals.

II.—Of the cerebriform tissue.

338. The cerebriform or encephaloid tissue, is a very common morbid production. It has been confounded under the name of cancer with several others, and in particular with scirrhus. It was

first characterized by Bayle and Laennec. It is the medullary cancer, fungous inflammation, and fungus hæmatodes of some English writers.

This tissue exists under the form of naked or enveloped masses and under that of infiltration.

In the state of crudity, it forms masses of various sizes. Each mass is lobed and lobulated; and the lobules are commonly contorted like the convolutions of the brain. This tissue is then firm like bacon rind, semi-transparent, colourless, or whitish, or greyish. The lobules are connected by an imperfect cellular tissue of extreme softness, and become confounded as the mass increases. Numerous very minute vessels, with very weak walls, are ramified in this cellular tissue, and in the cerebriform substance itself.

When the development is complete, the mass is of a white colour, tinged or dotted with blue, or pale red in some parts. This morbid tissue has then a great resemblance to the cerebral tissue, but is less united and less tenacious. It presents various degrees of consistence in the same mass, which may be compared with those of the different parts of the encephalon.

The cerebriform masses, which are not enveloped with a distinct membrane, are enveloped with a layer of soft cellular tissue. Others have a semi-cartilaginous envelope, lined with soft and vascular cellular tissue like the former. Sometimes the cyst is incomplete in its development. In all cases, it appears posterior in its formation to the substance which it contains.

The cerebriform infiltration is very common, especially in the tissue of the neck of the uterus. In this state, the period of crudity is very short.

The softening of this tissue gives rise to a pultaceous matter, of a pale red colour. In this state, the vessels sometimes bursting infiltrations of blood take place in the cellular tissue, or effusions resembling those of apoplexy in the softened substance. The blood then becomes concrete, and is in part absorbed. There sometimes even forms a membrane, in the shape of a cyst, around the blood. Sometimes serous infiltrations take place in the surrounding cellular tissue, or serous effusions in the substance itself, which is then fluid, like that of the white softening of the brain.

However great may be the resemblance which this morbid tissue bears to the substance of the brain, it is not identical with it; nor can we admit the opinion of M. Maunoir, who considers this tissue as the product of an effusion of nervous matter

When the softening is external, or in contact with the air, the surface is grey or greenish, fetid, and inflamed. Sometimes it putrifies, and is thus destroyed.

This tissue multiplies in the organization, especially during its state of softening, although in a less degree than the tubercles. It has a greater tendency than the tubercle to increase, or gradually extend itself. It does not appear to be capable of being eliminated, and of healing spontaneously.

It may exist in all the organs. It is frequently observed in the mamma, the testicle, the uterus, the liver, the lungs, the encephalon, the stomach, the periosteum, the meninx, the bones, their medullary membrane, the serous membranes, the mucous membrane, the muscles, the glands, the lymphatic ganglia, and the common cellular tissue.

OF SCIRRHUS.

839. The scirrhous tissue is less common than the preceding. It is often confounded with it under the name of cancer.

It most commonly exists under the form of isolated masses.

In the state of crudity, it is difficult to be distinguished from the tubercle and cerebriform tissue. It is hard, but its consistence varies from that of cartilage, or bacon rind, to that of the intervertebral ligaments. It creaks under the point of the scalpel when scraped. It is white, bluish-grey, but slightly coloured, or colourless and semitransparent. It forms irregular masses, rarely lobulated, and commonly homogeneous. It is sometimes divided internally by fibrous or cellular intersections. This internal tissue is sometimes regularly radiated, like that of a turnip, sometimes alveolar, and sometimes irregular. Distinct vessels are rarely seen in it.

Scirrhus softens to the consistence of the jelly of boiled meat, and sometimes to that of syrup, in which state it is sometimes colourless, sometimes yellowish, greenish, greyish, or pale reddish. Sometimes, in this state, it is gummy or pultaceous, and sometimes resembles honey.

This morbid tissue presents a considerable diversity of appearance, whether in the state of crudity, or in that of softening. Bayle describes five or six species of cancers. Several of Mr. Abernethy's species of sarcoma are referable to this kind of tissue.

Scirrhus sometimes softens partially, and then presents the appearance of cicatrices (Nicod). In a case of this kind which I lately saw, it seemed to me, that what appeared to be cicatrices, was the skin remaining sound in small patches, in the midst of a great number of superficial and irregular ulcerations.

Scirrhus has been observed in most parts of the body, in almost all the organs, and in almost all the tissues.

IV.—OF MELANOSIS.

840. Melanosis,* the *cancer melané* of M. Alibert, is a morbid tissue characterised by its black colour, which was first noticed in man, as well as in other animals by some observers, but was distinguished and named, some years ago, by M. Laennec.

* Breschet, *Considerations sur une alteration organique appellée Degenerescence noire*, &c. Paris, 1821.

This substance exists under the form of isolated masses, naked, or furnished with envelopes, under that of infiltration, and under that of plates at the surface of the membranes.

The masses of melanosis vary in size, from the smallest volume, to that of a nut. They exist in a greater or less number in the same individual. They are sometimes pretty regular, sometimes mammillated or lobulated, and sometimes look as if formed of twisted and convoluted laminæ. These parts are connected, and the masses surrounded, by cellular tissue. The vessels follow this tissue, but do not penetrate into the black substances. This substance is black or brown, opaque, without smell or taste, firm, tenacious, and apparently homogeneous; but if it be broken by percussion, and washed with water, the water is coloured brown or black, and the tissue deprived of its colour, and rendered greyish.

Melanosis occurs in plates at the surface of the mucous or serous membranes. It also occurs infiltrated into the substance of the mucous membrane, of the false membranes, ganglia, &c.

Melanosis, submitted to chemical examination, appears to be composed: 1st, of coloured fibrine; 2dly, of blackish colouring matter, soluble in diluted sulphuric acid, and in a solution of subcarbonate of soda, colouring these fluids red; 3dly, of a small quantity of albumen; 4thly, of chlorure of sodium, subcarbonate of soda, phosphate of lime and oxide of iron.

The composition of melanosis, therefore, is very similar to that of the coagulum of the blood, that is, to the colouring matter of the blood and fibrine, both being in a peculiar state. There are also met with in it three fatty substances.

Melanosis softens slowly, under the form of blackish pap; and, according to the place in which it occurs, this substance is effused into the cavities, or infiltrated, so as to colour the humours and tissues. Sometimes, but rarely, subcutaneous melanosis ulcerates. Dr. Ferrus has observed a case of this kind. In the state of softening, even when extreme, this tissue has little tendency to spread and increase. It does not exhibit so deleterious an action upon the organism, as the preceding tissues. The alterations which have been most commonly observed, are a general discoloration, dropsies, torpor, and a debility similar to that which takes place in scurvy.

Melanosis has been observed in many parts of the body, and especially in the common cellular tissue, in the muscles, the heart, the lymphatic glands, the orbit, the eye, the lungs, the liver, the kidnies, the pancreas, the spleen, the cellular tissue of the mamma, the accidental cellular tissue, &c.

Melanosis appears to result from an aberration of some of the constituents of the blood, and especially its colouring matter.

V.—Of cirrhosis, &c.

841. Cirrhosis, or the fawn-coloured morbid tissue, sometimes

exists under the form of masses. It has also been seen under the form of plates, and in that of the cyst.

When in masses, the tissue is fawn-coloured, dull, flaccid, moist and compact, like the tissue of the surrenal capsules. It does not present distinct fibres. The masses vary from the size of a millet seed to that of a cherry stone. They sometimes exist in prodigious numbers. The largest appear scaly.

