MANUAL

OF

GENERAL, DESCRIPTIVE, AND PATHOLOGICAL

ANATOMY,

BY

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TRANSLATED FROM THE GERMAN INTO FRENCH,

WITH ADDITIONS AND NOTES,

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TRANSLATED FROM THE FRENCH,

WITH NOTES,

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IN THREE VOLUMES.

VOLUME I.

PHILADELPHIA:
CAREY & LEA.—CHESTNUT STREET.
1832.

SLEIGHT AND ROBINSON, PRINTERS.
No. 111 Nassau St., New-York.

TO

GEORGE C. SHATTUCK, A. M., M. D., M. M. S.,

OF BOSTON,

THESE VOLUMES ARE RESPECTFULLY

DEDICATED.

PREFACE

OF THE AMERICAN TRANSLATOR.

We feel ourselves called upon to state why the publication of this volume has been delayed so long: should we mention all the adverse circumstances which have retarded its progress, it would be matter of surprise to many that it appears now: but we shall not trespass upon the patience of the public, and will only plead in excuse, the magnitude of the work, the difficulty of procuring a copy of the original with which to compare the translation, and the labor of this revision; as these difficulties are in some measure removed, the publication will proceed in future without delay; in fact, the second volume is now in the press.

In submitting our work to the profession, we claim their indulgence; we know it to be defective, and but illy fitted to meet the eye of criticism: a translation seems to be an easy thing: we advance no new theories, are responsible for no assertions, and are not bound to defend the opinions of the author: our object is merely to present his views with plainness and perspicuity: we may read, we may understand, but if we attempt to convey the meaning to others, unexpected difficulties are encountered. These are increased if the work be translated through the medium of a second language, and still more, if this medium, like the French of Meckel's manual, (we say it with high respect for those eminent men whose *names* appear on the title page,) be incorrect. Farther, a work of this character demanded a more able interpreter, some one whose name would have been a passport to its excellence: let it be remembered, however, that the manual has now been extensively known for six years; that during this time, translations have been announced both in America and England, (in this country four to our knowledge,) and have been withdrawn, probably from the want of patronage, and we trust that our attempt will not appear presumptuous.

In regard to the original, Professor Meckel's reputation as an anatomist, and a man of profound science, is immense; his works are extensively and favorably known in Europe; and of all scientific works in a foreign language imported into this country, no one has been circulated so extensively as the French translation, which is now out of print. Farther, we have the written testimonies of some of the most eminent medical men in the United States, among whom we would mention Drs. Coates,(1) Horner,(2) Mott,(3) Physick,(4) Sewall,(5) J. A. Smith,(6) N. Smith, (7) Stevens,(8) and Warren,(9) (whose courtesy we take pleasure in acknowledging,) all of whom have been in the habit of referring to the work for years, and consider it one of the best treatises on anatomy ever written. We should not mention this, unless called upon by a passage in the preface to Cloquet's anatomy, translated by Dr. Knox of Edinburgh, and republished in this country; a good translation of a valuable work. We quote the passage. Speaking of Cloquet, the Dr. says: "His omission of what is called 'General Anatomy,' with all its absurd theories, its tiresome diffuseness, its verbosity, and unprofitable minuteness, ought to be deemed by the student a great advantage, and a recommendation of the work; and should any one doubt this, let him peruse the first volume of the 'Manuel d'Anatomie Générale, descriptive, et pathologique,' by J. F. Meckel, where he will find, under the title 'General Anatomy,' all the absurdities without the good sense contained in the '*Elementa*

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Physiologiæ' of Haller; and in addition, more idle, extravagant, unintelligible theories, misnamed anatomical, than ever yet were collected in a single volume."

We should not expect, after this thorough condemnation of general anatomy without trial or jury, we had almost said without a *judge*, to find the Doctor employing his time and talents in translating a work on the same subject. One would think, too, that in guarding against *absurd theories, absurdities* stated as *facts* would have been avoided; yet this is not the case. The translation of Cloquet has been followed by that of Béclard's General Anatomy, into which Dr. Knox has introduced many strange things, not idle, extravagant, unintelligible theories, pardonable terms in regard to a favorite *opinion*, but statements professing to be *facts*, absolutely contradictory to common sense.(1) We admit that the French translation of Meckel contains assertions on one page which are contradicted in the next; these, perhaps, may be found in our volumes, but a mere reference to the original will prove them to be errors of translation; it is surely something new in criticism to attach the responsibility of these to the author, and if the position be tenable, we would only say—poor Béclard! We respect Dr. Knox for his talents and information, but not for consistency,(2) or for possessing that tone of kind feeling and liberal sentiment, which ought to exist between the educated men of every nation.

We have admitted in the preceding paragraph, that contradictions occur in the French translation, which was evidently hurried: some of these errors are important to the student, and to correct them, our translation has been compared with the original. Here, the translator and publisher would acknowledge their obligations to Dr. ALFRED C. POST, of this city, for his generous kindness in translating several notes and passages omitted in the French, and for the correction of several errors in the text; but he is not responsible for those which may have passed

(1) Such as comparing a *muscle* to a *mitten!* &c. For a nice dissection of Dr. Knox's translation, see the preface to the American version by J. Togno, M. D., published at Philadelphia, 1830.

(2) We almost repent of this charge, more especially if the work was selected by the Doctor "with the consent of his publishers, as one worthy of transla.ion," and if the medical men on the other side of the Atlantic ever feel, as do many on this, the "wholesome stimulus of prospective want."

unnoticed. Dr. Post's opportunities have been great: the best advantages which our country afford, have been open to him: added to these, by residing in France and Germany, and by attending lectures at the most celebrated universities he has acquired a good knowledge of the languages of those countries, and can command new sources of learning. The path of usefulness is now open before him, in which we most cordially wish him success.

We have endeavored in the American translation to present the meaning of the author faithfully: but we regret, that notwithstanding the utmost care in revising the manuscript and correcting the proofs, some errors are introduced; the most important are noticed in our *errata*, and for them we would again ask indulgence. The volumes are already so large, that we have increased them only by adding such facts as have been observed since the publication of the French; the original notes of Professor Meckel are designated by figures; to those added by the French translator, the letters F. T. are attached: our own are marked with an asterisk*: for them we have depended on the medical journals, more especially the American Journal of the Medical Sciences, published at Philadelphia, whose Quarterly Periscope presents a brief summary of the discoveries made throughout the world.

Hitherto, we have depended for our advance in the science of anatomy principally upon Europe. While the American practice of medicine combines the advantages of the different European systems, and our medical men are not deficient in talents and application, the unjust and oppressive laws of our country exclude them from the study of anatomy. We say unjust and oppressive; what can be more so, than to make a surgeon amenable to a civil tribunal for a professional error, while at the same time, if detected in attempting to gain the knowledge necessary to avoid those errors, he is exposed to fine, imprisonment, the stigma of public opinion, and the risk of being torn to pieces by an infuriated mob. We congratulate the profession, however, that the time is rapidly approaching, when the study of anatomy may be prosecuted in this country without the dread of the debtor's or of the state prison. Through the continued and well directed efforts of Dr. John C. Warren, the able Professor of

Anatomy and Surgery in Havard University, the legislature of Massachusetts have finally passed an act legalizing the study of anatomy; this act imposes additional penalties for violating the sepulchres of the dead, but at the same time it is all that any reasonable medical man can wish. Dr. W.'s exertions in the cause of science have been great, and this last effort, happily crowned with success, entitles him anew to the gratitude of the profession. We hope that the course of the legislature of Massachusetts will be followed by the governments of the other states, and anatomy will then receive that attention which its importance demands.

But we trespass upon the public, and will conclude with observing that no exertions shall be spared to render the succeeding volumes of our translation worthy of their patronage.

New York, Nov. 10.

PREFACE

TO THE FRENCH TRANSLATION.

We have long wished for a work which should comprise all the important facts of General, Descriptive, and Pathological Anatomy, and of Physiology. A task so arduous demanded a knowledge both extensive and profound, and could be accomplished only by one of the first anatomists of the age. Meckel, who honorably sustains the medical reputation of his family, and to whom the world is indebted for several productions of merit, has fearlessly undertaken this laborious work. His treatise on anatomy is considered as a standard in his own country, and will doubtless be favorably received in this. It is one of the finest productions of Bichat's school, Bichat, the envy of all Europe, and to whom Meckel has paid the most brilliant tribute of respect that talent can pay to genius, by professing for him a calm admiration. We have been careful in our translation to add all the new facts which have been discovered since the publication of the original.(1)

(1) *Handbuch der menschlichen Anatomie*, Halle and Berlin. Vol. i. 1816. *Gen. Anatomy. Osteology, Syndesmology*, and *Myology*, Vol. ii. 1816. *Angeiology* and *Neurology*, Vol. iii. 1817. *Sphlanchnology* and *Embrylogy*, Vol. iv. 1820.

ERRATA.

Page	17,	line	4,	for	*physiology*	read	*physiography.*
"	22,	"	5,	"	*every thing*	"	*the whole.*
"	27,	"	26,	"	*as*	"	*like.*
"	29,	"	5,	"	*ligaments*	"	*cartilages.*
"	31,	"	1,	"	*muscular*	"	*mucous.*
"	55,	"	41,	"	*disposition*	"	*system.*
"	75,	"	28,	"	*all*	"	*the whole.*
"	168,	"	21,	"	*in those*	"	*in the same.*
"	"	"	40,	"	*by*	"	*through.*
"	263,	"	18,	"	*fibres*	"	*fibrin.*
"	280,	"	3,	"	*of*	"	*by.*
"	291,	"	43,	"	*to*	"	*with.*
"	314,	"	14,	"	*hips*	"	*lips.*
"	350,	"	31,	"	*it depends only on*	"	*it exists in regard to.*
"	378,	"	4,	"	256	"	252.
"	"	"	5,	"	*six*	"	*two.*
"	384,	"	10,	"	*with*	"	*from.*

GENERAL ANATOMY.

MANUAL

OF

GENERAL, DESCRIPTIVE, AND PATHOLOGICAL

ANATOMY.

INTRODUCTION.

I. *Anatomy is the science of the organic form.* This term is not very convenient, as it suggests only one of the numerous means employed to attain a knowledge of the organism: hence, the terms *zoography, physiology, organography,* and *morphology,* have been proposed as substitutes for it; but as the word *anatomy* is sanctioned by long usage, and does not retard the continual progress of the science, it may be retained without inconvenience, and probably will be always used.

That series of practical rules by which we gain a knowledge of the organism, constitutes the *art of anatomy.* Its relations with anatomy are then those which exist between the means and the end.

II. The particulars of the organic form are,

1. The *external form*, which may also be called the *configuration;* it is determined by the relations which exist between the three dimensions.

2. The *inner form* or the *texture*, (*textura*,) the manner in which the body or its parts are composed. The term *structure* is also given arbitrarily to the composition of the whole body, inasmuch as it is formed of large parts, while *texture* is applied to the composition of these parts, since they themselves are produced by the union of parts still smaller.

3. The *size*.

4. The *color*.

5. The *physical properties*, the degree of cohesion, of elasticity, &c.

6. The *relation of locality* of one part in regard either to the others, or to the whole body, and consequently, *a.* its *situation*, its *place* in the organism; *b.* its mode of *connection* with the parts adjacent.

In the sketch of the organic form, we consider more or less completely,

1. The *Chemical composition*, and

2. The *properties* and *actions* of the organisms, in order to present as complete a view as possible of all their characteristics.

In fact, we may say that anatomy is to a certain extent the historical part of physiology; hence it would be convenient to consider these two sciences as forming but one, and to place them first in all books.

III. The *subject* of anatomy is extremely varied; it may then be presented in a great many different *forms*.

IV. Thus:

1. The science of the organization may comprehend a greater or less number of different organisms. The subject of anatomy, in general, is to make known the form of *all* the organs; but the objects are so many and various, that it has been subdivided into *phytotomy*, or *vegetable anatomy*, and *zootomy*, or *comparative anatomy*.(1) In

(1) The unity of the organic composition, the most important fact of animated nature, is now admitted by all enlightened naturalists. The meditative Greeks discovered it; but when they studied it in detail, they objected to what were termed its numerous exceptions. This difference arose from the fact that Aristotle, and after him Galen, who have been followed by all anatomists, founded comparative anatomy on the unity of functions, because they knew not how to proceed, except upon perfect organs, exercising determinate functions, and did not recognize identities, except in pursuing the insensible gradations of forms. An example will show better than abstract remarks the defect of this method, which prevented the unity of anatomy from being recognized, although that of the organic composition was admitted, and which determined the naturalists to make as many distinct systems of anatomy as they could perceive different characters. Take, for instance, the four limbs of a cat; they carry the trunk; they are the organs of *support;* they are composed of moveable parts, which, put in action by the muscles, serve to move the trunk; they are, then, the organs of *locomotion;* they are terminated by moveable phalanxes, which extend and bend—these are the organs of *prehension*, to seize and retain their prey; finally, the last phalanx, which is naturally turned backward, can be brought in the same direction with the others, so that the sharp nails, which terminate it, project—they are the means of *attack* and *defense*. Now, if we consider the four limbs of the ape, we find they are capable only of the first three functions; they perform only the first two in the dog, and the second in the seal. Their anatomical relations are, however, the same. Anatomy demonstrates, in the limbs of the cat, of the ape, of the dog, and of the seal, the same bones, the same muscles, the same ligaments, the same envelops, and the same nails; they differ only in slight modifications of form and size, to assist their uses. How then ought we to regard these forms, proportions, and functions?

Impressed with these great principles, J. St. Hilaire discovered, that to attach to anatomy a philosophical and truly scientific character, we must neglect the organs themselves, their too fugitive forms, and various functions, and consider only the organic elements, which change or increase from new developments. In this manner he arrived at organic elements, which are, strictly speaking, the same, and discovered, that the functions of the organs are much modified, according as some of their parts vary in length and thickness. Such is the path pursued by this naturalist, to give a philosophical turn to anatomy. His doctrine is, in fact, that of Aristotle, but with this important distinction, which gives it the character of a real discovery: Aristotle did not recognize the analogy, except while the functions were preserved; that is, he admitted no similarity when organs, composed of elements, employed these same elements, partly before, partly behind, or on the side; in a word, directed them to other organs. Hence, a resemblance in form, and an equivalent destination, assured him that the organizations were identical: in short, he mistook the appearance only for the rule. J. St. Hilaire does not say that the organs, but the materials of which they are composed, are always the same. This distinction changes the state of the question entirely, for then the identity remains a general fact, even when the organs do not continue the same, as on leaving the classes. In fact, it is only when the connections and mutual relations of two parts are similar, that they are analogous according to the new theory, which attaches but a secondary importance to the different uses entailed by their newly acquired relations, and introduces for the first time in anatomy, the principle of the dissemination of the organic ma-each of the two organized kingdoms, the science may treat particularly of a class, an order, a genus, or even a species. In fact, we must know the forms of all the *species*, to have a complete phytotomy or zootomy, and lastly, a complete anatomy.

2. The limits of anatomy may also be contracted or extended, because the organic form is not confined in each species by absolute rules, nor are all individuals formed after the same type. Thus:

a. Anatomy is not the same at all periods of life:

b. The two sexes differ from each other, at all ages, at least in the perfect species:

c. The species comprehend a greater or less number of *varieties*, of *races*.

There is then an anatomy of *ages*, *sexes*, and *races:*

These differences may be considered as regular, inasmuch as they are constant, and necessarily belong to organized bodies.

A second class of differences comprises the *irregularities*, so called either because they are not necessarily connected with the essential forms of organized bodies, and most of them arise more or less evidently by a departure of the formative act from the laws of formation, or because they endanger more or less imminently the existence of the organism.

Pathological anatomy treats of these aberrations from the primitive type.(1)

The anatomy of a species, to be complete, should comprise all the conditions above mentioned. We may, however, separate some of them from the rest, and consider them only.

terials, which is so fertile in results; by virtue of which these materials, when displaced, take on new actions, as do all those organs which have become rudimentary. Thus the doctrine of our learned compatriot is founded on the following: 1. That identity does not always depend upon the organs as a whole, but only on the materials of which each is composed. 2. That inquiries after identity should regard the mutual, necessary, and consequently invariable, dependence of the parts. 3. That the organic elements which touch, are, from their position, necessarily constrained to assist one another reciprocally. 4. Finally, that an organ, whether in its normal or pathological state, never possesses extraordinary activity, unless some other one of the same system, or of those connected with it suffers proportionally, and in the same ratio. J. St. Hilaire briefly terms these the four fundamental laws of every organic formation, *theory of analogies, principle of connections, elective affinities of the organic elements*, and *balance of organs*. Regarded in this new light, anatomy will change the view of physiology, and will finally allow it to rank among the sciences; it will even have a direct influence upon the practice of medicine; for, first, it will establish general pathology on a rational foundation, and refer to a single principle the many facts observed by pathologists, although ignorant of the law which embraced them all; secondly, it will teach us to mistrust the experiments on animals, in which we have hitherto confided implicitly. Many physicians draw conclusions from these experiments in regard to man, saying, "the organs are the same, and consequently the functions must be similar." A blow from the claw of a cat, or the tiny hand of a child, would lead to an opposite conclusion. The stomach of the dog is unique like that of man; but an enlargement in the size of its parts would change the nature of its functious. Will the dog then vomit, as man does? *Be careful how you conclude*. F. T.

(1) Our idea of pathological anatomy would not be correct did we suppose, from the definition, it treated only of monstrosities, or of variations from the formative type; for it makes us acquainted, also, with all the accidental alterations of the organic tissues produced by disease. Hence, to avoid all doubt, we say, that it treats of all aberrations from the primitive type, congenital or accidental. F. T.

The differences of the first class are not generally excluded from works which treat of the form in its regular state. It is to be regretted that the periodical differences arising from age are not usually sufficiently appreciated, being often very wrongly separated more or less from the anatomy, and considered as branches of a science with which they have no connection. On the contrary, the study of the normal state is often separated from that of the anomalies. This is also wrong; first, because the line of distinction between the rule and the exception cannot always be exactly drawn. Secondly, because the anomaly is often a comment on the rule, and is a deviation only at the age when it is found. And finally, because, as anatomy proposes to give a complete view of the organic form, this end can be attained only by treating of *every* particular of this form.

V. Anatomy may be presented in very different *forms*. Sometimes it is thought sufficient to *describe* successively the organized bodies as a whole, and in detail; sometimes general results are deduced from these isolated descriptions, in order to obtain directly a knowledge of the peculiarities which distinguish the different tissues which compose the organism, and the general laws according to which the organic form seems to have been produced.

Hence anatomy is divided into two parts, according as it treats of a single species of animals, or embraces all organized bodies, into *general* and *special*, or *topographical anatomy*.

The first comprises the general conditions of the organisms, and the union of the parts which form them: the other is confined to their details. The first acquaints us with the different *systems* composing the organism, the other learns us the distinctions between the *different parts of the same system*. The former pertains rather to *physiology*, the latter to *surgery;* but the second is indispensable to the physiologist, as the first is to the surgeon.

GENERAL ANATOMY.

SOURCES.

The sources of general anatomy, are all the works on general anatomy, and on physiology, as well as on the different branches of the former; since we there find an exposition, more or less exact and complete, both of the general properties of the organic formation, as of those of each of the systems which unite to form the organism.

Under the first head we recommend several chapters of the first volume of *Dumas* (*Principes de Physiologie*, Paris, 1806;) under the second, Haller's (*First lines of Physiology*,) Bichat, (*General Anatomy*, Boston, 1822,) with Beclard's additions, and Sœmmering, (*Lehre vom Baue des menschlichen Kœrpers*, Frankfort, 1800.) The last is mentioned, principally, for the general conditions of most of the organic systems, particularly the *bones*, *ligaments*, *muscles*, *nerves*, *and vessels*.

In most of these works, the healthy and unhealthy state of the parts are considered at the same time, but without saying all that can be said upon the latter topic, and without always ascribing to it the importance it merits. Portal (*Anatomie medicale*, Paris, 1804,) has treated all the organized systems in both of these states on a good plan.

The French anatomists have, generally, described pathological alterations in their treatises before the writers of other nations. Munroe's book (*Outlines of the Anatomy of the Human Form*, London, 1813) is an exception to this remark.

The principal treatises on the alterations of textures, and of the structure of the human body, and the most important for exact descriptions, and the great number of facts tending to establish the systems of pathological anatomy on a firm basis, are those of

Morgagni, (*De caus. et sedibus morb.*)

Baillie, (*Morbid Anatomy of the Human Body*, 1793.)

Voigtel, (*Handbuch der pathologischen Anatomie*, Halle, 1804,) and

Mechel, (*Handbuch der pathologischen Anatomie*, Halle, 1813.)

The principal works upon each part of general anatomy will be mentioned hereafter, when treating of those parts.

GENERAL ANATOMY.

PART I.

GENERAL LAWS OF FORMATION.

§ 1. The human body, as well as all those that resemble it, is composed of various parts, which have the mutual relations of preservation or of generation, and which reciprocally play the part of means and end, one with the other, and of which the actions, infinitely varied, have, for a result, life, and the preservation of every thing formed by their union.

§ 2. These parts are so different in *form, chemical composition, physical and vital powers*, and the phenomena dependent upon them, that it is much easier to point out their differences, than their analogies. Nevertheless, when the thing is examined attentively, we can mention certain general qualities, in regard to all the conditions above, so that these considerable differences then seem to be only simple modifications of a single and even primitive type.

§ 3. The organic form, consequently also the human form, presents two points of view: 1st, its intimate composition, the texture of its parts; 2d, the external composition, the structure or the form. But when closely regarded, it is seen that these two points differ only in degree.

§ 4. As regards *texture*, the component parts may be reduced to others *more simple*, which in their turn differ from each other, in their degree of simplicity, and may, therefore, be divided into *proximate* and *remote*.

§ 5. *The remote constituent parts of the organic form*, are finally reduced to two, of which one appears constantly under a given form, which is not the case with the other, although this is equally susceptible of figure. These parts are the *globules* and a *coagulated* or *coagulable substance*. The part is *solid* or *liquid*, according as the latter, in the first or second state, exists alone, or with globules, and it has an *external form* in the former case. All the solid and fluid parts do not contain these last two constituent materials: but the globules never exist alone; they are always imbedded in a coagulated or coagulable substance.

§ 6. The term *globule* is not well adapted to corpuscles having a definite form; for it is proved that many of them, particularly the *glo-*

bules of the blood,(1) are not equally thick in all directions, but are flat and lenticular, since, if rolled on an oblique surface, their edges may be seen with a microscope.(2) They are however never angular, but always rounded, and vary in *form*, *size*, *number*, *color*, *and chemical composition*, not only in different subjects and in different parts of the same subject, but even at different stages of life, whether they pass or return, and are regular or irregular.

Thus, in regard to *form*, the globules appear more *complicated* in some parts than in others. In the blood, according to the best authorities, they are formed of a central part, which is solid, and of an external part, which is hollow, vesicular, and incloses the first, but does not adhere to it. Every where else their structure appears more simple, for one only of these two parts is perceived; but whatever may be the region of the body in which they are examined, their general form appears the same in the same animal, that is, they are never found oblong in one part, and rounded in another. In man they are rounded.

The globules differ much in volume in the different parts of the body: they are smaller in the liver than in the kidneys, and larger in the spleen than in the liver.(3) Those of the nervous system are smaller than those of the blood;(4) these latter are in their turn larger than those of the lymph, of milk, and of chyle.(5) At the commencement of suppuration(6) they are smaller than when it has existed for some time.(7)

(1) C. H. Schultz has very recently attempted to demonstrate that blood endowed with the vital principle is not composed of globules swimming in serum, but forms a homogeneous mass, which is divided into numerous corpuscles, exercising, upon each other and on the parietes of the blood-vessels, the most lively action; so that they are reciprocally drawn together, or rather are united, and then reform themselves anew: they attract each other mutually, and join to form one mass: this mass resolves itself into several parts; and the same thing occurs again. This new theory of the vitality of the blood founded on microscopic observations, if confirmed, will have a powerful influence on physiology, and will serve to explain the existence of animal scions, which have been rejected too soon, because we could not understand them. See two important memoirs of Schultz in the *Journal Complementaire: Observations microscopiques sur la circulation du suc propre dans la chélidoine et dans plusieurs autres plantes*, vol. xvi. p. 208. and vol. xvii. p. 136. *Mémoire sur les phénomènes de la vie dans le sang, démontrés par les observations microscopiques*, vol. xix. pp. 19 and 212. The observations of this physician have been resumed by Dutrochet, who thinks they were founded on an optical delusion.—Same Journal, vol. ix. p. 289. This subject demands more attention, and we invite to it the talent and zeal of physiologists. We ought, however, to add that Dœllinger (*Was ist Absonderung und wie geschieht sie*, Wurtzburg, 1819, p. 21.) had already rejected the theory of globules swimming in serum; but he admits the existence of globules: he thinks too that the blood should not be termed a fluid; for it does not run like water, but like the fine sand contained in an hour-glass. F. T.

(2) Hewson, *Experimental Inquiries*, London, 1777, vol. iii. p. 15. Leuwenhœck says they are globular in man and the mammalia, but flat in fishes.—(*Arc. Nat.* vol. i. p. 51.) Schmidt states they are round in man and the mammalia, and elliptically oblong in all other animals.—(*Sur les globules du sang*, in the *Journal Compl. du Dict. des Sciences Med.* vol. xviii. pp. 107 and 210.) See also the work of G. A. Magni, (*Nuove osservazioni microscopiche sopra le molecule rosse del sangue*, Milan, 1776,) as likewise that of Prevost and Dumas, (in the *Bibliothèque Universelle*, 1821, July, August.)

(3) Wenzel. *Prodromus eines Werks über das Gehern des Menschen und der Sæugthiere*, Tubingen, 1806, chap. iv.

(4) Prochaska. *De Struct. Nerv.* Vienna, 1779, chap. iv.

(5) Hewson. *Exp. Inq.* tabs. 1 and 4.

(6) Home. *On the Properties of Pus*, London, 1778, p. 14.

(7) M. Edwards, from his microscopic researches upon the cellular, fibrous, and vascular tissues, the muscles, and the nervous tissue, or pulpy substance of the brain

Some fluids, as urine, contain very few globules; the same is true of some solids, as the mucous tissue, the fibrous parts, the cartilages, the bones. On the contrary, there are more in the blood, the muscles, and the nervous substance. More are found in the blood than in chyle and milk; they are also more numerous in perfect pus than in that which is just forming.

The *color* and *chemical* composition of the globules are determined usually by those of the parts; since the latter are constituted by them, and they cause the differences of the parts. This proposition appears incontestible, at least as regards the solids.

In all these respects the globules are subject to periodical changes. The analogy between man and animals renders it probable that at different periods of life they vary considerably also in him, both as regards form and volume; for in the fetuses of birds and reptiles, globules of blood have been found of another form and much larger than in the adults. The same remark is true in respect to color and chemical composition; since the two qualities do not remain the same in the same parts at all periods of existence. Their number certainly changes regularly at different times. At the commencement of the first period, when the fetus is forming, no globules can be perceived, and the substance of the new being is composed entirely of a coagulable, homogeneous liquid; this soon separates into a fluid part and another which is more consistent; the latter is surrounded by the former, and, as a plate of zink moistened with water, is alternately in a positive or negative state of electricity, according to its situation, so the positive state every where prevails in the solid portions, or the globules, and the negative, in the liquid which surrounds them. But when the fluid, which was at first homogeneous, once divides into globules and a liquid, the globules continue for some time more apparent than they are afterwards, and then may be discerned in all parts of the fetus.

§ 7. These two remote constituent parts, the globules and the coagulable liquid, produce, either the second alone, or both combined, two principal forms: in the first, the length much exceeds the other dimensions; in the second, it is more nearly equal to the breadth, although they both exceed the thickness. The first form is called *fibrous*, the

and nerves, has determined that the elementary parts of these tissues are formed and arranged in the same manner in every animal observed by him. Edwards thinks he can establish, as a general law, that the proper elementary structure of these different tissues is the same in all animals. A still more remarkable fact is developed by his researches, viz., that the form and size of the globules are always the same, whatever is the organ or animal in which they are examined. We must then believe that the primitive form of the molecules of solid and organized animal matters is always constant and definite. In fact, as Edwards states, the organic tissues above indicated are formed of spherical corpuscles $\frac{1}{300}$ of a millimetre in diameter, whatever may be the other properties of these parts and the functions for which they are designed.—(H. M. Edwards. *Mémoire sur la structure élémentaire des principaux tissus organiques de l'homme*, Paris, 1823.) F. T.*

* M. Raspail concludes, from some recent microscopic observations, that the membranes, when isolated, and reduced to their proper consistence, are not composed of globules perceptible by our means of observation, and however coarse those examined may be, their surfaces appear smooth, and not granulated.—*Am. Med. Jour.* Nov. 1828, from the *Repertoire d'Anatomie.*

second, the *laminar:* the fibrous form belongs usually only to the coagulated liquid, which is sometimes changed into *fibres*, even without the globules, as in the bones, tendons, &c.