This tissue softens under the form of greenish brown putrilage. Its effects, whether local, or general, are not of any importance. It occurs pretty frequently and in great abundance in the liver, which is then lessened in size, wrinkled and rough. It has also been seen in the kidney, the prostate gland, the epididymis, the ovary and the thyroid gland.

842. M. Laennec has designated by the name of *Sclerosis* a tissue greatly resembling, or identical with, the compact white tissue, and which he found infiltrated in the subperitoneal cellular tissue of the lumbar region of a cancerous person. It differs from all the morbid tissues in the circumstance that it has never been seen softened, but is placed along with them on account of its tendency to spread.

843. The same pathologist has designated by the name of *Scaly Scirrhus*, a tissue of a dull white colour, semitransparent, and foliated like the flesh of the cod, which he once saw contained in a cyst resembling mother of pearl, in a patient affected with cancer.

VI.—Of compound morbid tissues.

844. Morbid tissues very frequently occur combined with each other; and their association is one of the greatest sources of difficulty in the study of pathological anatomy.

The composition sometimes takes place by simple juxta-position, and sometimes by intimate and mutual penetration.

The most common combinations are the following:

1. Those of the fibrous, cartilaginous and osseous tissues in the cysts which contain vesicular worms.

2. The combination of earthy ossification and tubercle, especially in the bronchic glands.

3. That of tubercle and cerebriform tissue, of frequent occurrence in the liver and testicle.

4. That of scirrhus and earthy ossification, also not uncommon in the liver.

5. That of all the morbid tissues, with ossifications, with other analogous productions, with inflammation, hypertrophy, serous, sanguineous and purulent effusions, &c., forming the compound cancers of the stomach, mamma, &c.

FOURTH SECTION.

OF ANIMATED FOREIGN BODIES.

845. The animals* which are met with in the organization, and which live at its expense, are intestinal worms, and animals attached to the surface of the body, penetrating into its substance, introduced into the cavities, &c. The knowledge of these animals is one of the most difficult parts of medical natural history, and one of those that have been rendered most obscure by inaccurate observations.

ARTICLE FIRST.

OF INTESTINAL WORMS.

846. The Intestinal Worms or *Entozoa*† (Rudolphi,) form, or at least grow and reside in the organization. They are unable to live elsewhere. They are met with not only in the alimentary canal and the tubes which open into it, but also in the cellular tissue, the muscles, and in the substance of organs the most remote from the surface of the body, such as the brain. Their organization presents numerous variations (38.) Their origin is very obscure. Confining ourselves to those which inhabit the human body, we may arrange them into three orders, viz. Vesicular Worms, Flat Worms, and Cylindrical Worms.

I.—Of the vesicular worms.

847. The Vesicular Worms,‡ *Entozoa cystica* of Rudolphi, consist in a great part of their extent of a caudal vesicle of greater or less size, belonging to one only, or common to several worms. The body is depressed or rounded, always very small; the head (which is wanting in one genus) is furnished with fossulæ (two or four), suckers (four,) and a crown of hooks or of four recurved proboscides. They have no visible intestinal canal or genital organs. These worms always inhabit the substance of the organs in a distinct cyst. They were long confounded together and with cysts, under the name of hydatids. Even at the present day, natu-

* J. H. Ioerdens. *Entomologie und Helminthologie des Menschlichen Korpers, &c.* 1801—1802.

† C. A. Rudolphi. *Entozoorum, sive Vermium intestinalium Hist. Nat. Parisiis et Argentorati.* 1810. *Idem. Entozoorum Synopsis. Berolini*, 1819.

‡ Laennec. *Memoire sur les vers vesiculaires, &c. in Bulletin de l'Ecole de Medicine.* Paris, An. xiii.

ralists reject one or two of the genera of this order which are the following : *Acephálocystis*, *Echinococcus*, *Cysticercus* and *Diceras*.

848. The genus *Acephalocystis*,* which was proposed by M. Laennec, but has not been adopted, either by M. Rudolphi or by M. Cuvier, is composed of animals which consist of a vesicle destitute of head or body, of a rounded form, from the size of a small pea to that of a middle-sized apple, with thin and soft walls, which are transparent, whitish, homogeneous, fragile, and filled with an aqueous and albuminous limpid fluid. It is doubtful whether spontaneous motions have been observed in them. It would appear that these equivocal beings are produced by internal gemmæ. They are met with in almost all the organs. Seven or eight species are known. They are always encysted, if we except the clustered mole, which is considered as formed by the aggregation of worms belonging to a species of this genus.

849. The genus *Echinococcus*, established by M. Rudolphi, who perhaps includes in it the Acephalocystides, and which M. Cuvier does not admit, contains animals which consist of a single or double external vesicle, to the inner surface of which are attached several minute granular worms like grains of sand, of which the body is ovoidal, and the head (like that of *Tænia armata)* furnished with a crown of hooks and suckers.

One species, *Echinococcus hominis*, inhabits the human viscera, and especially the liver.

850. The *Cysticercus* has the body rounded or depressed, wrinkled, and terminating in a caudal vesicle. The head (like that of *Tænia armata*) is furnished with four suckers and a recurved proboscis. They live singly in a very thin cyst.

The Cisticercus of the cellular substance, *C. cellulosæ*, with the head square, the neck very short and enlarged anteriorly, the body elongated and cylindrical, and a transversely elliptical caudal vesicle, is the species which occurs so commonly in the hog. It has also sometimes been met with in the muscles, brain and heart of man. Some other species also occur in the human body.

851. The *Diceras rudis* has the body oval and depressed. It has a loose coat. Its head is furnished with a rough, filamentous, bifid horn. It is not precisely known if it inhabits the substance of the organs. It was discovered by M. Sultzer, in substances voided in consequence of a strong purgative. Its existence was doubted by M. Rudolphi, but it was again found by M. Le Sauvage, of Caen, who sent specimens to the Society of the Faculty of Medicine at Paris, where I have seen them.

* Laennec, *loc. cit.*—Ludersen. *Diss. de hydatidibus.* Gotting. 1808.—H. Cloquet, *Faune des Medicins.* T. i. Paris, 1822.

II.—Of flat worms.

852. The Flat Worms are those whose soft and depressed body is furnished with sucker pores at its lower surface or extremities; the *Entozoa trematoda* of Rudolphi; and those whose body is elongated, continuous or articulated, and the head furnished with fossulæ, suckers, and one or more naked or armed proboscides: the *Entozoa cestoidea* of Rudolphi. Both kinds are destitute of intestinal canal, and furnished with ramified ovaries. This order comprehends, in the human body, the genera *Tænia*, *Distoma*, and *Polystoma*.

853. The genus *Tænia* has the body greatly elongated, flat, and articulated, and the head furnished with two or four small suckers. Two species are met with in man.

The broad or unarmed tapeworm, *Tænia lata*, *Botriocephalus latus* (Bremser. Rud.), has the head nearly square, two naked sucker fossetes, the head oblong, as well as the fossetes, which are marginal, the neck almost wanting, the anterior joints in the form of rugæ, the next broad and short, and the last elongated. Its length is twenty feet and upwards. This species is common in Switzerland and Russia, very rare in England, Holland and Germany. It is not met with in dead bodies.

The solitary or armed tapeworm *Tænia solium*, also vulgarly, but erroneously named the solitary worm, has the head furnished with four sucking oscula, and in their centre a blunt proboscis, armed with hooks. The head is hemispherical and distinct; the neck is enlarged anteriorly. The anterior joints are very short, the next elongated, the last longer, all of them obtuse, each furnished with a marginal pore, alternating vaguely from side to side. Its length is from five to ten feet and upwards. This species is common in England, Holland and Germany. It is sometimes met with in dead bodies. Both species are met with in France, but especially the second. They both inhabit the intestinal canal, particularly the small intestine.*

854. The *Distoma* or *Fasciola* has the body soft and depressed, with two solitary pores, the one anterior, the other ventral.