The globules tend very much, with the coagulable liquid, to form fibres; that is to say, to arrange themselves one after another, as is seen in the nervous and muscular systems; although in several parts, as in the substance of the viscera, they are deposed without any regularity, being placed indiscriminately in the coagulable fluid. The latter is, however, inseparable from the globules, for it envelopes them entirely: even the most delicate fibres are surrounded with a sheath, produced by this fluid, in which all the parts are, in some measure, placed, and in the liquid portions of which, the globules contained in the fluids float.

The properties of the fibres vary as much as those of the substances which constitute them. *There is, then, no single or elementary fibre.*

§ 8. The union of fibres and laminæ, or of the latter alone, produces spaces of different forms, called *cellules.* Gallini, Ackermann, and some others, were wrong in considering these cells as the only final elements of form. The very expressions of these authors refute their own opinions; for if "all the parts of the body are aggregations of laminæ of different sizes, joined one to another at different angles, so as to intercept between them, spaces or cells of various sizes,"(1) or if "four mucous laminæ joined at an acute angle, enclosing a space called a cell, are the homogeneous elements of every organization,"(2) it is easy to perceive, that the cellular formation comes manifestly from the lamellar, and thus that the cells are a secondary formation. To this it may be objected that the globules are, properly speaking, cells, and hence that the fibres themselves are composed of cells; but this opinion cannot be admitted, because these globules exist in a loose state in the fluids. Besides, there are many parts in which there are no traces of these hypothetical cellules, and which appear to be produced by a homogeneous fluid coagulated in large laminæ, as is seen particularly in the serous membranes. It is equally improper to call the fibres the crystaline forms of organized bodies.(3)

§ 9. In the body the fibrous formation exceeds the lamellar very much, and the parts themselves in the whole form in which the dimensions of length and breadth are equally developed, such as the fibrous membranes, the broad bones and muscles, manifestly exhibit the fibrous texture internally, a circumstance belonging, unquestionably, to the law, in virtue of which the dimension of length, in the whole body, exceeds the other two. The fibres are easily distinguished in the nerves, muscles, most of the bones, and the fibrous organs. A tissue, at once fibrous and lamellar, is found in the viscera, and partially, also, in the bones.

§ 10. These elements, disposed in fibres and laminæ, which originally differ much in figure and composition, produce, when united, several *proximate* or *immediate constituent parts of the form*, which vary considerably,

(1) N. Gallini, *Betrachtungen ueber die neuen Fortschritte en der Kenntniss des Menschlichen Kœrpers*, Berlin, 1794, p. 61.
(2) Ackermann, *Darstellung der Lehre von den Lebenskræften*, vol. i. p. 11.
(3) Autenrcith, *Physiologie*, vol. i. p. 7.

both in their internal and external figure. These bodies have received the name of *systems*, in relation to their *form*, by which we understand, that the different parts of a given combination resemble each other, and differ from the others in all the parts of the body. Many, as the mucous, nervous, and vascular systems, deserve this term in a still more special manner, because they form an uninterrupted whole. Here the connection is less intimate in some systems than in others ; for example, the bones and muscles do not offer, like the above mentioned, an uninterrupted continuity in their proper substance ; nevertheless, they are so united into a whole by peculiar systems, to wit the fibrous, that the periosteum which covers the bones, not only has the same structure as the accessory ligaments which pass from one bone to another, and as the tendons of the muscles which are inserted into it, but also forms with them a continuous whole.

Other parts of the body, on the contrary, as the viscera, and serous membranes, are isolated, and are retained, one to the other, only by the first three systems, which are universally diffused, and form an uninterrupted whole.

The different parts of the body receive also the name of *tissues*, (*textus*,) in regard to their internal structure ; and that of *organs*, by reason of the actions they execute ; for each acts, in its manner, for the preservation of the body, which is itself called an *organism*, in reference to the activity of the parts constituting it.

§ 11. These different parts vary much from each other, in their external and internal form, their chemical composition, their mode of vital activity, and their functions. They differ most, however, in the *degree of complication*. There are, in this point of view, two grand principal classes, which may be called, the first, the class of *simple organic organs or systems, or of similar parts*, (*partes similares*,) because they are found in the body more than once ; the second, the class of *compound organs or systems, or of dissimilar parts*, (*partes dissimilares*,) or as Bichat terms them, of *apparatus*, because they are found in the body only once, or at most twice. The union of the simple organs takes place in a determined manner, many of them uniting to give rise to parts designed to accomplish *a special function, single, or at most double*. Combining thus, they form the apparatus ; so that the body, considered as a whole, results from an assemblage of compound systems which we must decompose and reduce to their elements, if we wish to have an exact and complete idea of the conditions of their existence. The hand, the foot, each viscus, the different organs of the senses, &c. are examples of these apparatus. Nevertheless, we should observe, that the line of demarkation between the simple and compound organs is not rigorously traced. The simple organs themselves are composed of several different parts, and combine and unite differently. As for the more complicated organs, we can, with attention, refer them to simple systems, since we finally find, in several, the same conditions which are presented by the latter. This is the case, at least with many of them, and particularly with those termed *viscera :* doubtless all these do not differ from other parts, sufficiently to constitute special organs; but when examined attentively, we ascertain, first, that they are only simple modifications, or branches of one and the same system, the cutaneous; and secondly, that they are so analogous to the vascular system, that no perfectly distinctive characters can be assigned to them: both are canals having their parietes formed essentially of two layers, an internal and an external, of which the latter tends to move the contents, and which are both formed with vessels and nerves. We are then embarrased in attempting to decide on the subject of certain parts, whether they should be regarded as simple or compound organs. The skin, for instance, is certainly an apparatus, a compound organ, if we consider it in its totality, as is necessary to acquire an exact idea of its functions: but, we can distinguish in it several particular systems, since we can reduce it mechanically, not only to parts which are found in other organs, but into those which are peculiar to it, as the cutis, papillary tissue, epidermis, hair, and nails.

§12. We ought not, however, to think, from what has been said, that a classification founded on the difference of tissue and of composition, is useless and impossible; on the contrary, it appears more proper, not only to examine the simple and compound organs separately, but farther, in making the table of the most simple systems, to consider all the parts manifestly connected with a compound organ, as belonging to this organ, and to describe them with the others, rather than follow the opposite course, and to refer the history of these different parts to that of the simple systems to which they belong. This method is decidedly the best, at least for those systems which do not form an entire whole, as the vascular and the nervous systems.

§13. The number of systems should be determined after a profound study of the properties possessed by the different parts; since we must admit as many particular systems as we can demonstrate different tissues. But at the same time we must be careful to refer to the same system, all the parts which resemble each other in these different points of view, however great may be the distance between them.

§14. To approach the truth as nearly as possible in this respect, we must clearly distinguish the final forms and the final tissues, to which all the formations are reduced, that is, the laminæ and the fibres, from the forms which proceed from a particular arrangement of the latter, and which appear to constitute so many distinct species, because each of them has less analogy with all the others than exists between those of their parts, which are found in different regions of the body. Sufficient attention is not generally paid to this difference; hence why the forms of the second species have been united with those of the first.

Haller(1) and some other physiologists admit only three tissues, to which all the others are referred; these are the *muscular* fibre, the *nervous* fibre, and the *mucous* tissue. They assert that all the organs which are not formed from the first or second of these fibres, belong to the third division.

This resembles the division of those authors who admit three primitive forms: 1, the *cellular*, or *membranous;* 2, the *vascular*, or

(1) *De part. corp. hum.* vol. i. p. 46.

fibrous; and 3, the *nervous*.(1) These two classifications have the same defect, for if, in arranging the first elements, only the difference of texture is considered, the number of divisions is too great, since the nervous and vascular formations belong evidently to the same class, that of the fibrous organs. But if we attend to the specific differences of the external and internal form, and of the actions, these two classifications are insufficient, because the number of the forms and of the modifications of the vital phenomena is much greater.

The classification of Dumas(2) is more correct; he admits four tissues; the *cellular*, or *spongy;* the *muscular*, or *fibrous;* the *mixt*, or *parenchymatous;* and the *lamellar*, or *osseous*. The first three represent truly the primitive form, although the term *muscular*, given to the second, is badly chosen; but the fourth should be rejected, as the osseous tissue evidently belongs to the second class.

§15. Nevertheless, as these classifications announce only the primitive forms, and consequently may be referred to what has been stated above, (§7,) they are far from removing the differences pointed out between the particular systems. It is less correct also to derive certain systems from others, and hence to regard them as modifications, than to say, *certain systems are extended more generally than others, and contribute to their composition and preservation, while they do not exercise a similar influence upon them.*

With these ideas, Bichat has formed his general anatomy, although his classification is not perfectly correct. He admits *general systems*, and *particular systems;* the first, which are also called *generative*, because they are generally distributed, and concur to form all the others, are six in number: the *cellular*, or *mucous*, the *arterial*, the *venous*, the *exhalent*, the *absorbent*, and the *nervous systems*.(3) He has even increased this number by one, having subdivided the nervous system into the nervous *system* of *animal*, and that of *organic* life. If we unite, as should be done, the second, third, fourth, and fifth, we reduce the systems to three, the *mucous* tissue, the *vascular* system, and the *nervous* system, which, adopting Bichat's meaning, might be called primitive, or general systems, but to which this name is not applicable when we confine ourselves to the acceptation universally received.

Besides these three, we usually establish but a small number of systems, because the general characters of the tissues, in different parts of the body, are neglected, while other tissues, which are composed of very different elements, are considered as primitive; and, in tracing their history, we describe the different parts which concur to form them, but without reflecting that several of these parts, although they do not form a connected and coherent whole, and often differ, even in their external form, do not the less belong to one and the same system, when their most essential properties are considered. Thus a muscle is described as composed of a fleshy and of a fibrous portion, without thinking that the first alone enters into our idea of what a

(1) Walther, *Physiol.* vol. i. p. 97.
(2) *Prop. de phys.* vol. ii. p. 4.
(3) Bichat's General Anatomy, trans. by G. Hayward, vol. i. p. 79.

muscle should be, and that the second belongs not to the muscle only, but also to other and very different parts.

Other systems are then referred to the *bones*, *cartilages*, *ligaments*, *muscles*, and *viscera*. Hence anatomy is divided into *osteology*, to which is joined *chondrology*, as most of the ligaments are blended with the bones, *syndesmology*, *myology*, *splanchnology*, *angiology*, and *neurology*. Nevertheless, this division does not exhaust, by any means, the subject of anatomy. The bones, cartilages, ligaments, muscles, and viscera, are, it is true, essentially different organs: but, first, the class of ligaments is faulty for two reasons: because it comprehends two kinds of different tissues, on the insufficient ground merely that both extend from one bone to another; secondly, because there are several organs, which deserve, as much as the ligaments, to be admitted to that class, even after rectifying it, as it might be amended. Again, the class of viscera, which may safely be called a negative class, embraces organs so dissimilar, that no general characters can be assigned it; and we know not how to retain it, at least, as we do not wish to give it the name of the class of the most complicated organs or apparatus.

§ 16. Here we cannot overlook the services which Bichat has rendered to anatomy, regarded philosophically, and as a science, although we must admit he has made too many classes.(1) He mentions fourteen besides the generative systems,(§ 15,) viz: 1, the *osseous system*: 2, the *medullary system*: 3, the *cartilaginous system*: 4, the *fibrous system*: 5, the *fibro-cartilaginous system*: 6, the *muscular system of animal life*: 7, the *muscular system of organic life*: 8, the *mucous system*: 9, the *serous system*: 10, the *synovial system*: 11, the *glandular system*: 12, the *cutaneous system*: 13, the *epidermoid system*, and 14, the *pilous system*.(2)

Among these systems, we suppress the medullary system, which is the same as the cellular tissue, and the synovial system, a slight modification of the serous system: the two muscular systems should be

(1) Bichat gen. anat., Vol. ii. p. 141.

(2) It may be well to mention how modern physiologists and anatomists have divided the organic tissues since Bichat.

Walther thinks that all the tissues are derived from the *cellular*; and that they proceed from this primitive tissue in two series: one comprising the *serous and synovial membranes*, the *mucous membranes* and *glandular tissue*, the *dermis*, *epidermis*, the *horny* and *pilous tissues*: the other, the *muscular tissue*, the *fibrous membranes*, the *fibro-cartilages*, the *cartilaginous*, and *osseous tissues*.—(*Darstellung des Bichat'-schens systems*: in Schelling and Marcus, *Jahrbüchen der Medicin*.) Vol. ii. P. i. p. 49.

Dupuytreyn has diminished the number of tissues admitted by Bichat, and has added one very important, which Bichat had omitted: 1, the *cellular system*: 2, the *vascular system*, *arterial*, *venous*, and *lymphatic*: 3, the *nervous system*, *cerebral*, and *ganglionic*: 4, the *osseous system*: 5, the *proper fibrous system*, *fibro-cartilaginous*, and *dermoid*: 6, the *muscular system*, *voluntary* and *involuntary*: 7, the *erectile system*: 8, the *mucous system*: 9, the *serous system*: 10, the *horny system*, *pilous*, and *epidermoid*: 11, the *parenchymatous system*, *properly so called*, and the *glandular*.

Chaussier divides the parts of the animal body as follows: 1, the *bones*: 2, the *articular cartilages*, of *prolongation*, of *ossification*: 3, the *muscles*: 4, the *ligaments*: 5, the *vessels*: 6, the *nerves*: 7, the *vascular ganglions*, *glandiform bodies*: 8, the *simple follicles*, or *crypts*, *proximate*, *compound*: 9, the *lachrimal*, *salivary*, and *mammary glands*, the *pancreas*, *liver*, *kidneys*, and *testicles*: 10, the *lamellar*, *muscular*, *albugineous*, *simple villous*, or *serous*, *compound villous*, or *follicular*, and *coriaceous membranes*, and *epidermis*: 11, the *lamellar* or *cellular*: 12, the *viscera*, the *digestive respiratory*, *circulatory*, *urinary*, and *genital organs*, and those of the *senses*.—(*Table synoptiques des solides organiques*.)

united. We ought not to separate the fibrous system from the epidermoid system, which, perhaps, should be joined to the dermoid system. Finally, all the probabilities authorize us to unite the dermoid,

H. Cloquet admits fifteen tissues, viz: *cellular tissue, membranes, vessels, bones, cartilages, fibro-cartilages, ligaments, muscles, tendons, aponeuroses, nerves, glands, follicles, lymphatic ganglions*, and *viscera*.—(*Cloquet's Anatomy*, Boston, 1830.)