The Hepatic Distoma, *D. hepaticum*, which has the form of an oval leaf, occurs in the gall-bladder of man and many other mammifera, but especially the sheep.

The *Polystoma*, *Hexathyridium* of Treutler, has the body depressed, with six anterior pores, a ventral pore, and a posterior pore. The polystoma of the fat, *P. pinguicola*, which is truncated anteriorly and pointed behind, has been met with in a tumour of the human ovary. The polystoma of the veins, *P. venarum*, appears to be an external worm. (457.)

* See a memoir of mine, on the occurrence of taenia solium in a numerous body of men previously quite healthy, in the Edinburgh Medical and Surgical Journal for July, 1821. The generation of the taenia in these men seemed to be the direct result of the use of unwholesome animal food.—K.

III.—Of the cylindrical worms.

855. The Cylindrical Worms, *Entodzoa nematoidea (Rud.)* have the body elongated, rounded and elastic. They have an intestinal canal, terminated by a mouth and an anus, genital organs, separated in two different individuals. This order comprehends in man the three following genera: *Filaria, Trichocephalus* and *Ascaris.*

856. The *Ascarides* have the body round, attenuated at the two extremities, and the head furnished with three tubercules. The penis of the male is pointed and bipid. Two species occur in the human body, the *lumbricoides* and *vermicularis.*

The *Ascaris lumbricoides* which has the head naked, the body, from three to 12 inches long, marked with two opposite grooves, and the tail somewhat blunt, inhabits the small intestine. The *Ascaris vermicularis, oxyurus vermicularis* of Bremster has the head obtuse, and furnished with a vesicular membrane on the two sides. Its body is a little thickened at the anterior part. The tail of the male is bent and obtuse; that of the female is straight and flattened. It inhabits the large intestine, and especially the rectum.

857. The *Trichocephalus* has the anterior part of the body capillary, and the rest abruptly enlarged; the mouth orbicular; the penis simple and sheathed.

In man there occurs the *T. dispar.* It is unarmed, the capillary part is very long, and its head pointed. The body of the female is nearly straight, that of the male spirally twisted. The sheath of the penis is ovoidal. This worm, which has been observed by Morgagni, Wrisberg, Rœderer and Wagler, is very common. It inhabits the large intestine, and especially the cœcum.

858. The *Filariæ* have the body elongated and nearly equal, and the mouth orbicular. The penis of the male is pointed and simple.

The *Filaria medinensis*, which is very long, and has the head attenuated, the tail flattened and bent in the male, semicylindrical, pointed and curved in the female, is met with in the human species, but only between the tropics. It inhabits the subcutaneous cellular tissue, and especially that of the feet. It was formerly considered as a penetrating external worm, but it appears to be really an Entozoarium. *Filaria bronchialis* is a doubtful species, observed and described by Treutler, under the name of *Hamularia lymphatica.*

859. The *Strongylus gigas* has been ranked among the worms which inhabit the human body, because Ruysch says he once saw in the human kidneys worms similar to those which occur in the kidney of the dog.

The *Spiroptera hominis* is another doubtful species, observed by Messrs. Barnett and Lawrence, having come from the urinary bladder of a woman.

M. H. Cloquet has recently described, under the name of *Ophiostoma ponterii*, a worm that was voided by a man while vomiting, and observed by M. Pontier.

Many other worms have been indicated as inhabiting the human body, which occur only in animals. Others are merely larvæ, or other objects more or less resembling worms, which occur fortuitously among excreted matters, or have been frequently placed there in order to deceive.

ARTICLE II.

OF PARASITIC ANIMALS.

860. Parasitic animals are still much more foreign to the organization than the entozoaria.

Some of them, however, are insects originating, living, and reproducing at the surface, and in the substance of the skin. Such are the *Pediculus hamanus corporis*, *P. h. capitis*, *P. h. pubis*, *Pulex irritans*, *P. penetrans*, and the *Acarus scabiei* or *Sarcoptes.*

Other insects are deposited beneath the skin and in the mucous cavities, in the state of eggs, are developed there in the state of larvæ, and afterwards make their exit. Such is the œstrus, so common in the horse, the ox and the sheep, and which has also been found under the skin of man and in the sinuses of his face. Larvæ of the genus *Musca* and some others are also sometimes developed in the auricular canal of children neglected as to personal cleanliness, at the surface of ulcers, &c. It must not be forgotten that many cases of excreted larvæ are to be referred to frauds or to fortuitous circumstances.

861. Certain other animals penetrate, in the adult state, into the mucous cavities of the body, remain there a longer or shorter time, and induce various alterations in them. Of this kind we may mention leeches, *Hirudo medicinalis*, and *H. Alpina.* The *Gordius* or *hairworm* is probably another. It has been thought that the common earthworm could penetrate into the body, but this is not the case. The *Furia infernalis* of Linnæus appears to be an imaginary worm.

Lastly some insects only injure the external surface of the body mechanically, or deposit a poison in it, and are altogether foreign to the organization.

Observations

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APPENDIX.*

No. I.

Observations and Cases, illustrative of the Pathology and Treatment of Necrosis.†

It has been long known, that when a bone dies, or becomes necrosed, a process is begun by the constitution to repair the loss; new bone is formed, and deposited in the manner best calculated to support the limb or parts diseased: and, when the bones of an extremity are implicated in the disorder, the limb preserves its strength, and, though somewhat unshapely, is sufficient for the ordinary purposes of locomotion. This very beautiful and wonderful process, viz. the regeneration of bone, has for many years engaged the attention of pathologists and physiologists. Theories sufficiently ingenious have been devised, and, to confirm these, numerous experiments performed on living animals,—man himself not escaping. Some of the works written on necrosis and regenerated bone, I know only by report, and at second-hand; but the general conclusion from all has uniformly seemed to be, that the principal agent employed by nature in the formation of new bone, is the periosteum,—at least this was the opinion of all the practical surgeons, (and they are not few) with whom I have had an opportunity of conversing on the subject. It has occasionally happened, that their notions were not exceedingly clear: some fancying that the periosteum, in cases of necrosis, is converted into a large compact osseous case; others entertaining similar opinions, though not so coarsely expressed. The process is thus described by a very ingenious author. " Necrosis is generally the result of disease in the soft parts; and, where the necrosed portion is of considerable extent, especially where the affection takes place in a cylindrical bone, it gives rise to a carious action in the periosteum. A degree of excitement arises, producing a secretion of ossific matter, which is deposited in the cellular tissue of the membrane; and, as the quantity of ossific matter increases, the cellular texture in which it was laid is progressively removed by absorption; so that, after some time, there is the appearance of a strong and compact frame-work of new bone, more or less completely enveloping the old bone."

* From the Edinburgh Medical and Surgical Journal.

† My views as to the regeneration of bone have been so much misunderstood, and at times have been intentionally so grossly misrepresented, that I thought it but doing myself justice to reprint them here, under the form of an Appendix.

A modification of this opinion has been adopted and well defended by others. The periosteum, they observe, cannot be the organ for the secretion of new bone, in cases where the periosteum has been removed. The objection is unanswerable. They conclude, therefore, that the whole of the soft parts around the bone contribute to the formation of new ossific matter; amongst which it is evident they must include the periosteum, when that membrane is present.

Early in 1814, I began to consider these opinions as untenable: the formation of new osseous matter in cases of necrosis, compound fracture and caries, did not seem to be connected with the periosteum or soft parts, in those cases which came under my observation; and I remarked, in one very interesting case of hip disease, in which the *trochanter major* was the only part affected with *caries*, that nature had attempted repairing the injury done the bone, though no *sequestrum* or dead portion existed, by a secretion of new ossific matter around the circumference of the ulcer in the bone, which new osseous matter was evidently formed by the vessels of the old bone, the periosteum remaining perfectly sound and unchanged. It was not, however, till the winter of 1815, that I perceived fully the inaccuracies which had crept into the writings of authors on necrosis, and on the regeneration of bone, and that I formed the following opinions, which I shall now sketch very briefly.

Necrosis, or the death of a bone, may arise from a variety of causes, and may be complicated with other diseases and conditions of the part affected, rendering the process of the formation of new bone obscure and difficult to be understood. The simplest case, perhaps, is the death of the shaft of a cylindrical or long bone, either in whole or part, occasioned by a blow.

Case I.—I was requested to examine the leg of a boy who had been struck about two years before on the spine of the tibia, by a stone thrown at him with some force. At the time I saw him, he ran about as if nothing ailed him; the leg was swelled, and purulent matter flowed out in abundance by three fistulous orifices; these led to a *sequestrum* of considerable length. The disease could be traced directely to the blow, and the leg, indeed, had never been well since that period; he had preserved his health, however, and been always able to run about without the aid of crutches; circumstances which seldom happen to those who have enjoyed the benefit of hospital air and surgical treatment. I ascertained that the bone had never been fractured.

In such cases, and I have seen several, a portion of bone only is dead; the external layers of the old bone become vascular, spongy, and full of holes, for the transmission of vessels; new osseous matter is deposited in the interstices; the whole bone becomes much thickened, and occasionally heavy and compact. This progress of regeneration has been well described by Leveillé, who endeavoured, some years ago, to extend the doctrine to all cases of necrosis; it is merely a thickening of the old bone. If examined in a recent state, the periosteum will be found very vascular and pulpy, but neither thickened nor ossified; and, when the disease has ceased, or the cause of irritation been removed, the membrane recovers entirely its natural texture. Yet I have seen specimens of this description (and they are very common in museums) described as belonging to cases in which the entire regeneration of bone had taken place; and as proofs of the conversion of periosteum into an osseous case, sometimes equalling half an inch in thickness!

When the whole shaft of a bone dies, as in the *femur* or *os humeri*, the process set up by nature is still of the same description, differing in situation. New bone is formed by the extremities of the old bone, and commences at these extremities, shooting downwards and upwards, to form a case, which, in a few rare favourable instances, at last entirely envelopes the shaft of the old or dead portion of the bone. When a portion only of the shaft is dead, the formation of new bone commences at the nearest healthy point, wherever that may be. The cause of the formation of new bone is the presence of the necrosed portion, though the same effect may be produced by an ulcer in the bone, by the presence of any solid extraneous body, or of some other source of irritation. Hence, if, by the unhappy interference of surgical art, the necrosed portion of bone (in cases wherein the shaft has died throughout its whole thickness) be prematurely removed, or much of the new formed bone be destroyed in awkward attempts to accomplish the same object, the process for regenerating bone will cease, and amputation become indispensable, in order to save the life of the patient. I shall afterwards endeavour to show, that, generally, when an external layer or piece of bone has died, it ought to be early removed; that when an internal portion of bone has become necrosed, it ought to be taken away by an operation, whenever it shall have become a source of much irritation to the patient, or *whenever it can be readily got at;* but the treatment, in cases where the shaft of a bone has died throughout its whole thickness, will be such as has already been described.

But this process of the regeneration of bone being slow, and often defective towards the middle, even under the most approved treatment, the shaft of the bone is not unfrequently detached from its extremities; and spontaneous fracture happening, amputation becomes necessary.

Case II.—James Macdonell, æt. 16, had his thigh amputated at the *trochanter major* in the winter of 1814–15, for a necrosis of the *os femoris.* The state of the parts found, on examination of the limb, was as follows:—The dead part was a portion of the whole shaft, four or five inches long, lying loose in a large cavity filled with pus, and projecting by its lower end through the skin. The new bony case was imperfect, forming about half a cylinder corresponding to the outer and back part of the limb; so that on the anterior and inner aspect, the *sequestra* were only covered by the soft parts. The new bony case was continued from the upper and lower ends of the old bone, which were sound; but these upper and lower portions were joined only by soft parts, the deposition of new bone not being complete in the middle of the limb. Hence the limb, which had retained its natural length so long as the *sequestra* remained connected to the sound ends of the old bone, became so remarkably shortened as soon as the absorbents had detached this dead piece, in consequence of the retraction of the inferior portion, now unconnected with the superior, except by soft parts.

Precisely similar must have been the case in two very beautiful preparations, now in the possession of Mr. Russell of Edinburgh. In these preparations, the new bone may be seen shooting downwards and upwards from the extremities of the old one, and endeavouring to form a case or sheath for the dead portion of bone, which, in these, is composed of the whole shaft of the bone. The process is also very finely illustrated, by a preparation in the possession of Dr. Barclay of Edinburgh.

Not unfrequently these different modes of regenerating bone exist together in the same limb, *i. e.* wherever the shaft of the bone has died throughout its whole thickness, new bone shoots from the old in irregular nodules and bridges, or arches are formed, connecting together the nearest points of sound bone, and enclosing the necrosed portion or portions in a sort of cavity. At other places, where the bone has not died throughout its whole thickness, the remaining sound bone becomes very vascular, spongy and thickened, acquiring sufficient strength to support the limb, and not unfrequently depositing new ossific matter, which, projecting forward, ultimately encloses the portion of bone which has become necrosed.

In gunshot nercrosis, or the death of a bone from gunshot wounds, the formation of new ossific matter is generally complicated, and the regeneration of new bone is often effected by circumstances which do not exist in cases of simple necrosis. When a bone has been struck by a musket ball, or other hard body projected by gunpowder, death of the bone struck will, to a certain extent, take place. This, however, most not be considered as an invariable sequence, for cylindrical bones are often struck by musket balls, without being either fractured or killed; nor does death of the bone inevitably happen, though the individual struck be close to the mouth of the musket fired at him.

Case III.—M. J. a private in the —— regiment of infantry, whilst on patrole (a service he did not much like), was supposed to have fired a ball through his left hand, by placing the palm of the hand on the muzzle of the gun. He was carried to the nearest military station, and I saw him a few hours afterwards. The ball in its passage, had shattered the metacarpal bones of the middle and fore fingers; many splinters lay exposed on the back of the hand, but still adhering more or less to the surrounding soft parts, and to each other. The laceration of the skin and muscles was great, and the bleeding had been considerable. In such cases, it has been recommended " to enlarge the wounds and to remove the broken pieces of bone." I followed an opposite treatment with very marked success. After removing a few splinters not larger than pin-heads, which lay on the very surface of the wound made by the exit of the ball, the constant application of cloths dipt in cold water was ordered, and persisted in for three days; after which a slight suppuration made its appearance, the wounds were in a few days healed up. The man retained the use of his hand; nor were there even any dead pieces of bone discharged, nor did any untoward symptom occur throughout the cure.

The case of A. B. of the same regiment was not so fortunate. He was a young man of healthy constitution, and had the character of a good soldier. A musket ball was accidentally fired through his hand by another person; he had no medical attendant for about thirty-six hours; warm poultices, the very bane of surgery, were applied uninterruptedly for some weeks, and I saw him, for the first time, five weeks after receiving the wound, with a swollen hand and arm, suppurating wounds, diseased bones, and hectic fever. My opinion was asked regarding the propriety of amputating the hand, to which, however, I refused my assent.