Lenhossek numbers only eight tissues: 1, the *cellular tissue*: 2, the *mucous, serous, fibrous*, and *mixed membranes*: 3, the *cutaneous system*, including the *epidermis, nails*, and *hair*: 4, the *vascular, arterial, venous, capillary*, and *lymphatic system*: 5, the *nervous system*: 6, the *muscular system*: 7, the *glandular system*: 8, the *osseous system*, with the *cartilages* and the *medulla*.—(*Physiologia medicinalis.*)

Mayer also admits eight: 1, the *lamellar*, or *albugineous tissue, tissue of the crystaline* and *cornea, epidermis, hair*, and *nails*: 2, the *cellulo-fibrous, cellular, adipose, medullary, serous, synovial tissues*, and *that of the vascular membranes, dermoid system, system of the mucous network, tissue of the uterus*: 3, the *fibrous tissue, proper membranes of the glands, of the spleen* and *kidneys; albugineous membrane of the testicles, tissue of the corpora cavernosa, tissue of the sclerotica, of the dura-mater*, and *of the periosteum*, the *perichondrium, fibrous articular capsules, ligaments, aponeuroses, tendons, neurilema*: 4, the *cartilaginous tissue of organic life*, or *fibro-cartilage*, that of *animal life*, or *articular cartilage*: 5, the *osseous tissue*: 6, the *glandular tissue*: 7, the *muscular tissue*, and, 8, the *nervous tissue*.—(*Ueber Histologie und eine neue Eintheilung der Gewebe des menschlichen Kœrpers*, Bonn, 1819.)

Rudolphi divides the solid parts into *simple* and *compound*. The *simple* parts are: 1, the *cellular tissue*: 2, the *horny tissue*, which comprises the epidermis, epithelium, nails, and hair: 3, the *cartilaginous tissue*: 4, the *osseous tissue*: 5, the *tendinous fibre*: 6, the *vascular fibre*: 7, the *muscular fibre*: 8, the *nervous fibre*. The *compound* parts are: 1, the *vessels*, both *general* and *special*; the *former* comprising the arteries, veins, and absorbents, and the *latter*, the *special canals* of the *excretory organs*, as the biliary, salivary, urinary, and seminal ducts: 2, the *membranes*, which are also divided into *general*, as the serous, mucous, and fibrous, the dermis and epidermis; and *special*, as the membranes of the ovum, of the eye, and encephalon: 3, the *viscera*: 4, the *glands*.—(*Grundriss der Physiologie*, Berlin, 1821.) *See also* C. A. Rudolphi, *Programma de corporis humani partibus similaribus*, Grispwald, 1809; and S. J. Bugaiski, *Dissertatio de partium corporis humani solidarum similarum aberrationibus*, Berlin, 1813.

J. Cloquet classes the tissues of the human body as follows: 1, the *cellular system*: 2, the *adipose system*: 3, the *vascular system*: 4, the *nervous system*: 5, the *serous system*: 6, the *mucous system*: 7, the *ligamentous system*: 8, the *elastic system*: 9, the *cartilaginous system*: 10, the *fibro-cartilaginous system*: 11, the *osseous system*: 12, the *muscular system*: 13, the *erectile*, or *cavernous system*: 14, the *glandular system*: 15, the *horny system*.—(*Anatomie de l'homme, ou Description et figures lithographiées de toutes les parties du corps humain*, Paris, 1821.)

Heusinger refers all the organic tissues to eleven: the *formative*, or *cellular*, the *horny*, the *cartilaginous*, the *osseous*, the *fibrous*, the *membranous*, the *nervous*, the *serous*, the *vascular*, the *parenchymatous*, and the *glandular*.—(*System der Histologie*, Eisenach, 1822.)

Ducrotay de Blainville admits a *generative element*, the cellular, or absorbent tissue, and two *secondary elements*, the muscular, or contractile fibre, and the nervous, or exciting fibre. By slight modifications, the cellular tissue produces nine systems: the *dermoid, mucous, fibrous, fibro-cartilaginous*, and *cartilaginous, osseous, serous, synovial, arterial, venous*, and *lymphatic*. The first secondary element produces three systems, the *subdermoid muscular, submucous muscular*, and the *profound muscular*: and the second secondary element forms four: the *pulpous ganglionic*, the *apulpous ganglionic*, the *nervous system of animal life*, and the *nervous system of organic life*.—(*Principes d'Anatomie comparée*, Paris, 1822.)

Beclard admits 11 classes of tissues: 1, the *cellular and adipose tissue*: 2, the *serous membranes*: 3, the *tegumentary membranes*: 4, the *vascular system*: 5, the *glands*: 6, the *ligamentous tissue*: 7, the *cartilages*: 8, the *osseous system*: 9, the *muscular system*: 10, the *nervous system*: 11, the *accidental formations*.—(*Elémens d'anatomie générale*, Paris, 1823.)

We may also consult, in regard to similar parts, or simple tissues of the animal economy, Fallopia, *De partibus similaribus humani corporis*, Nuremburg, 1575.—Malacarne, *I sistemi e la loro reciproca influenza indagati*, Padua, 1803.—Prochaska, *Bemerkungen über den Organismus des menschlichen Kœrpers*, Vienna, 1810.—Mascagni, *Prodromo della grande Anatomia*, Florence, 1819: Milan, 1821, 4 vols.

F. T.

muscular, and glandular systems. Thus the twenty-one systems admitted by Bichat, are reduced to twelve, and even to ten, viz: the *mucous*, *vascular*, *nervous*, *osseous*, *cartilaginous*, *fibrous*, *fibro-cartilaginous*, *muscular*, *serous*, and *dermoid* systems.(1)

These will be examined in the general anatomy, according to their general conditions, and in the special anatomy, topographically, or according to their local relations; when the general considerations of the organic form, including the human form, shall have been first given.

§17. The general laws of the organic form, and hence those which belong to man, are as follows: first, *the outline is not sharp and angular, but rounded.* This law is true, both in regard to the form of the whole body, as well as to that of each of its organs, and its smallest elements. The roundness of the form usually depends upon the fact, that all the solids are accompanied with fluids, for the first effect of solution is to smooth down the angles of solid bodies. We mention, as examples, the round form of the cavities of the body, of the viscera, vessels, nerves, muscles, bones, &c.

§18. II. *The dimension of length exceeds the others.* This law, already mentioned above; (§9,) is seen no less in the body as a whole, and in the external form, than in the internal form, or the texture of its parts. The whole length of the body, much exceeds its breadth and thickness. It is divided into three principal regions, the *head*, *trunk*, and the *limbs*, or *extremities*. Of these, the head alone is round, but it is only the upper and bulging extremity of the vertebral column, that is of the osseous base of the trunk, in which the dimension of length evidently predominates. This column is enveloped by lateral expansions, producing cavities designed to lodge the apparatus placed before them, but it is not entirely concealed. The excess of length is most manifest in the extremities, generally, and in their different parts. It is the same with all the particular systems. The dimension of length much exceeds the other two in the vascular and nervous systems. It is especially marked in the hair. The number of the long bones, muscles, and fibrous organs, is much greater than of those which are broad or thick. The intestinal canal, the trachœa, ureters, urethra, &c., are very narrow in proportion to their length.

This rule applies exactly to the texture, since the fibrous is the most common of all, and every large fibre is divided into an endless multitude of others which gradually become smaller and smaller.

§19. III. *The structure of the organism is radiated.* From the central parts, which are largest, originate others, which are smaller, which move in all directions, and in which the dimension of length especially predominates. Thus the extremities arise from the trunk: the long, and narrow ribs, from the spine; the nerves, from the brain, spinal marrow, and ganglions, the vessels from the heart. But, besides these grand centres, from which the rays commence, there is an infinite number of the second order, since each ray usually divides into several,

(1) Perhaps it would be better to suppress, not only the fibro-cartilaginous system, which is a mixed, or compound tissue, as its name indicates, but also the serous system, which has the same relations with the mucous, or cellular tissue, as exists between the dermoid and epidermoid, which Meckel has very properly united. F. T.

which, in some systems, particularly the general, as that of the nerves and vessels, also, in *their turn* subdivide. The rays then *ramify*.

Another general law is, that the number of rays augments as they depart from the principal centre of radiation, and their volume diminishes in the same proportion. Thus, instead of one long bone, as in the arm and thigh, we find two, which are smaller, in the forearm and leg, twenty-six in the foot and twenty-seven in the hand, still smaller. The number of the muscles and tendons inserted into the bones, and of the ligaments, multiplies in the same manner, and they diminish in size in the same ratio. In the whole course of the nervous and vascular trunks, branches and twigs are constantly sent off in every direction, at different angles, and at certain distances from the principal trunks they divide into others still smaller, which are themselves again subdivided.

This division is true, not only in respect to length, and from without, inward: it also occurs in the thickness of the organs; for the muscles and nerves represent bundles composed of cords, which are, in their turn, formed of fibres and filaments.

§ 20. IV. At the side of this *law of ramification* proceeds another, *the law of anastomosis*. These rays, it is true, subdivide a great many times, but the subordinate rays which result from this division, unite in different ways with each other, and with the principal ray. The same remark is true in regard to the continuity, that is, to the thickness of the organs; for these anastomoses take place from above, downwards, and also from within, outwards. The different trunks, branches, and twigs of the nerves and vessels, the different tendons of the same muscle, the simple fibres, their fasciculi, both large and small, in the nerves, or at least in many muscles, the fibres of the bones, and those of the fibrous organs, mutually anastomose together. We can, to a certain extent, mention here those bones placed side by side, which, in addition to the ligaments necessary to keep them in place, are connected by interosseous membranes.

§ 21. V. *These rays are not straight, but usually more or less curved.* This law, which has been termed *the law of the spiral line*, is seen in the vertebral column, which describes several curves; it is confirmed also by most of the long bones. The cochlea, semicircular canals, several vessels, excretory ducts, and nerves, are also examples. Finally, this is sometimes seen very evidently in the double monsters: since, when two heads are placed side by side, or two bodies are united by a head, the direction of these two bodies or two heads is always different; so that the monster, considered as a whole, appears spiral.

§ 22. VI. *The different organs are somewhat analogous.*(1) It has already been stated (§5) that the texture of the most dissimilar organs can be reduced to two elements of form, which are generally united; we have there indicated the analogy which exists between the final structure of the organs, and to which many writers have wrongly given still more extent. As the structure of almost all the organs is radiated, (§19,) it follows that the analogy of their external form is demon-

(1) See our *Memoir on the analogy of organic forms*, in our *Beytræge zur vergleichenden Anatomie*, vol. ii. p. 2.

strated. It exists even where there is no manifest radiation; since we there remark parts first dilated, and others which are contracted. Thus, the brain is joined to the spinal marrow, the vertebral column to the skull, the vascular trunks to the heart, the esophagus to the buccal cavity, the intestinal canal to the stomach, the trachea to the larynx, the cystic duct to the gall-bladder, the ureter to the pelvis of the kidney, and the urethra to the bladder.

Another great analogy between the different systems is established by the circumstance that those which vary the most from each other are formed after the same type in the same parts of the body. Thus, the simple trunk of the arteries of the superior or inferior extremities is almost always divided into two different branches, at the place where the number of bones is doubled; in general, the divisions and unions correspond exactly in the different systems situated near each other. The number of the arteries destined for the fingers and toes is the same as that of these appendages. The nervous trunks and the vessels anastomose in the palms of the hands and soles of the feet. In the same manner, the tendons of the flexor and extensor muscles of the fingers and toes are united by mucous and tendinous slips. The different parts of the nervous system and of the vascular system proceed together.

The whole form of the body is repeated not only in those systems which are generally diffused in the entire economy, and which form a whole more or less continuous—as the cellular tissue and the nervous, vascular, osseous, and muscular systems—but also in each of the organs. We should refer to this the form already pointed out as belonging to so many systems, the peculiarity of which is an enlargement at one extremity and a continuation into a narrower process at the other. We must refer to this also the manner in which most of the organs, and principally the glands, receive their vessels. In fact, we always observe a considerable depression, a fissure, about the centre of these organs, through which the vessels enter and emerge exactly as in the fetus. Here the organ is open to a certain extent, and is much more so the nearer it is to its formation, exactly as in the fetus, which at first is open entirely before.

The peculiar analogy of certain systems is still greater. This is seen particularly in the genital organs and the intestinal canal.(1)

§ 23. VII. *The body is formed symmetrically.* We find an analogy, and even a resemblance to a certain extent, not only between the different organs, but particularly also between their different regions.(2) This analogy may be demonstrated, both in the breadth, and in the length, and thickness, or even between its right and left sides,(3) between its upper and lower extremities,(4) and between its anterior

(1) A. A. Meckel. *De genitalium et intestinorum analogia*, Halle, 1810. Trans. in J. F. Meckel's *Beytr. zur vergl. Anat.* vol. ii. p. 2. No. 1.

(2) J. F. Meckel, *loc. cit.* p. 95.

(3) Du Pui, *De homine dextro et sinistro*, Leyden, 1790.—Heiland, *Darstellung der Verhæltnissen zwischen der rechten und linken Hælfte des menschlichen Kærpers*, Nuremberg, 1807.—Loschge, *De sceleto hominis symmetrico.*—Erlangen, 1795.—J. B. Monteggia, *Fasciculi pathologici*, Turin, 1793: *morbi symmetrici et asymmetrici.*—Mehlis, *De morbis hominis dextri et sinistri*, Gœttingen, 1818.

(4) Vicq-D'Azyr, *Sur les rapports qui se trouvent entre les usages, et la structure*

and posterior faces.(1) We must here remark generally, that the *similitude is never perfect*, and that usually one extremity predominates, more or less, over the other. This is sometimes expressed by the greater volume, and sometimes by the greater development in the radiation of corresponding parts. Nor is the symmetry equally great in all directions, nor between the different corresponding regions. The most perfect is the lateral symmetry, or that of the two sides of the body; and the most imperfect, that of its anterior and posterior faces. The nervous, osseous, ligamentous, and muscular systems, and the genital apparatus, are the most symmetrical parts; we find less symmetry in the vascular system and in the thoracic and pelvic viscera, if we except the genital apparatus.

§ 24. 1. The *most perfect lateral symmetry* is in the external form, and on the surface of the body. Hence, it is better known there. In fact, the body seems to be composed of a right and a left half, since most of the organs are *double*, and those which are single, are placed more or less on the median line, so that a plane drawn from before backward, would divide them into two nearly equal parts, as they are formed of two lobes united and blended on the median line. These latter, when placed between cavities, form *septa;* and on the contrary, are called media of communication, *commissures*, when placed between two corresponding parts, which are otherwise separated.

Similar arrangements are found in all the systems, and we may say with justice that a commissure exists more or less perceptibly in all the body, although it is often interrupted; this, at the same time, forms a septum between the right and left sides.(2) Thus, the falx cerebri descends from before backward, from the centre of the skull; and the internal ridges of the frontal and occipital bones correspond to it. Below it, is the corpus callosum which unites the two hemispheres of the cerebrum; below, is the septum lucidum, formed of two layers closely applied to each other, and which represent in the brain what the falx and spinous ridges have in the skull. The nasal cavity is divided into two parts by a partition, which is bony above and behind, and cartilaginous before; the former of these portions being formed by a part of the os ethmoides, and by a particular bone, the vomer. The frena of the lips in front, and the uvula behind, represent this septum in the mouth. In the chest, the internal parietes of the pleuræ, which partly touch, and are partly separated by organs placed between them, form the anterior and posterior mediastina, and thus establish a line of demarkation between the two halves of the thoracic cavity. A longitudinal septum, generally perfect, exists between the right and left sides of the heart. This septum is only indicated in the abdomen, where the two halves seem blended together; the division has been destroyed, or its

des quatre extrémités dans l'homme et dans les quadrupèdes; in *Mém. de Paris*, 1774, vol. ii.—Meckel, *loc. cit.*, p. 97—148.—Falguerolles, *De extremitatum analogiâ*, Erlangen, 1780.

(1) Meckel, *loc. cit.*, p. 148.

(2) F. L. H. Ardieu, *Considérations sur la ligne médiane*, Strasburg, 1812.

formation has been prevented, by the considerable mass of organs which are inclosed by this cavity. We trace it, however, forward and above, in the suspensory ligament of the liver which extends from the inferior face of this gland to the umbilicus, and below, in the analogous but less extensive fold of the peritonœum, which reaches from the bladder to the umbilicus, covering the remains of the obliterated umbilical artery and urachus; and finally, behind, in the other fold of the peritonœum, which goes from the anterior face of the lumbar vertebræ to the intestinal canal, and which is called the mesentery. On the median line of the penis in the male, and of the clitoris in the female, we find a perpendicular septum. The corpus spongiosum of the penis, and the septum and the raphe of the scrotum in the male, are situated exactly on the median line. The cellular tissue, which unites the skin to the subjacent parts, is thicker in all regions of the body on the anterior and superior, than on the posterior face. The vessels frequently anastomose together on the median line, as is seen in the coronary arteries of the lips, the sinuses of the medulla spinalis, and the cerebral arteries, which, supplying the two hemispheres of the brain, unite by numerous transverse branches. So, likewise, the two vertebral arteries unite on the median line, to produce the basilary, and the anterior and posterior spinal arteries descend along the spinal marrow. Several sinuses of the dura mater exist on the median line of the skull. The aorta, venæ cavæ, thoracic canal, the azygos vein, and partly even the esophagus, describe a curve, which corresponds very nearly to the median line of the thoracic and abdominal cavities.

The vertebral column, sternum, occiput, os frontis, os ethmoides, and os sphenoides, are those parts which are unmated and distinct, and serve to join the corresponding parts of the same system, as they are united with them, and wedged in by them. Those bones which meet on the median line, but remain always distinct, although united by an intermediate substance, as the ossa parietalia and ossa ilia, form the connecting link between them and those which do not touch in the least.

The brain and spinal marrow, the heart, womb, vagina, prostate gland, bladder, urethra, thyroid, and thymous glands, the intestinal canal, the trachea, larynx, and tongue, are unmated, but are formed of two similar portions, between which the median line passes, at least to a certain extent.

All the other organs are mated, and are rarely united by their own proper substance. They are connected in various ways. Thus the kidneys lie on each side, and are united above by the blood-vessels, and below by the ureters, which go to the bladder. The lungs are joined above both by the trachea and pulmonary blood-vessels, while the extremities are perfectly insulated, or at least are united only at their upper ends, where but a small number of parts are found belonging to them in common.(1)

(1) See a note by J. F. Meckel, on the differences between the right and left portions of the body, in respect to the proportional size of the arteries and veins, in *Deutsches Archiv. für die Physiologie*, vol. i. p. 450.

§ 25. 2. The *symmetry* of the *upper and lower parts* of the body is less than than that of the lateral portions; but it cannot be mistaken. It is especially seen in the pectoral and abdominal members, where it is indicated by the number of subdivisions which they include. The form and number of the parts of the different systems, which contribute to form the members, are the same in all, except some slight differences, which depend for the most part upon the difference of functions performed by the superior and lower extremities, so that one cannot doubt but that these are constructed after the same type, even in man. The upper and lower regions of the central parts of the whole body also correspond, when the head and trunk are supposed to be united. To the central part of the vertebral column alone are attached peculiar and distinct bones, called ribs. Next come, above and below, vertebræ without ribs; above are the cervical, below the lumbar, the number of each being less than that of the dorsal. To the former is annexed the head, to the latter the sacrum, which is, like the head, an aggregation of large vertebræ; these are similar to each other, partly in their increase of size, and also because they unite more slowly, and sometimes do not fuse upon the median line, because the number of pieces of which each is composed has become more considerable, because they are more solidly united to each other; and finally, because they are fused together, and articulate with moveable bones—the coccyx below, the lower jaw above. Hence, we may consider them as imperfect vertebræ, since the first represents the arch, the second the body of the vertebra.

The upper and lower parts of the body correspond manifestly also in the energy with which hair is there produced. We may especially compare together the hairs of the beard, of the nose, and genital parts, which surround the upper and lower openings of the intestinal canal, and the apparatus connected with it, since they appear in the same places, and are or are not developed under the influence of the same conditions.

But the two extremities of the intestinal canal, and the organs which are there annexed, also correspond.

The intestinal canal commences above by a considerable dilatation, the buccal cavity and the pharynx; next comes the esophagus, the muscular parietes of which are attached to the adjacent bones, and are susceptible of voluntary motion. The same arrangement is observed in its inferior extremity, the rectum, which continues above with the colon. The parietes of those two extremities also are provided with very strong muscular fibres. The same thing occurs a second time in the remainder of the alimentary canal, and two new expansions are remarked; the superior is the stomach, which is continued with the small intestine; the inferior, the colon, and still farther, the cœcum, which opens in the same manner with the large intestine.

Farther, in the upper and lower parts of the body there are several organs which manifestly correspond. The respiratory apparatus may be compared with the urinary apparatus; and the thyroid and thymous glands, the tongue, and the nose, correspond to the genital parts.

The first comparison is established more easily than the second. The principal organs of the two apparatus, the lungs and the kidneys, are similar: first, in number, they are two: second, in situation, they are separated one from the other—are not inclosed in a common sac, and are placed along the vertebral column: third, in their mode of connection; for they are united by large vessels which enter them, and canals which come from them, all of which are united on the median line, the lungs by the trachea, and the kidneys by the ureters and urethra: fourth, by their structure; apart from the general conditions presented by the texture of the glandular organs, the formation of the cellules of the lungs is represented by the size of the vessels which secrete the urine, and of the large or small cellules so commonly found in the kidneys.

The genital parts and the other organs may be compared, and a parallel drawn between them from structure and functions. The thymous gland, which is composed of two lateral lobes more or less evidently separate, corresponds to the ovaries and testicles in its glandular structure, and in its situation, since it is the deepest of all. The thyroid gland, an unmated organ, is placed much higher and more externally, and represents the prostate gland with the vesiculæ seminales, and the uterus. The external and internal form of the tongue, the abundance of its vessels and nerves, the development of these vessels and of these nerves in papillæ, the nature of its epidermis and, finally, the arrangement of its muscles, vessels, and nerves, resembles the glans penis, and clitoris. So, too, with the nose and larynx; the first may be compared with the urethra and vagina, in regard to its structure, its texture, and its functions. With regard to the larynx, the powerful influence of the state of the genital parts upon the bosom and on the voice, already assures us that we may compare it to these organs, but as it fulfills peculiar functions, we ought not to expect to find in the lower half of the body any thing exactly corresponding to it.

Besides the analogies already indicated between the upper and lower halves of the body, they correspond: *a.* in the arrangement of the vascular system. The aorta and venæ cavæ are distributed in almost the same manner, and form, above, the vessels of the head and upper extremities, and below, those of the pelvis and lower extremities.

b. In the arrangement of the nervous system: the cerebral nerves, and even one of the spinal nerves proceed from behind, forward, while the direction of those of the spinal cord, except the upper, which move somewhat obliquely, is from before, backward. The spinal marrow, after giving off the spinal nerves, is prolonged, and sometimes bulges like a button, which corresponds to the brain.

c. In the arrangement of the muscular system: since several of the muscles of the back and belly are repeated in the upper and lower parts of the body.

We have already remarked that the greatest analogy exists in the arrangement of all the systems which unite to form the *extremities.*

The diaphragm forms between the upper and lower parts of the body a partition resembling the median line. (§ 24.)

§ 26. 3. The more obscure analogy between the *anterior and posterior faces* of the body is generally neglected for that which is seen in the two directions above mentioned. However, we must point it out, although the external face of the body offers but few faint traces of it.

The vertebral column is evidently represented on the anterior face of the body by the sternum, since this bone closes the cavity of the chest before as the vertebral column closes it behind. The sternum corresponds particularly to the centre or pectoral portion of the vertebral column; nevertheless, it extends both above and below, beyond the cartilages of the ribs with which it is united, and as it is shorter than the pectoral portion of the spine, so that, in regard to one dimension, it represents only an imperfect spine, the upper and lower extremities, which do not support any ribs, are incomplete imitations of the cervical portion and of the lumbar portion of this column.

The costal cartilages represent also the false ribs, since they remain always behind the true ribs, either in their smaller size or in their texture and chemical composition.

In the anterior part of the abdomen there are no bones to correspond to the vertebral column; but the linea alba, that strong tendinous cord which extends along the median line from the sternum to the pubes, certainly represents it.

The internal mammary and epigastric vessels on the anterior face of the trunk, correspond to the large vascular trunks which descend along the vertebral column; and the medulla which passes through the spine, resembles the grand sympathetic nerve situated before this column. This law is recognized also in the doubleness of each lateral half of the spinal marrow which is itself composed of an anterior and a posterior cord, in the existence of an anterior and posterior series of roots of the spinal nerves, and in the division of the encephalon into the cerebrum and cerebellum. In the same manner the frontal and occipital bones correspond before and behind. In the spine, the arched ribs before, resemble the vertebral arches behind, and the more so, as the latter are developed by separate points of ossification.

The analogy extends also both to the trunk and limbs, between the extensor and flexor muscles, in respect to number, size, form, situation, and mode of insertion.

§ 27. We have said above (§ 23) that the symmetry is not perfectly regular. We have explained the possibility of this fact, and its reality is already in part proved by the details into which we have entered. A glance at the different systems, and at the different regions, will prove that the differences we have mentioned really exist. The osseous and ligamentous system, as also that of the voluntary muscles and the nerves associated with them, appear to be essentially formed of two exact halves, which correspond so closely, in volume, form, and situation, that they are almost perfectly similar. On the contrary, the vascular system, the grand sympathetic nerve, the organs of respiration, of digestion, and of the urine, are not symmetrical. The heart is not placed perpendicularly but obliquely, so that its septum does not correspond to the axis of the body. In its two portions we see the same divisions and the same general arrangement; but they differ much in capacity, and in the thickness of their parietes. The vascular trunks which belong to these two parts correspond neither in external nor internal form, nor in destination. The vascular system, considered as a whole, is composed of four trees united by the heart: these are the arteries and veins of the body, and the arteries and veins of the lungs. The first two trunks, as well as the last two, accompany each other, but neither the two parts of each tree, nor the portions of different trees which proceed together, perfectly resemble each other. The trunk of the aorta is not placed exactly on the median line, but is found, first on the right, and then on the left of the vertebral column. Hence it is arched. From this arch the carotid and subclavian arteries arise by a common trunk on the right side, while they have separate origins on the left. The large vessels of the right and left sides are very seldom alike in their origins, volume, and rout. The two venæ cavæ incline to the right; on the same side we find between them the azygos vein to which the small vein of the same name corresponds, but imperfectly on the left side. The two arteries of the heart arise each by a single trunk from their respective ventricles; but the pulmonary veins, when they arive at their auricle, are four in number, while those of the body are only two. So, likewise, we almost always see three or four veins corresponding to a single secondary arterial trunk.

The two lungs have neither the same volume nor the same form: the right lung is larger than the left, and is composed of three lobes; and its bronchia is shorter, but broader. For this reason, and also on account of the obliquity of the heart, the anterior mediastinum is directed obliquely from above downward, and from right to left.

If we extend our observations to the digestive system, we see the esophagus inclines more to the left than to the right, and that the stomach occupies the left side, whence it extends obliquely to the right, and near its left portion is the spleen, which, even when connected with the pancreas also situated more to the left than the right, corresponds but slightly to the liver, which, with its voluminous mass, fills all the upper parts of the right portion of the abdomen. The mesentery extends from above downwards, and from right to left. The large intestine continues with the small intestine, not on the median line, but on the right side; its right and left halves do not correspond. The kidney and capsula renalis of the right side are situated lower than those of the left, and have not exactly the same form: their blood-vessels and their excretory ducts are rarely arranged in a similar manner. The genital organs are more symmetrical; nevertheless, one testicle is sometimes larger than the other, and sometimes one remains in the abdomen, when the other descends into the scrotum. The direction of the womb is often oblique, which does not arise from accidental circumstances.

The least symmetrical organs correspond, however, in this respect, that they are formed at least of two similar halves. The digestive apparatus presents so little symmetry only because this want of symmetry is necessary from its length, and the functions it executes. Its whole extent may be divided into two nearly similar parts, which, setting aside its cylindrical form, are well indicated by the arrangement of the vessels. In fact, in almost its whole length, that portion of its circumference which is turned towards the mesentery, and in some parts especially, as the stomach, two opposite portions of the same circumference receive vessels which ramify uniformly, and which, proceeding each upon one of the portions of this canal, anastomose opposite their point of commencement.

Hence why the lateral parts of the least symmetrical organs resemble each other so much that the lateral symmetry is more perfect than the others, and the parts which correspond laterally execute precisely the same functions. Hence especially this more distinct symmetry, which in several respects, is indicated in other directions so obscurely that it is not perceived by one unaccustomed to tracing analogies, and who knows not how important it is to determine them when we wish to explain the cause of the phenomena of formation.