When a musket ball has struck and fractured a long bone, and the removal of the limb shall have been determined on, the bone ought to be sawn as high up as possible, since we know not to what extent the life of the bone may have been destroyed by the shock of the ball. Primary amputations seem to me calculated to improve the chance of the patient; since experience shows, that, when all sources of irritation are removed by the amputation of the limb, a bone which, under other circumstances, would have fallen into disease, and become necrosed in the portion which remained between the amputated point and head of the bone, may recover.

Case IV.—A. C. of the —— regiment of foot, was wounded on the 18th June 1815 by a musket ball, which entered on the inner part of the internal hamstring, about two inches above the knee, and having fractured the bone, as was supposed, remained lodged in it. A small portion of ball came away at Antwerp, and others long afterwards at Yarmouth. In January 1817 it became necessary to remove the limb, which was accordingly done on the 20th. He died on the 8th February, apparently completely exhausted. The bone was sawn through a little below the trochanter. On examination of the limb, the ball was found lodged about an inch above the condyles; the shaft of the femur was necrosed internally to within an inch of the trochanter minor; the contained *sequestrum* was large, but was evidently not composed of the entire shaft of the bone: several *cloacæ* existed, all of which were lined by a membrane greatly resembling periosteum. This membrane was very little thickened, though vascular; the deposition of new bone along the femur was very considerable, and the whole appearance greatly resembled a common case of necrosis.

We have, in the above case, an admirable illustration of the advantages which primary amputation possesses over secondary, even in cases where no fracture of the bone existed, and where the mischief done in other respects to the limb was inconsiderable.

In general, when a long bone has been fractured by a musket ball, and it has been resolved to attempt saving the limb, the splinters easily got at, and other extraneous matters, as clothes, &c., ought to be removed; the ball itself, if possible, extracted, and means taken to subdue the inflammation, which will certainly follow. After a time, new osseous matter is secreted, shooting forwards from the sound portions of bone, enveloping the fractured and necrosed portions in a case of new bone, possessing a density and extent proportioned to the original injury; the necrosed portions of bone are now enclosed by new osseous matter; the thigh is much shortened, and swollen, and firm; the large internal diseased cavity, containing the necrosed portions of bone, becomes fistulous, and is lined by a membrane resembling that of incurable or intractable sinuses in the soft parts; the necrosed portions of bone excite frequent inflammation, terminating in abscesses; whilst, in consequence of the continued irritation, a new osseous deposit is formed, occasionally of immense magnitude. Previous to this, the patient has suffered much; and he is generally at last cut off, either by some unlucky operation, by being thrown into an unhealthy hospital, or his constitution sinks from weakness and distress.

Necrosis not unfrequently attacks the bones in cases of gunshot fractures, though amputation has been performed by a dextrous operator.

Case V.—Captain B———, residing in the south of England, requested my advice regarding a discharge of purulent matter from the thigh, which had been amputated about two years before. He was originally struck by a ball near the knee-joint, in the action of Salamanca; and amputation was performed soon after, a few inches above the site of the wound. The operator was perhaps the most expert at that time to be found in the British service; the wound healed well, but could not be brought to a perfect cure; it remained open, discharging purulent matter, and giving the patient great uneasiness. A second amputation was performed, and afterwards for similar reasons, a third; yet in 1816 the stump continued open.

I am inclined to think that the bone had originally been killed by the shock of the ball, and died probably throughout two-thirds of its shaft. This might not be apparent during these successive operations; for the external lamina of bone, at the place where the saw is applied, are seldom dead, or even diseased. I shall now briefly enumerate the more common causes of necrosis in gunshot fractures, and in cases connected with military practice. These are,

1st, The amputation of the limb below the point at which the shock of the ball has affected the bone.

Case VI.—W. S. of the hussars was wounded on the 18th June 1815, by a cannon shot, which destroyed the knee-joint. He suffered amputation on the 20th; the bone was sawn through about four inches above the knee; the stump remained open. In the beginning of 1817, a long exfoliation or sequestrum came away from the face of the stump, which still remained open, with a discharge of purulent matter. Such cases are very common.

2d, Death of the bone from the shock of the ball, with or without fracture, as in the case of A. C. already described, and in the following.

Case VII.—J. H.——— of an infantry regiment, was wounded at Orthez by a musket ball, which entered the right thigh, a little above its middle. The ball lodged in the limb, but was cut out, about three months afterwards, at the distance of a few inches above the seat of the original wound. Several pieces of bones were extracted about July 1816; but he died exhausted in January 1817. On examination, the *os femoris* was found necrosed quite to the trochanters of the bone, from within an inch of the condyles; the periosteum was vascular, and somewhat thickened; some deposition of new bone had taken place. Numerous *cloacæ* led into the interior of the bone, where a very long and complete sequestrum existed.

Necrosis will more readily follow, should the ball be allowed to remain imbedded in the bone. Amputations very high in the limb are frequently necessitated, in such cases, by the long continuance of the disease, and the little hopes of recovering.

3d, Sloughing sores, as in hospital gangrene;—these require little illustration. They destroy the integuments and soft parts; and, ultimately laying bare the bone, it also perishes, giving rise to successive amputations on the same limb.

CASE VIII.—W. S. ——— of the ——— regiment of infantry at Pampeluna, on 26th July 1813, received a gunshot wound in the ankle joint; gangrene seized the limb eight months afterwards, at Passages, where it became necessary to amputate above the knee-joint. He was afterwards placed in Plymouth Hospital, the stump being open all the time. Whilst in the above hospital, a large internal exfoliation or *sequestrum* was extracted. The stump, notwithstanding, did not heal; and it was deemed necessary to amputate the limb higher up. The operation was performed on 25th January 1817, and the stump was nearly well in the month of March 1817. On examination, the portion of bone amputated was found much diseased in structure, but there was no necrosed portion remaining. The periosteum was thickened and vascular; the upper portion of bone much increased in size, apparently from the deposition of new bone within its own substance; the number of *foramina* indicated its great vascularity. An extensive caries was found about the middle of this portion of bone. No ossification of the periosteum was perceptible.

4th, Protrusion of the bone from great retraction of the muscles and skin, after amputation, from any cause whatever. The following case is selected from the Memoirs of the French Academy, in illustration of the above cause assigned for necrosis, such instances being rarely met with in British practice.

CASE IX.—"Un soldat reçut un coup de feu qui traversoit l'articulation du genou. Un mois ou six semaines après sa blessure, la malade fut en état d'être transporté a l'Hopital de Gard, Une longue diette, une suppuration abondante, et la formation de plusieurs dépôts considerables, avoient epuisé le malade. M. Attouel lui coupât la cuisse en deux temps; et malgré toutes les precautions qu'il avoit prises, l'os fit une saillie considerable. M. Attouel ne crut pas devoir retrancher cette portion d'os avec la scie. Il borna les chairs au niveau de la cicatrice, qui commencoit à se faire, en appliquant sur l'os des plumasseaux trempés dans l'eau mercurielle, avec l'attention de garantir les environs, de l'action de ce medicament. L'usage de cette eau continuée pendant quelques jours, fit assez d'éffet pour consumer l'os dans toutes sa circonference à la profondeur de deux on trois lignes. Il ebranloit légèrement la pièce de temps en temps; elle se separa entièrement vers la cinquantieme jours de l'operation; et la guérison parfaite suivit de près la chute de cette portion d'os."