But the want of perfect symmetry may usually be explained by the law above mentioned, (§ 23,) and, in accordance with which, one of two opposite corresponding parts is almost always more developed than the other. All the right side is larger than the left. The right portion of even the most symmetrical organs is larger than the left. The larger lung and the liver are placed on this side. The common trunk of the right carotid and subclavian arteries seems to be produced by a greater energy of the formative power. The cerebrum develops itself at the expense of the cerebellum, and the inferior part of the spinal marrow offers hardly a trace of expansion which may be regarded as corresponding to the brain. Where such marked differences exist, we see another organ very largely developed in the parts where the system is so considerably diminished, of which there is scarcely a trace on the opposite side. The spinal marrow terminates rather high in the vertebral column, although we see appear in the pelvis, and in front of the sacrum which corresponds to the cranium, (§ 25,) a special apparatus, that of the genital system, which very much resembles the nervous system in structure and functions.

On the contrary, on the opposite side, at the upper extremity of the body, where the brain so remarkably predominates, the generative system is but imperfectly indicated ; for, first, the different parts here situated are not united in a single body, as constantly happens when the development of parts, which, if regularly formed, constitute a whole, is disturbed and cannot be perfected ; secondly, these different parts have not a common function, since the tongue belongs to the digestive, and the nose to the respiratory system, while the thyroid and the thymus glands are not included in any.

The differences between the organs which are here compared are such as to oblige us to enter upon a more profound examination, in order to prove that the analogy established is not forced. We have said that the genital system corresponds, partially at least, with the brain, or, perhaps more exactly, with the nervous system.

Our arguments are :

1st. This proposition is rendered very probable by the functions of the two apparatuses. The nervous system is the principle of all life and of all formation in the organism. The existence of the individual is more closely connected with the integrity of its central parts than with that of any other organ. A similar relation exists between the principal parts of the generative system and the life of the species. We may even, and with justice, say that the generative system has the same effect on the formation of the individual, when we reflect upon the remarkable modifications its presence or absence produces in the activity of the mind and of the body.

2d. The form of these two systems argues in favor of this opinion. The remarkable exception made, by the perfect symmetry of the genital organs, to the common arrangement of the other organs with which they have some affinity, must be mentioned. The round form of the ovaries and testicles also furnishes a point of comparison. The texture of the testicles and brain is very analogous, since both are formed of very delicate fibres, similar in flavor and chemical composition. The dura mater forms septa between the two hemispheres of the brain, and between the cerebrum and the cerebellum, which partially resemble the septum of the scrotum, and partly those found in the substance of the testicle, which are formed by the prolongation of the tunica albuginea. The corpus highmorianum, which arises from the testicle by numerous roots, may be compared to the spinal marrow ; it opens externally on each side by an excretory canal comparable to the nerves, although the brain and spinal marrow are necessarily connected with the organs by several rays. But few lymphatics arise from the brain and the spinal marrow, while very many originate in the testicles, in order to strengthen the influence which those organs have on the body. We ought also to remark that the arrangement of the blood-vessels in the brain and testicles is very analogous, since in both the circulation of the blood is evidently retarded.

3d. The study of these organs comparatively in the animal series presents still more points of agreement, of which we shall mention only one of the principal, the development of one of the two systems accompanied by the wasting of the other.

We have already stated (§ 25) several arguments which justify the comparison established between the genital parts and those organs situated in the upper half of the body, the development of which appears to be restrained in part by the brain, as that of the lower extremity of the spinal marrow is checked by the genital system. It might be objected that the uses of the tongue relate to the functions of the alimentary canal, and so with the nose, which is very intimately connected with the organs of respiration. But on one side, the genital system is only developed out of the alimentary canal; and again, the senses of smelling and of taste are at least as closely connected with the sexual appetite as with that for food. We shall avail ourselves of this favorable opportunity to explain the difference between the upper and lower extremities of the body, relatively to the arrangement of the two extremities of the alimentary canal and of the organs near them. Below, the canal is entirely separated from the genital and urinary systems blended together; above, on the contrary, it unites with the respiratory system, and the tongue inclosed in the buccal cavity corresponds to a part of the genital apparatus. This arrangement depends partly on the analogy between the genital and digestive systems, and partly on the fact that the epiglottis and velum palati form septa, which, by changes in their direction, can separate the nasal cavity and the trachea, and consequently the organs of respiration, from the buccal cavity, and even from the pharynx, and necessarily from all the digestive apparatus.

The form, situation, texture, and liability to the same kind of disorganization, justify the comparison established between the thyroid gland and the womb, or prostate gland. That the thymus gland corresponds to the testicles and ovaries, is known from its similarity in form, situation, texture, the analogy of the fluid secreted, and the circumstance that its activity ceases when the testicles or ovaries come to maturity.

The differences between the anterior and posterior faces of the body, which we have compared together, are reconciled in the same manner. All the posterior or dorsal half is more completely developed and more strongly marked than the anterior. The occipital is thicker than the frontal bone, and the bones of the skull are generally stronger than those of the face. The face is naked, while the skull, especially behind, is thickly covered with hair. The muscles are more numerous and stronger along the spine than along the sternum. The sternum is formed like an imperfect spinal column; as it represents only the anterior part the bodies of the vertebræ properly speaking, and corresponds to the lower extremity of the spine, to the coccyx. The linea alba is still more imperfect and feeble. The ribs ossify; the costal cartilages do not ossify, or but rarely, and at an advanced age. The posterior part of the ribs is, in its turn, much stronger than the anterior. The ribs below the tenth belong properly to the spine. An artery winds on each side along the rudiment of the anterior vertebral column, and corresponds to the aorta, which is placed before the proper spine; the whole in conformity to the law, that formations of an inferior order are characterized by a want of concentration.(1)

(1) See our remarks on the progressive advancement of the organization, or on the difference between the formations of a superior and inferior order, in our *Beytræge zur vergleichenden Anatomie*, vol. ii. part 1, Leipsick, 1811.

Notwithstanding these adjustments, corresponding parts, even the right and left halves of the body, always differ essentially. The symmetry is, then, *not* perfect. The organization of man has no advantage in this respect over that of animals, notwithstanding what Heiland intimates when he says that the dualism (lateral) is particularly marked in the human body.(1) So far is this from being true, that the farther we proceed from man, the more distinct is the lateral symmetry, with a few exceptions. For not only do the organs, which are but slightly symmetrical in him—for instance, the heart, some parts of the vascular system, the respiratory system, the urinary system, and digestive system—become more and more so as we descend the scale, but even the organs most symmetrical in man, as the nervous system, and the brain especially, become still more so in animals.

§ 28. The conditions enumerated form the object of an anatomy, which compares a body with itself, considering it only in reference to its different parts. But this body may be compared with itself, considering it in time, that is to say, in regard to the different periods of its existence.

VIII. *No organ possesses precisely the same qualities at all periods of the existence of the organism.* There are none which are alike at all periods of their existence. Each organ, and consequently the whole organism, passes through certain regular and normal stages.(2) This very important law, called the *law of development*, gives rise to the following considerations:

1. There is for each organ, and for the whole organism, a period of imperfection, in which the whole development is not attained; this is called the period of *youth*, or *infancy;* a second called that of *mature age*, or *period of maturity*, *of perfection;* and a third, that of *old age*, or *of decline.*

2. *The resemblance is much greater between different organs, and the different regions of the body, the nearer each respective organ, and the whole organism, is to its origin; the more recent the organism, the more symmetrical it is.* The heart is, at first, perpendicular; its septum corresponds exactly to the median line, and its two portions have the same size and thickness. The liver projects as much to the left side as to the right; its left lobe is as large as the right, and its sus-

(1) *Loc. cit.* p. 5. Walther (*Physiologie*, vol. ii. p. 102.) is not more correct when stating that the dualism of the two portions of the body is less evident in the inferior classes of the animal kingdom, and commences to be perceptible only when the nervous and muscular fibres can be distinguished. In fact, the bodies of many animals destitute both of muscles and nerves are evidently formed of two symmetrical halves.

(2) See, in regard to the changes which supervene during the first periods of existence till birth, the work of F. G. Danz, *Grundriss der Zergliederungskunde des ungebornen Kindes*, Francfort and Giessen, 1792-3; and for the particulars of the structure of the body till the latter periods of life, the dissertation of Seiler, (*Anatomiæ corporis humani senilis specimen*, Erlangen, 1800.) Consult also Hopfengærtner, *Einige Bemerkungen über die menschlichen Entwickelungen, und die mit derselben in Verbindung stehenden Krankheiten*, Stuttgard, 1792.—A. Henke, *Ueber Entwickelungen und Entwickelungs-Krankheiten des menschlichen Organismus*, Nuremberg, 1814.—C. A. Philites, *De decremento alterâ hominum ætatis periodo, seu de marasme senili in specie*, Halle, 1808.

pensory ligament is on the median line. The stomach is perpendicular. The upper extremities are more similar to the lower than at later periods. The sternum is, at first, composed of several cartilaginous pieces, which afterwards become so many bones. Each piece is placed between two costal cartilages, and the latter are always implanted in a groove, hollowed from two pieces of bone. This analogy afterwards disappears, since the osseous pieces, each of which corresponds to a vertebra, fuse together, so as to form only one body.

Generally, the mode of development of the organs is the same, or at least almost similar, which increases the analogy remarked between different parts and different regions, during the first periods of life. Thus the spinal marrow, and probably also the brain, arise at first by two layers, which are not even united. The intestinal canal forms in the same manner.

The heart is at first only a single cavity, with thin parietes. The cerebrum also exists before the cerebellum, and its parietes are extremely thin in proportion to its cavity. The intestinal canal is a continuation of the umbilical vesicle or of the vitelline sac, as the genital and urinary systems are probably of the allantoid membrane. The extremities of the urinary, genital, and digestive apparatus, are at first blended together, and form a drain. This arrangement certainly exists in the upper end of the body, for at first the palate does not exist between the nose and the mouth, which form but one cavity. The male and female genital organs are more similar in form and situation when studied in the young fetus.

3. *The color of the organs develops itself gradually.* At first, the whole body is whitish, and even transparent; it gradually assumes a deeper color, and becomes opaque. Each organ does not acquire its peculiar color till a later period.

4th. *Every organ is softer and more fluid, the nearer it is to its origin; it gradually acquires its normal degree of consistence, and its cohesion increases till the end of life.* Thus, *softness* characterizes the first, and *rigidity* the latter periods of life. This law is founded on the fact that all the solids come from the fluids, both at the period of the first formation of the new organism, and during the rest of life. The substance of the organ is not only soft and fluid, but it is also surrounded with an abundant fluid, or if hollow, it contains a liquid, the quantity of which is very considerable in proportion to the thickness of its parietes. The nervous and vascular systems prove this assertion. The vascular system is composed at first only of channels formed in a homogeneous material, and has no distinct parietes. The progressive increase in the consistence of the organs is clearly seen in certain portions of the vascular system, in the uterus, in the serous membranes, in certain organs, as the spleen and some fibrous organs, where an osseous tissue is formed, which is almost regularly developed in them at an advanced age. When the degree of cohesion equals that of the bones, there appears in the mass, at first homogeneous and fluid, a peculiar system, very dense in relation to the others: this is the cartilaginous, which gradually changes to a tissue still more solid, the osseous.

5th. *This state of great fluidity is attended with a want of a determined texture during the first periods of existence.* At first we do not see even globules in the organic substance; these globules then appear, but they are not yet united to form distinct organs; when this is commenced, fibres are not yet formed. All these circumstances unite to strengthen the resemblance between different organs in the extreme periods of life.

6th. *All the organs do not appear at the same time.* This proposition is true in regard to the whole system and to each of its different parts. It is more difficult to determine the order in which the systems are developed in man, and in the superior animals generally, which pass very rapidly through the first periods of existence, than in the inferior animals; and it often happens that organs of great importance do not appear until the growth is terminated: but we are certain that vessels and nerves are the parts first seen in the primitive homogeneous mass, and that the intestinal canal begins to form almost at the same time. At first, the trunk of the body exists alone; no trace of the limbs or head is perceived; next we see the head, then the upper extremities, and afterwards the lower, the parts of which also gradually develop themselves. The organs of sense and of generation are seen at a period still more advanced. The muscles and the bones, especially the teeth, are developed still later. Finally, the dermoid system is the last to form, since a long period elapses during which the nails and hairs, the latter especially in certain parts of the body, are entirely wanting, or are developed but imperfectly. Naturally the similar parts are the slowest to show themselves in the regions which appear the last.

7th. *These parts, which are but repetitions of other more perfect parts, and which especially correspond to them, are the last to appear.* Thus the sternum and linea alba, do not appear till long after the vertebral column; the thymus and thyroid glands are formed after the genital organs; the right ventricle of the heart appears after the left.

8th. *The external form develops itself much more rapidly than the texture and chemical composition of the organs.* There is no perceptible difference between the gray and the white substance, in most of the cerebral mass, when its parts are entirely formed. A bone, when cartilaginous, has its external characteristic form. But this form differs remarkably at different periods.

Generally, the form is more simple, as the organ is younger. The brain has no circumvolutions nor layers; and the cartilage forms a homogeneous mass, although the bone is fibrous, and has not the same texture in all its parts. The heart, which afterwards contains cavities, is at first, single, and is formed like a vessel, &c.

9th. *The organs arise almost entirely by separate parts, which gradually unite to form a whole.* The whole body, the nervous system, the intestinal canal, are, at first, formed of two halves, which afterwards unite upon the median line. The vascular system, at first, forms islands filled with a fluid substance, isolated lakes, which, by slow degrees, form themselves by intermediate passages into a canal, with numerous ramifications in their intervals, and gradually give rise to a network of vessels. The kidneys are, at first, composed of several lobes, which are then more numerous than at subsequent periods. The bones develop themselves by several different points of ossification, which are afterwards united.

10th. *All the organs have not the same proportional volume at every epoch of life.* The brain, the whole nervous system, the heart, the whole vascular system, the liver, the kidneys, and still more the capsulæ renales, the thymus, and thyroid glands, are, at first, larger in proportion to the other organs, than they are at later periods.

On the contrary, other organs, the intestinal canal, the spleen, the genital parts, and the lungs, remain for a long time relatively small. We also observe certain organs shrink after a time, before others, which, though small at first, had acquired considerable size. This is the case with the thymus gland, which is formed late, and the sexual organs, particularly those of the female.

Hence the respective proportions of parts of the entire system differ very much at different periods of life. The clavicle, so small in the adult, is, at first, six times as large as the humerus and femur.

In virtue of the same law, the mutual relations of different parts of the body do not remain the same at different periods of life. The head, which at first does not exist, soon acquires almost the size of the trunk; and the limbs are, for a long time, but stumps, the upper being the larger.

11th. *The duration of the organs is not the same.* For this reason, the organism is not constantly formed of the same number of organs. Some of its parts are temporary, others remain during life. The membrana pupillaris is destroyed before birth; the membranes of the ovum, the placenta, and umbilical cord, disappear soon after this period. After a time those portions of the vascular system which coexisted with these organs, are entirely obliterated. A little later the thymus gland becomes smaller, and gradually vanishes; at twelve years of age we cannot trace it. The first twenty teeth are shed at the age of seven years.