The French surgeon blames the application of caustic for the peculiar form assumed by the *sequestrum;* but no sufficient reason is assigned for such an opinion. I shall afterwards endeavour to show, that *sequestra*, or exfoliations forming in stumps, generally affect the forms already alluded to, whatever may have been the cause producing the death of the bone; and it is remarkable that, in the Memoir of M. Louis, whence the above extract was taken, and in the very next observation to the one already quoted, there is detailed, with considerable minuteness, the case of a young man who suffered amputation of the thigh for a gangrene, which destroyed the leg as far as the knee-joint. Some months afterwards, the stump not healing, the surgeon extracted a sequestrum, or necrosed portion of the femur, five inches in length. The words in the original are—" Il tira sans douleur, et sans qu'il sortit une seule goutte de sang, une portion de la totalite du femur, de la longueur d'environ cinq pouces." To account for the great length of the *sequestrum*, the surgeon supposed that the gangrene had extended along the *os femoris*, and produced, in this case, the same effects as the caustic application in the preceding one; but ample experience has shown, that, whatever the cause may be by which the extremity of the bone, after amputation, has become denuded or exposed to the contact of surrounding diseased soft parts, the sequestrum will more or less assume the form already pointed out.

It sometimes happens that, after gunshot fracture of an extremity, no effort is made by the constitution to secrete new bone. Several circumstances may give rise to this; but, in the following case, the deficient secretion of bone to replace that which had been destroyed, seems to have been occasioned by the removal of a large portion of the old bone. As the presence of the diseased or necrosed bone is, generally speaking, the cause of the formation of new osseous matter; so this process will cease, or not take place, on the removal of the exciting cause.

Case X.—J. T. was wounded at New-Orleans on the 8th January, 1815, by a grape shot, which entered in front of the right shoulder, and passed out nearly opposite on the back part, shattering, in its course, the upper part of the humerus and scapula. In August 1815, an incision was made in the line of the deltoid muscle, and several small pieces of bone extracted. Previous to this, nearly twenty pieces of bone had been removed. His general health had originally suffered much; but, at this time, his constitution had in a great measure recruited. October 12, 1816.—It was now determined that the diseased head of the humerus should be removed by an operation; and, on the 18th of the same month, an incision having been made, and the deltoid raised, (few pieces of diseased bone being present,) the extremity was amputated at the shoulder joint. On examination of the limb, it was found that no new ossific matter had been deposited any where.

Mr. Hunter remarks, that bones fall into disease more slowly than soft parts; and, when they become diseased, are proportionally slow, or in the act of restoration; for all processes go on more slowly and with more difficulty in bones than in soft parts. In addition to this slowness of recovery in bones, it may be remarked that they occasionally have no tendency whatever to become well, even where the sequestrum or dead portion of bone has been removed. In such cases, the fistulous openings continue; they lead into a diseased cavity in the centre of the bone, which, in order to recover, would require being dressed from the bottom;—the application of the actual cautery might, in some instances, prove useful.

Case XI.—J. B. was wounded by a musket ball, on the 11th December 1813, before Bayonne, about four inches below the knee. Both bones were said to have been fractured, and the ball came out on the inner side of the same leg. He was sent to Plymouth in August, 1814, where various incisions were made, chiefly in the line of the tibia, and several portions of bone taken away, to the number of about sixteen. He, however, continued to lose health and strength, so much that it was determined to remove the limb below the knee-joint, which was accordingly done towards the end of 1816. On examination of the limb which had been removed, the tibia had evidently been fractured; the bone was much swollen, and very vascular, above and below the site of the fracture. *No sequestrum or dead portion of bone existed: but several cloacae or large apertures, leading into a fistulous cavity in the centre of the tibia.*

Necrosis from gunshot wounds, when the case is not complicated, presents the same appearances as simple necrosis, arising from a constitutional cause. This has been already exemplified by the case of A. C. and T. H.

Case XII.—J. B. was wounded at New Orleans, about the 8th January 1815. A grape-shot struck the arm high up, and fractured the bone. Amputation of the arm was performed in February 1817, from which he recovered. On examining the bone of the amputated extremity, it appeared that the operation had been performed close to a fistulous orifice in the bone, leading into a diseased cavity, containing a necrosed portion of bone. The shaft of the bone had not died throughout its whole thickness, but only an internal portion. The external layers of bone had become thick, vascular, and there is a considerable deposition of new bone over the whole surface of the old one.

The vascularity of the old bone is judged of by the numerous foramina which everywhere penetrate into its substance, and by which the periosteum transmits prolongations into the tissue of the old bone. This membrane is thickened, pulpy, and vascular. On tearing it from off the bony substance, it is evident that none of the new ossific matter has been formed by it; and the few small osseous points which remain on it, after being detached from the surface of the bone, are found, on examination with a magnifying glass, to be fragments broken off from the new ossific matter, formed originally by the vessels of the old bone.

I ought here to point out the many practical conclusions which result from the preceding cases and observations; but as it is my intention to resume the subject at a future period, I shall notice only the most obvious and readily understood.

In necrosis of the *os humeri* extending to the neck of the bone, and requiring amputation, it will be safest to remove the limb at the joint:* and in necrosis of the *femur*, it will be proper to saw the bone through in the trochanters. In gunshot wounds, complicated with fracture or injured bones, local antiphlogistic means must be rigorously enforced. The formation of extensive abscesses, and death of a large portion of bone, will thus be avoided; for we have proved that, by these means, bony parts will recover after being struck by a ball, which, under the ordinary treatment of deep incisions, hot fomenta-

* See a preparation finely illustrative of this in the Museum of Dr. Barclay of Edinburgh.

tions, poultices, and neglect, fall into disease, and finally become necrosed.

When the stump remains open, after amputation for gunshot fracture or hospital gangrene, having seized the stump and destroyed the soft parts around the bone, renders it probable that a portion of bone has also died, successive amputations higher up ought not to be performed hastily. Experience shows that the necrosed portion will, after a time, be detached, and may be extracted without difficulty. It is even doubtful if successive amputations be admissible, since, as far as I have observed, the *sequestrum* is generally of such length as to prevent the operator from removing the whole of the diseased bone, unless the amputation be very high.

When the necrosed portion is suspected to consist of the whole shaft of the bone, or of any portion of the shaft of the bone, throughout its entire thickness, splints ought to be worn, and absolute rest enjoined: these splints, aided by a circular roller, may prevent the early occurrence of fracture, and the amputation of the limb.

I am aware that a host of objections will be offered to this theory of necrosis. It will be asserted, that specimens of the entire regeneration of bones are to be found in every anatomical museum; that the periosteum has been found ossified in innumerable instances; that in others the soft parts around the necrosed bone were evidently converted into new bone; and finally, that the experiments of Duhamel and Troja, repeated by so many, must necessarily throw much doubt on the subject. To all these assertions I have to reply, 1st, That the preceding opinions relative to necrosis, are merely a statement of pathological facts, drawn from a constant observance of nature; 2d, That I have never seen any specimens of an entirely regenerated bone in any museum, nor do I know of the existence of such a specimen; 3d, In no dissection performed by myself or others, has the new bone, in cases of necrosis, been found to depend for its origin on the periosteum, or surrounding soft parts, but, on the contrary, it has uniformly appeared to be a secretion from that portion of the old bone which remained alive. New osseous matter thus formed may be readily distinguished from old living bone, however altered: it is irregular, nodulated, and full of *foramina*, for the transmission of vessels: the edges, or those points farthest removed from the base, are generally thin.

Though I have never met with an ossification of the periosteum, it is by no means my intention to say that such an occurrence is impossible, or even rare; most tissues of the human body are liable to be converted into a substance much resembling bone; the *dura mater*, for example, has been found ossified; the pleura, periosteum, the coats of arteries, and even the cicatrix of an old ulcer; but these are diseased, not healthy processes; they resemble each other, and may be classed together, but cannot possibly be confounded with the regeneration of bone in cases of necrosis.

Edinburgh, July 1821.

R. KNOX.

No. II.

Observations on the Regeneration of Bone, in Cases of Necrosis and Caries, being a Supplement to a Memoir on the same Subject, inserted in the Edinburgh Medical and Surgical Journal for January 1822. By R. Knox, M.D., Member of the Wernerian Natural History Society, and of the Medico-Chirurgical Society of Edinburgh.

In the observations submitted to the public in January 1822, will be found the brief details of a theory of Necrosis,* or rather of the regeneration of bone in cases of necrosis, founded on Pathological Anatomy, and on careful, repeated observations of experiments made by nature herself, daily presenting themselves in surgical practice, but which, from the frequency of their occurrence, are generally overlooked.

The subject of Necrosis was, as it were, forced on my attention; for in military hospitals, most cases of fractured limbs, which the surgeon, from a variety of reasons, may have endeavoured to save, become ultimately cases of necrosis. In this ample field of observation, I collected, some years ago, most of the facts and cases on which was founded the very simple theory of the regeneration of bone, proposed in the memoir already alluded to. Since the period of its publication, I have examined the Hunterian Museum of London, that belonging to the School of Medicine at Paris, and a collection of pathological anatomy still existing in the Veterinary School at Alfort; and, through the politeness of Sir James M'Grigor, an excellent collection of pathological specimens, collected by his care, and placed in the Military Hospital at Chatham. In these anatomical collections exist a few specimens of much interest, two of which I shall describe in the course of this essay; but it may be worth while previously to investigate briefly the history of necrosis, and to inquire into the opinions of very celebrated men, who, in sketching the mode according to which bones grow, and are regenerated, are supposed to have differed so widely from each other.

Though we owe to Mr. J. Hunter most of those sound and correct notions on physiology and pathology, which distinguish British surgery from all others, candour obliges me to state, that the observations of Haller, and his pupil Detleff, on the formation of Callus and growth of bones, do not admit of being called in question. With a slight variation in terms, a similar explanation of these phenomena has been offered the public in a variety of forms, too numerous to be noticed. In thus admitting the accuracy of Haller and Detleff as observers, we are not bound to put faith in their explanations, nor in the extension of their doctrines to all cases. Thus, though it may be true, that, in the chicken, the periosteum does not contribute towards the formation of bone, we know that it is different with man. In stripping the bones of the human fœtus of their periosteum, the most careless observers

* It has been usual for authors to comprehend, under the term *Necrosis*, the death of a bone and its replacement by a new one. I have already shown, that the regeneration of bone may or may not take place, and shall therefore continue to employ the term *Necrosis*, as meaning simply the death of a bone, or of a portion of bone.

must have remarked the facility with which the membrane may be removed; and hence, in early years, a partial destruction of periosteum does not necessarily give rise to an exfoliation from the surface of the bone; but, in the adult or aged, the death and separation of an external lamina of bone will generally follow the destruction of its corresponding periosteum, to which the want of pliability in the various tissues of the aged may somewhat contribute.

In the history of the formation and growth of callus, as given by Haller from the experiments of his pupil Detleff, there is much accuracy of observation, truth and beauty in the details, and clearness and precision in most of the conclusions. But whoever carefully peruses these experiments, will, I imagine, be satisfied, that they are applicable to cases of simple fracture only; that they do not explain the reuniting process in compound fractures, and can never be applied to the disease called necrosis, or to the regeneration of bone, which usually happens to a greater or less extent as a consequence of this disease. This eminent writer was, moreover, unfortunate in the employment of the term *callus*, and of some mechanical explanations, which have been singularly misrepresented by his antagonists.

Some years afterwards, Bichat, in his "Anatomie Générale," adopting a very confined and partial view of the subject, boldly asserted that Haller was wrong. He next describes the manner in which he supposes fractured bones are reunited,—a description applicable only to compound fractures. He does not condescend to detail the experiments (if any were ever made) which led him to these conclusions. Hence we are necessitated to conclude, that being but little acquainted with the subject, he resorted to those sweeping analogies, which form at once the merits and defects of his writings.*

The description given lately of the formation of callus by some experimental authors, agrees very nearly with the opinion entertained by Hunter, Haller, and other writers of their times. They divide the phenomena into three stages; but this must have been done merely for the convenience of description, since no such exist in nature. In the first period of simple fracture, they have ascertained† that there is an effusion of blood and coagulable lymph; that the colouring matter of the blood soon disappears; and (what might very readily have been imagined, independent of all experiment,) that the periosteum, medullary membrane, and other soft parts, speedily reunite. Now, all these appearances were well known, and had been well described, partly by Haller, Detlef, and others, but most minutely by Mr. J. Hunter and his pupils. Modern experimenters, however, imagine, that the fluid effused between the fractured extremities differ from the mere coagulable part of the blood, which they suppose to have been absorbed; a conjecture which, when proved, would give support to the opinion of Haller.

In the second stage, they describe an inflammation and swelling of

* What, for instance, can be fancied more incorrect than the following passage, in which he endeavours to refute the experience of ages, because it is at variance with some one of his ill-digested theories? "Recouvrez avec la peau l'extremité osseuse du moignon amputé; déjà celle-ci suppurera, que l'os commencera à peine à se ramollir; aussi les bons practiciens ont ils renoncé a ces pretendues reunions par premiere intention, si vantées a la suite de l'amputation à lambeux."‡

† See "Additions a l'Anatomie Génerale de Bichat, par Béclard."

‡ An. Gen. t. iii. p. 135.

the periosteum and soft parts, and hence arises a tumour perceivable externally. A coagulable matter (which I suppose to be the same with that described by Hunter, Haller, and others,) is effused in abundance under, and in the tissue of the periosteum, which, as they say, finally become osseous, prior to the conversion into bone of the remaining coagulable fluid occupying the space between the fractured extremities. But the fact is, that there is an affected nicety of description in all this, a distinction without a difference, and an effort made to conceal, by the employment of vague and novel terms, the close resemblance of the description to that of former physiologists. The more external parts of the effused fluid, which is afterwards to be converted into bone, will naturally ossify first, since the periosteum and surrounding soft parts will speedily heal and re-establish the continuity of the vessels; whilst the portion of fluid situated betwixt the fractured extremities of the bones, will longer retain the semi-cartilaginous state. Again, the external part will pass almost at once from the semi-fluid to the osseous state, because vessels containing red blood pass readily to it from the neighbouring soft parts; whereas the deeper seated effused lymph will have its vitality supported at first by vessels containing colourless fluids only, and which admit of red blood, and, consequently, of ossification only at an after period.

Thus, we find, on a careful analysis, that there is nothing either interesting or novel in these pretended researches into the healing of fractured bones, nothing which had escaped the notice of preceding ages.

In the regeneration of osseous matter, which accompanies the death of the bone in necrosis, many have supposed that the processes employed by nature were entirely different from those employed in reuniting compound and simple fractures. They adopted the opinions of an ingenious theorist, Duhamel, and have maintained them with extreme obstinacy, though there probably does not exist in the world a pathological specimen in the least confirmative of so false a theory.

It cannot be necessary to notice here, at any length, the opinions which have arisen out of the experiments of Duhamel and a few other experimental physiologists. They seem reducible to the following heads, viz.

Those who maintain that the new bone, in cases of necrosis, is formed between the layers of the periosteum, an opinion most amply refuted by an examination of numerous pathological pieces, in which the periosteum was stripped off the new bone, without there adhering to it a single osseous particle; and by the uniformly observed fact, that the osseous granulations in necrosis arise from the surface or edge of that portion of old bone still remaining alive, and in no instance from the periosteum or soft parts.

The experiments, moreover, of Dr. Macdonald,* show, that in pigeons, the internal periosteum is not formed till after the formation of the new osseous tube.