The capsulæ renales sometimes disappear in old age; and, perhaps, the same thing occurs with the ovaries.

We may establish it as a principle, that the parts which grow the latest, are those which disappear, or at least those which cease to be active the soonest, and which are most easily destroyed. This is proved by the facility with which cicatrices of the skin and of the bones open again in general diseases.

Many of the organs which disappear are replaced by new organs. As others serve only to replace those which are not sufficiently active, their disappearance is not necessarily attended with the formation of new parts, and only with an increased action on the part of some already formed.

12th. *Some systems pass through a greater variety of degrees than others, not only in respect to texture, but in external form, situation, and proportional volume: the history of their life is more complicated.* The vascular system stands first in this respect; the intestinal canal, with its appendages the genital organs, come next. The osseous system, at different periods of life, varies very much. The differences are less in the nervous system, and still less in the others.

13th. *In some parts we can always trace the primitive formation; in others we cannot, although we know not exactly the cause of this difference.* Thus, in the adult, we rarely see the four pieces of bone of which the os occipitis is composed, or the two halves which unite to form the frontal bone, or the lower jaw, while the existence of the intermaxillary bone, and the articulation of the mastoid portion of the temporal bone with its squamous and petrous portions, are always very perceptible. Nevertheless, this circumstance may possibly depend on the fourteenth law, and the fact, that the traces of the transitory normal formations, which correspond to the constant formations generally existing in the animal kingdom, are preserved longer than those of any others.

14. *The degrees of development through which man passes from birth to the period of perfect maturity, correspond to constant formations in the animal kingdom.*(1) All the organs prove this assertion.

The fetus, in fact, is allied to animals much lower in the scale,(2) from the circumstances of the greater resemblance between the different parts and the different regions during the early periods of life, the smaller number, the uniformity of color, the greater degree of softness, the less distinct texture, the relative difference of volume of the organs, and their production by the union of parts at first isolated. The most general law in this respect is that the organisms which the fetus resembles, are the more inferior, the nearer it is to its origin when the comparison is made; whence it follows, that the embryo, from its first formation to the time of its maturity, passes through a series of forms more and more complicated.

(1) See our *Essay on the resemblances which exist between the fetal state of the superior and the permanent state of the inferior animals*, in our *Beytræge zur vergleichenden Anatomie*, vol. ii. p. 11., No. 1., Leipsick, 1811.

(2) There is, perhaps, in anatomy no axiom more incontestable than this; but we must guard against abusing it, and should not confound *analogy* with *identity*. Thus, it is too much to say that man, from the period of formation to that of birth, passes successively through different forms, which are permanent in the inferior animals. First, this proposition is never true in respect to all parts, but only in regard to some, so that the relations supposed by modern physiologists to exist between the human fetus and reptiles, fishes, cætaceæ, &c., rest only on analogies, more or less remote, between some of its organs and those of the animals in these classes. Again, we must not forget that the human fetus, from the period of its formation, irresistibly tends to assume the peculiar form of man, and so too with those of all animals. These remarks seemed necessary to anticipate the forced applications which might be made of one of the discoveries most honorable to modern anatomy, and to keep within reasonable bounds that enthusiasm which exists with us; for by falsifying the principles of a science we retard its progress. F. T.

The proofs drawn particularly from the organs are:

a. In regard to the vascular system. At first only one system of vessels is found in the embryo, the omphalomesenteric vein. This state of the vascular system corresponds to what is observed in the medusæ and zoophytes allied to them, in which also only one order of vessels exists: and farther, because the vessels have no proper parietes distinct from the mass of the body. When the development is more advanced, the heart appears as an enlarged point slightly dilated, a little muscular, oblong, channeled, and curved from the vascular system, as in many worms, where, although a complex system of vessels exists, the heart is wanting. Even in the arachnides and the branchiopedous crustacea, the heart resembles a thin elongated sac, and the vessels arise from its extremities and parietes. At first only one dilatation exists, even as in the most perfect *crustacea*, where the heart is contracted to a sort of small quadrangular and muscular cavity.

A later formation, in which a second dilatation is produced by the separation of the auricles with the venæ cavæ, corresponds to the heart of most mollusca, of fishes, and of the lowest reptiles; this is more perfect, and presents two cavities, each composed of an auricle and ventricle; but here the two auricles and the two ventricles communicate, as the septum between them is imperfect. This formation includes also the hearts of certain reptiles, for example, that of the scorpion turtle, and of the *lacerta apoda*, and as respects the communication between the two ventricles only, that of most reptiles, of those which constitute the upper orders. At first, as only one ventricle exists, there is only one artery, which, as in the mollusca, fishes, and reptiles, commonly arises by a considerable muscular dilatation which is, in fact, a third cavity. The pulmonary artery does not begin to form a distinct trunk till after the aorta, and during all fetal existence these two vessels are united in a common trunk by the arterial canal.

So too in most reptiles, particularly those where the heart is completely developed, we not only recognize two aortas coming from the heart, which meet at an acute angle, and are blended together; but the pulmonary artery communicates during life with the corresponding aorta by a broad canal, as is evident at least in the turtle. In the plungers, among the mammalia, the communication between the two auricles is so often found open, that it forms a new analogy between the human embryo and animals. A peculiar system, that of the vena porta, which is intermediate between the arterial and venous system, is seen only in the vertebral animals: as we descend the scale, the veins of the intestinal canal empty immediately into the vena cava inferior. This system of the vena cava is deficient during the first periods of fetal life, and the blood of the intestinal canal then returns directly to the heart; since the vena porta is the first vessel which appears, and the liver is not yet formed. We trace this primitive formation in the venous duct, even when the development is perfect.

b. The nervous system also somewhat resembles the organization of animals.

α. It is formed by the union of two distinct cords, and is similar in this respect to the arrangement in most invertebral animals, in which the two cords which unite one ganglion to the following are more or less evidently separated from each other.

β. As at first the spinal marrow exists alone, there also the formation corresponds to that of the most inferior worms.

γ. The spinal marrow is much longer at first, and descends lower in the vertebral canal; even so the *medulla dorsalis* of worms, of most mollusca, of fishes, of several reptiles, and of all birds, extends to the posterior extremity of the body; and even in almost all the mammalia it is longer than in man. In the fetus, a cavity extends entirely through it: in the superior vertebral animals, this remains during existence.

δ. In the fetus, the parietes of the ventricles of the brain are thin, its surface has no circumvolutions, and the gray substance predominates: these circumstances are similar to what always exist in reptiles and fishes. The brain, properly speaking, has no circumvolutions in the mammalia or in birds. The proportion between the gray and white substance is greater in animals than in man. The surface of the cerebellum is indented before that of the cerebrum, both in animals and in man, since this organ is fissured in several fishes, in all birds, and in all the mammalia.

ε. Finally, both in the fetus and in the animal kingdom, the organs of sense, the appendages of the nervous system, appear very gradually, and these organs in their development present very great resemblances to what occurs in animals.

c. The intestinal canal is at first closed at its upper and lower extremities, as in most of the intestinal worms. The posterior end remains closed longer than the anterior extremity, as is seen in several zoophytes, where the mouth performs at the same time the functions of the anus. At first the intestinal canal is not longer than the body, and enlarges gradually; so too we see, generally speaking, and with but few exceptions, that it always shortens as we descend in the animal scale. Another analogy also with its mode of development in animals is its greater simplicity during the first periods of fetal life; since then there is no distinction between the large and small intestines, and the stomach is but slightly distinguished from the rest. The cavities of the nose and mouth are at first united, a little later they are only joined posteriorly, and finally the want of separation between them is expressed by the imperfect union of the upper lip on the median line; so too the posterior part of the palate is constantly closed in birds, the velum palati is wanting in these animals and in almost all reptiles, and many mammalia have a hare-lip. While the teeth develop themselves very late in the embryo, they never appear in several mammalia, in birds, in many reptiles and fishes, and in most of the invertebral animals.(1)

(1) This defect however is more apparent than real, at least in the mammalia edentata and in birds. Thus J. F. St. Hilaire has remarked that the lower jaw in the fetus of the whale is channeled by a deep fissure, where he found the rudiments of

During the first periods of fetal existence, an appendage is attached to the ileum, which traces the communication existing anteriorly with the umbilical vesicle. This communication always remains in many birds. Finally, the liver diminishes in size, while the spleen enlarges from the first period of the existence of the fetus—phenomena perfectly similar to those found in animals.

d. The sexual parts are at first constructed after the same type, and their primitive form is that of the female.(1) Afterwards arrives a period when some of these organs, particularly the external, resemble the male form, in all individuals, at least in volume. So several zoophytes and mollusca have only one ovary, which in the former, as in the fetus, does not open externally. The testicles of the male fetus remain for a long time in the abdomen; an arrangement, which is the case during life in all animals, if we except some mammalia. The uterus, in its development, passes through those forms which are permanent in the animal series; in fact at first it has long horns, which resemble the separation of the oviducts in reptiles and fishes, and in most mammalia, and reminds us of the great length of the internal horns, in proportion to the body of the organ; these horns shorten, then the fundus of the uterus is somewhat deepened. Finally the neck is very long and thin in proportion to the body: the same as the horns of the uterus gradually become smaller in the animals allied to man, and the uterus of many of the apes differs but little from that of the female, except in being thin and narrow. The external genital parts appear late, as in animals.

e. The urinary system, one of those which is formed very late in the animal series, since it is not distinctly seen until we arrive at the fishes, does not appear very early in the fetus. The kidneys are at first united, as in most fishes and many reptiles; they are also lobed as in almost all reptiles, in birds, and in many mammalia. The number of lobes is greater and their size smaller, the younger the fetus is, as is also seen in fishes, birds, and the cetaceæ, and in the superior mammalia. The kidneys are generally larger in the last three classes of the vertebrated animals than in the mammalia; but also in the newly born infant they are much larger in proportion to the size of the body than at subsequent periods. We find the capsulæ renales very much developed in some of the mammalia, particularly in the order of gnawers, which also present other analogies with the proper organization of the fetus.

teeth in a substance analogous to that of the gum: these rudiments seemingly disappear early; for then the fissure closes, and the bone fills up. This anatomist has also recognized in birds the existence of rudiments of teeth reduced to pulpous nuclei, which secrete the horny substance of the beak instead of the phosphate of lime. The same arrangement exists undoubtedly in reptiles of the order chelonia.—*Système dentaire des mammifères et des oiseaux, sous le point de vue de la composition et de la détermination de chaque sorte de ses parties*, Paris, 1824. F. T.

(1) Muller, *De genitalium evolutione*, Halle, 1815, p. 6. D. de Blainville, *Remarques sur les organes génitaux*, in the *Bulletin de la société philomatiqne*, 1818, p. 155.

f. The thymus gland, which in its vital periods is similar to the capsulæ renales, appears late in the fetus, as in the animal kingdom. The mammalia are the first in which it is seen unequivocally; but it soon after acquires a considerable preponderance, and when the fetus is formed it resembles, in this respect, the gnawers, the amphibious animals, and several plantigrades, in which the thymus gland always remains fully developed.

The thyroid gland is at first formed of two lobes only, which are perfectly distinct, as in most mammalia.

g. The osseous system presents very remarkable analogies, viz. first, in the late period of its development. Most of the other systems are formed when the bones have acquired only a cartilaginous consistence. So, too, almost all the organs are developed in the vertebral animals before we see the skeleton. When the skeleton shows itself for the first time in the cephalopoda,(1) the part first formed corresponds to the bones of the head, which are also the first to ossify in the fetus. But in the former case the skeleton always continues cartilaginous; so, too, a number of fishes are called *cartilaginous*, by which is meant that their osseous system always exists in the state of cartilage; and in other animals of this class, as also in the reptiles, the bones never advance from the temporary conditions of fetal life, i. e. they always remain softer than in animals of the upper classes. In the higher animals the *texture* and *composition* of the bones in the early periods of life form a second analogy between man and animals. A third comes from their *external form*. There is not a single bone which, in the course of development, does not pass through some of the forms which are permanent in animals. This proposition is true, especially in regard to the bones of the trunk and head. In fact the pieces which gradually unite and form the vertebræ, the occipital bone, the temporal bone, the ethmoidal bone, the sphenoidal bone, the frontal bone, and the upper and lower maxillary bones in the fetus, always remain distinct and separate in most animals inferior to man; and the first periods of fetal existence correspond to the formations, which are permanent when we descend in the animal scale.

h. The external form of the fetus also passes through several inferior formations. The want of distinction between the head and the trunk,

(1) J. F. St. Hilaire thinks that the articulated animals, which form one of the great divisions of the invertebrata, also have a skeleton, but it is placed externally, instead of internally as in the vertebrata: he compares the rings of their bodies to vertebra and their feet to ribs. (See J. F. St. Hilaire, *Mém. sur un squelette chez les insectes, dont toutes les pièces identiques entre elles dans les divers ordres du système entomologique, correspondent à chacun des os du squelette, dans les classes supérieures;* in the *Jour. compl. du Dict. des sc. méd.*, vol. v. p. 140.—Id. *Mém. sur quelques règles fudamentales en philosophie naturelle*, same collection, vol. vi. p. 36.—Id. *Rapport sur un Mémoire d'Audouin, concernant l'organisation des insectes*, ibid. vol. vi. p. 36.—Id. *Mém. sur une colonne vertébrale et ses côtes, dansles insectes apiropodes*, same collection, vol. vi. p. 138.) This opinion has been adopted by Rudolphi, (*Beytræge zur Anthropologie*, 1812, p. 89,) and by Carus, (*Zeitschrift für die Natur und Heilkunde*, vol. ii. p. 308, 1822;) it is well developed in the *Dictionnaire classique d'histoire naturelle*, vol. v. p. 141., article *Crustacés*. F. T.

itself desutute of the extremities, is manifest in worms and the mollusca, as also the want of the neck after the limbs are developed assimilates the fetus to fishes and the cetaceæ. Many fishes, many reptiles, and even the cetaceæ among the mammalia, also want one or the other of the two pairs of members, and where the limbs appear for the first time in the animal series, they are merely stumps, without fingers or toes, as when they are first seen in the fetus. In no animal is the number of fingers greater than in man, and in many it is less. In many the toes, although the same in number as in man, are, to a certain extent, united by a swimming membrane; this is another analogy with the human fetus, where the fingers and toes are at first joined together, although one easily perceives that they constitute so many distinct parts. The vertebral column evidently terminates at first in a small prolongation, similar to a tail.