Others affirm, that the new osseous tube is formed by the vessels of the periosteum; that these secrete bony matter on the surface of the periosteum, which matter afterwards constitutes the tube destined to contain the dead bone and support the limb. But a single case of com-

* Disputatio Inauguralis De Necrosi et Callo, Edin. 1799.

pound fracture refutes these theories, which were founded originally on the experiments of Troja and Macdonald. Whilst we admire and praise the efforts made by these and other experimentalists to advance the boundaries of physiological science, it is nevertheless with very painful sensations that their works are perused; the mind shudders at the revolting tortures uselessly inflicted on the brute creation, and deeply regrets them. A little reflection on the part of those experimentalists, would have shown how vain, useless, and incorrect must be most conclusions drawn from experiments on pigeons and other animals, belonging to a class so widely different from man. These experiments have instructed us in the pathology and physiology of pigeons and chickens; they have shown, that after destroying the life of the bone, a new one will be produced; they have even shown more, (thus exceeding the expectation and puzzling the minds of their institutors;) they have demonstrated, that in pigeons new bone is formed when both the original bone and periosteum have been removed; a fact, as Dr. Macdonald observes, very difficult to explain.

In the experiments which Mr. Cruveilhier says he performed on the rabbit, we find that the periosteum was detached to a great extent from the bone; that threads of cotton were introduced between the membrane and bone, during all which great violence must have been done to both; yet the membrane reunited to the bone, which did not in any instance die. Hence we see of how little importance in some of the mammalia is any individual portion of periosteum in supporting the life of the corresponding portion of bone.

It seems reasonable that the performing of such experiments should cease. They are generally inapplicable to human physiology and pathology, more particularly those made on animals differing so widely in structure and vitality as man and birds. As well might we hope for the regeneration of human limbs after amputation, arguing from the success of a few such experiments on the lower tribes of animals.*

Finally, some have imagined that the soft parts generally surrounding the bone, reproduced another on the death of the original one; but I have already shown, that, were this the case, osseous matter ought to be found deposited in various places of the secreting surface, whereas we always find the new osseous secretion to proceed from the nearest healthy portion of the old bone, and from its extremities in those cases where the whole shaft has perished.

The manner in which new osseous matter shoots from old bone, appears to me sufficiently simple. The vessels supplying the remaining healthy old bone, whether proceeding to it from the periosteum, surrounding soft parts or otherwise, become increased in size, and perhaps in number; granulations arise on the surface, which, by degrees becoming firm, are afterwards converted into bone. These are found to shoot in various directions, but chiefly downwards and upwards in long bones, often separating widely from the surface of the dead bone, when not retained by careful bandaging. They occasionally stretch across, forming arches, and enclosing the dead portions of the original bone,—an appearance of frequent occurrence in compound fractures, by whatever cause occasioned. When arising from a fall or blow,

* Dr. Macdonald found, that the most cruel tortures inflicted on the extremities of pigeons, in no instance produced the suppurative inflammation. Yet he supposes, or rather asserts, that the vitality of these animals is similar to that of men.

sufficient to break, but not destroy the vitality of the bone, it is probable that compound fractures unite much in the same manner as simple ones. For as bones are slow in going through the various processes from health to disease, so the lacerated soft parts may suppurate and heal by granulations, whilst the bone will unite chiefly by what must be considered the first intention.

The manner in which the new bone acquires a periosteum, is still a subject of much interest. In the examination of a very few specimens, I have observed a thin membrane covering the new osseous granulations; but I know of no facts to decide whence this membrane proceeds. It is not unlikely that it is supplied by the cellular texture either of the new bone, or of the surrounding parts; and that in some instances it may be merely a prolongation of the old. New skin on ulcers does not always grow from the surrounding healthy edges; which fact may be applied to the formation of new periosteum.

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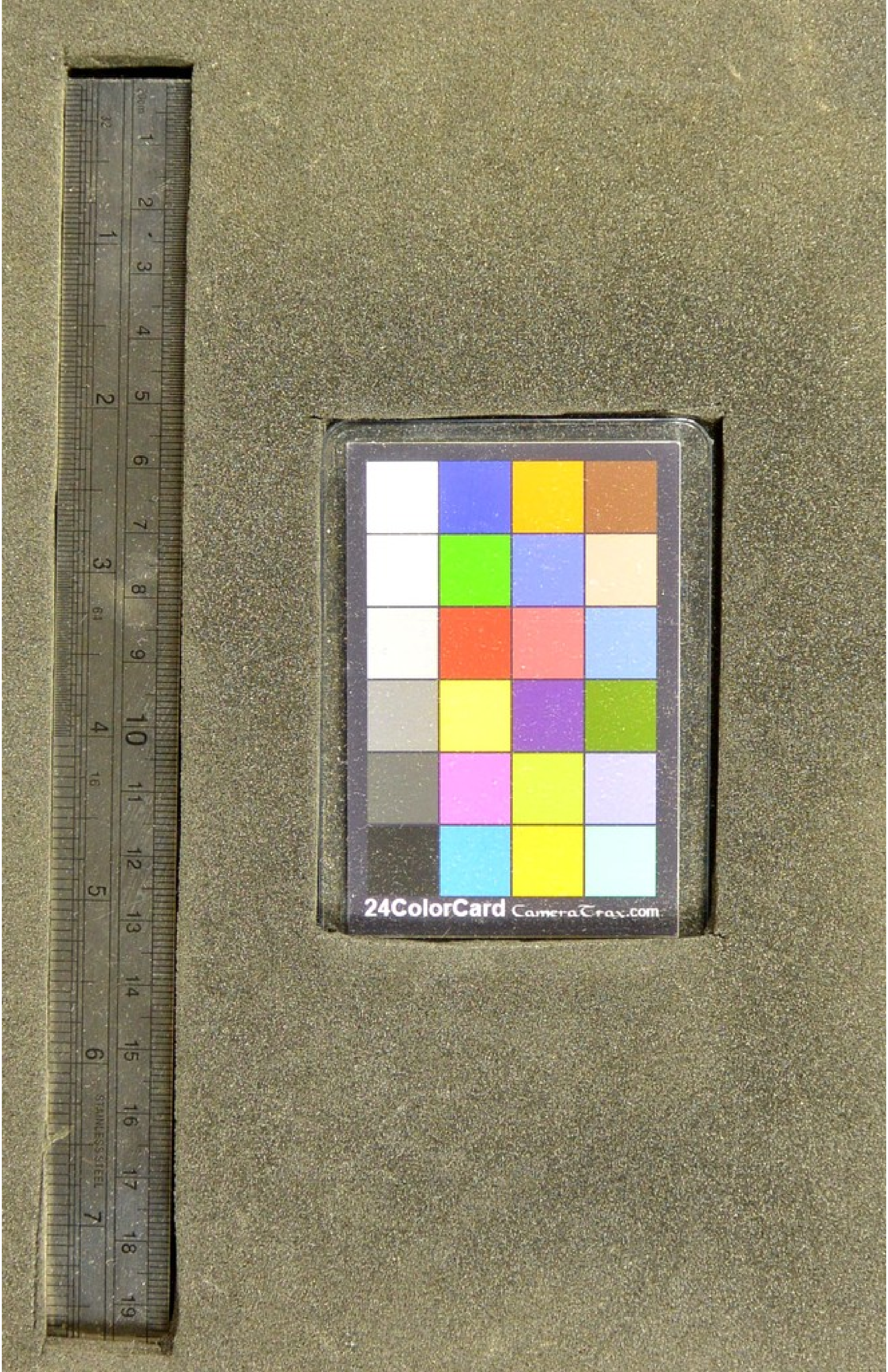
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