15th. ***Man is distinguished from the other animals by the greater rapidity with which he passes through the inferior formatioms.*** As his organization is the most perfect of all, he rises above the inferior degrees more rapidly than other animals, doubtless in order to gain time to arrive at his highest perfection.(1)

§ 29. IX. ***Although the form of the human organism varies at different periods of life, yet it presents certain peculiarities which distinguish it from all others, and characterize the human race as a separate species.*** This species, however, is only one of the numerous modifications of the primitive type which constitutes the base of all animal formations, so that its form necessarily resembles, in many respects, those of other animals, particularly those most allied to man. It is then almost incredible that, even recently, several writers would consider many of these conditions of the human form not as results of this law, but as proving positively that, after the original sin, man was even physically degraded from the great excellence he possessed in Paradise! They pretend that the traces of the intermaxillary bone prove that the cerebrum and cranium are diminished; they add, that the face is developed in the same proportion, that the plantaris muscle has attained at the same time the aponeurotic expansion of the sole of the foot, and that its actual rudimentary existence proves that men then walked on all fours, &c. All these assertions are unfounded: all these phenomena demonstrate nothing, since it might be proved in the same manner, by the arrangements of some other part, that man, before the deluge, was a different animal from what he is now. The human structure has nothing to distinguish it entirely from that of animals: it ought then to have the same forms: those presented by it serve to remind us, here and there,

(1) This law should be called the law of Harvey; for, although it was long forgotten and has been completely developed only by the moderns, it was, however, Harvey who founded it, in saying: *Est equidem, quod miremur, animalium omnium (puta canis, equi, cervis, bovis, gallinæ, serpentis, hominis denique ipsius) primordia tam plane galbæ figuram et consistentiam referre ut oculis internoscere nequeas.* (*De generatione*, Amsterdam, 1662, p. 77.) This law is of general application to the whole organic kingdom. We must, however, distinguish it from the false law of Harvey, of which we shall soon speak.

of what is found in animals. But these marks, such for instance as the intermaxillary bone, are easily explained by the preceding law; they trace that series of degrees of the organization through which the embryo, but not the whole human race, always passes; or they are the vestiges of the primitive state when the human formation was depressed to the level of the animal formation. In order to give some probability to the opinion we oppose, it is necessary, *at least*, to compare the human skulls before the fall of man and the deluge with each other, and with those of the present time.(1) Nor are there any facts to support a similar hypothesis, the partizans of which pretend, that as the human organism, in accordance with the preceding law, passes through different periods, so this is the case with the whole human family; and that certain races are now at a point formerly possessed by other races at present more elevated, and that these also are capable of gradual improvement.(2) In refuting this hypothesis, we cannot deny but that the different classes of organisms are developed gradually, and in direct proportion to their greater or less degree of perfection.

To determine the special conditions of the human organization, we can bring together the characteristic marks which distinguish it, so far as they depend on the conditions of the forms of the different parts; and also those drawn from the form of the whole body, and use them to trace a general picture.(3)

We become acquainted with the marked characters of the human organization, by studying, successively, the different systems and the different apparatuses.

Nevertheless, before proceeding farther, we should observe, that most of these characters distinguish man only from those animals which are the nearest to him, as the other mammalia.

1st. The *mucous tissue* of man differs from that of almost all other animals by its greater *softness;* perhaps the power he possesses of living in all parts of the world, and the frequent anomalies presented by his organization depend on this.

(1) The following passage from Ackermann, (*De naturæ humanæ dignitate*, Heidelberg, 1813,) will show that we have not misrepresented him, as is, uuhappily, too often done: "*Fuere tempora, quæ antediluviana dicimus, ubi ita despecta et abjecta erat humana species, ut brutorum animantium naturæ non æquivaleret tantum, sed et infra eam deprimeretur. Argumenta ultra omne dubium elata nobis exhibet anatomica corporis humani perscrutatio. Reperimus enim per totum corpus non rara vestigia degeneratæ in brutorum naturam humanæ fabricæ, ita ut inter multas rariores excitem species... Os intermaxillare, aperto indicio: aliquando in homine maxillas, uti in brutis magis versus anteriora protrusas fuisse, cranii recedentis amplitudine diminuta... Musculus plantaris pedis... argumento, aliquando hominem extremis digitis incessisse quod alio modo fieri non potuit, nisi etiam priore extremitate corpus suffultum fuerit.*" Who is not reminded of Stephanus and Sylvius?

(2) See Schelver's Memoir "*On the primitive race of the Human Family,*" in Wiedemann's *Archiv für Zoologie und Zootomie*, vol. iii. p. 1. No. 4. Schelver and Doornik pretend that all the races are formed by gradual improvement from the negro race. Pallas had already presented this opinion as a probable hypothesis. F. T.

(3) The distinctive characters of the human race have been well defined by Blumenbach, (*De Generis humani varietate nativâ*, Goettingen, 1795, p. 4. 46.)—See also W. Lawrence, *Lectures on Phys. Zool., and the Nat. Hist. of man*, republished at *Salem*, 1828.—Caldwell, *Thoughts on the Original Unity of the Human Race*, New York, 1830.

2d. The *vascular system*. The obliquity of the heart, the inclination of its apex to the left, and the adhesion of the lower face of the pericardium to the centre of the diaphragm, are characteristics of man, or at least are possessed in common with him only by a small number of apes, which resemble him very much.

There are but few animals, too, in which the vessels of the head and superior extremities arise, as in man. The distribution of the vessels is not the same; we distinguish the want of the *rete mirabile i. e.* of a plexus formed by the internal carotid artery before entering the eye; if this be not peculiar to man alone, it serves to distinguish him from a great many animals. We may also mention here, the arrangement of the thyroid arteries, which are two on each side in man, while in the other mammalia we find only one, &c.

3d. The *nervous system* of man differs from that of other animals in the remarkable size of the brain. Nevertheless, as a comparison of the brain with the rest of the body does not lead to exact results, either when we regard its weight, or consider its volume only, it is more convenient to contrast the encephalon with the spinal marrow and nerves. In doing this, we find the relation to the brain more favorable in man than in any other animal; and we discover that, in him, the brain is larger in proportion to the spinal marrow and nerves.(1)

At the same time the spinal marrow in man is proportionally thinner and shorter than in all other animals; since, in him, it occupies only the greater part of the vertebral canal, while in animals, with few exceptions, it fills all this canal.

If we compare the different parts of the encephalon, we find also, that man is distinguished from all other animals by the greater volume and development of the cerebrum in him, which predominates over all other parts of the nervous system.

The upper and anterior part of the brain principally exceeds those portions which relate to the organs of the senses. To the first law then is attached a second, viz. *That the cerebrum, properly speakiag, is very much developed in proportion to the organs of the senses.*

There are also, or at least they state as such, other characters peculiar to parts of the encepholon, viz.

1. *In the brain;* the existence of the small calculi of the pineal gland,(2) which are not constant except in man, but which exist also in the buck, and which are sometimes deficient even in man, as in old persons.(3)

The greater development of the cerebrum, properly speaking, is attended also with the presence of parts peculiar to man, as a special dilatation of the third cerebral ventricle, the third horn, and the eminence inclosed by this cavity.

(1) Sœmmerring, *Von Baue des menschlichen Koerpers*, vol. i. p. 85.—J. G. Ebel, *Observationes nevrologicæ;* in Ludwig, *Scrip. neurol. minor*, vol. iii. p. 148.
(2) Lisignolo, *De lapillis vel prope vel infra gland. pineal. sitis*, Mayence, 1785.
(3) Wentzel, *De penitiori cerebri structurâ*, p. 156.

The spinal marrow of man presents this peculiarity, that when perfectly developed, it is completely solid. In other animals we see along its centre a cavity, but in man, this does not exist always, being soon obliterated.

2. In the *organ of sight*. *a*. The vicinity of the eyes which are still nearer each other in the ape.

b. The absence of the membrana nictitans, although its rudiment exists in the inner angle of the eye, where it forms a semi-circular fold.

c. The absence of the suspensory muscle of the eye, a character which belongs also to the apes, but which, with this exception, distinguishes the organization of man from that of all other animals.

d. The existence of the eyelashes, although these are found in some mammalia, and also in some birds.

3. In the *organ of hearing*. *a*. The existence of the lobe of the ear, which is also seen in some apes, but in them it is much smaller.

b. The immobility of the external ear; this last, however, is not general, and is seen only in civilized people, and may be ascribed to a want of exercise: on the other hand it is common also to the ant-eater.

4. In the *organ of smell*. *a*. The projection of the nose over the mouth, and generally its prominence, a character to which, notwithstanding its generality, the *simia rostrata* is an exception, not to mention the trunk possessed by several mammalia.

b. The want of an organ like a sack, which has been lately discovered in all the other mammalia on the floor of the nasal fossæ, and necessarily the absence of a communication between the buccal and nasal cavities, the *foramen incisivum*, which always exists in the other mammalia.(1)

c. In the *organ of touch*. The smoothness of the skin, which arises from the fewness and shortness of the hair. It is well proved that no part of the skin of the ape is more naked than that of man; but the skin of the cetaceæ is undoubtedly less hairy than the human skin. The abundance of hair on some of the South Sea Islanders approximates the skin of man to that of the other mammalia.

4. The *osseous system*.

1. In the *head* we remark,

a. The proportion between the skull (*cranium*) and the face (*facies*).(2) The excess of the former over the latter distinguishes the human organization from all others. It exists because the brain is much greater in proportion to the other parts of the nervous disposition, especially the nerves and the organs of sense, as the skull is designed particularly for the brain, while the organs of the senses of sight, smell, and taste, are situated in the face. We may also separate from the

(1) See the *Description of an organ observed in the mammalia by Jacobson, confirmed by Cuvier*, in the *Annales du Muséum*, vol. xviii. p. 412—24.

(2) G. H. Crull, *Diss. de cranio ejusque ad faciem ratione*, Groningen, 1810.

brain-case that part of the head designed for the organ of hearing, inasmuch as the temporal bone which contains it is situated at the base of the skull; and secondly, its squamous portion, which is appropriated to the sense of hearing, is always separated from that part, and concurs to form the brain-case; thirdly, the Eustachian tubes unite the organ of hearing with the buccal cavity, consequently with the other organs of the senses. This mode of considering the subject is justified still more by comparative anatomy.

The skull also exceeds the face in size, from the predominance of the brain over the organs of mastication, with which the greater development of the organs of taste and smell coincides. The projection of the jaws forward and the retreat of the forehead, which is a consequent of it, have given rise to the *facial angle* of Camper.(1) This angle is formed by the union of two lines, one of which, called *Camper's facial line*, descends from the most projecting part of the forehead, along the edge of the upper incisors, and the second is parallel to the base of the cranium, and passes by the external auditory passage and the inferior edge of the nasal passage. It is evident that as the jaws retreat, and the forehead projects, the angle enlarges, although for several reasons it does not indicate precisely the relation of the face to the skull considered as the brain-case.

b. The situation of the occipital foramen. In man this foramen is found exactly or very nearly in the centre of the base of the skull; so that the centre of gravity of the head corresponds to its centre of motion when the head rests on the base of the skull: a circumstance very important in regard to the question of the erect posture of man.(2)

c. The arrangement of the upper jaw. Its anterior and internal part, in which the incisors are inserted, constitutes in animals, with the exception only of some apes, a bone, which remains distinct through life, and is called the intermaxillary bone,(*os incisivum s. intermaxillare.*) (3) This portion however is entirely separate from the rest of the bone in man also, but only during the early periods of existence; and in the intermaxillary fissure we can always trace more or less evidently the peculiar formation of animals.(4)

d. The shape of the chin, which in animals retreats more or less behind the alveolar processes, while in man it projects slightly before them.

(1) P. Campèr, *Diss. sur les variétés naturelles qui caractérisent la physionomie des hommes des divers climats et des différens âges*, translated by Jansen, Paris, 1791.—See also Stuart, *De mensch, zoo als hij voorkomt op den bekenden aardool*, Amsterdam, 1802, p. 51.—Wiedemann in *Archiv für Zoologie und Zootomie*, vol. i. part 1. p. 18.—J. E. Doorniek, *Wijsgeerig natuurkundig onderzoek aangaande den oorsprongliken mensch en de oorsprong like stammen van deszelfs geslacht*, Amsterdam, 1808.

(2) See the memoir of Daubenton, *Sur les différences de la situation du grand trou occipital dans l'homme et dans les animaux*, in *Mém. de l'Académie des sciences*, 1764, p. 568—575. F. T.

(3) G. Fischer, *Ueber die verschiedene Form des Intermaxillarknochens in verschiedenen Thieren*, Leipsick, 1800.

(4) Goëthe, *Zur Naturwissenschaft überhaupt, insbesondere zur Morphologie*, Stuttgard, 1820, p. 201.

e. The position of the teeth, in two respects:

α. These bones in man form an uninterrupted series, while in animals, except the anoplotherium,(1) we always observe a vacuum, caused either for the greater development of the canine teeth or by their absence.

β. Man is almost the only animal in whom the direction of the incisors is perpendicular to that of the two jaws.

2. The *trunk* also furnishes some distinctive characters:

a. The pelvis in man is peculiarly formed. With a few exceptions, the human pelvis is the only one which appears as a low, spacious cavity, surrounded by broad parietes, or as the bottom of a reservoir.

b. In man also the bones of the vertebral column, from above downward, increase considerably in volume, although generally the spinous processes, particularly of the thoracic vertebræ, are proportionally shorter than in animals.

c. The sternum. When man is perfectly developed, the sternum is formed at most but of three bones; while in the other mammalia its parts are very numerous, equaling the number of spaces between every two true ribs; an arrangement which is also regular in man at certain periods of life.

5. *The muscular system* in man differs from that of other animals by the slight development of some muscles and the greater power of others.

The muscles least developed are those which move the skin; the most vigorous, on the contrary, are those which serve to maintain the erect attitude, and those which prevent the inferior part of the trunk and the lower extremity of the thigh from bending forward, that is, principally those of the haunch and of the calf of the leg. The muscles which move the head are also more developed in other mammalia, both on account of their proper attitude, and because they serve to sustain the head, and to bite.

The composite systems and apparatuses present the following peculiarities:

1st. In the intestinal canal, the vermiform appendix of the cœcum is in some measure a distinctive character of the human formation. But the *vesicula umbilicalis* is not confined to man only, since the *tunica erythroides* which is found in all the mammalia, at least at certain periods, and the *vitelline sac* of birds, reptiles, and of many and probably of all fishes, correspond to this organ.

2d. In the genital apparatus, the separation which takes place soon after birth between the serous sac of the testicles and the peritoneal sac is a character which belongs exclusively to the male; for the canal of communication between these two cavities is never obliterated in the other mammalia. In the female, the external form of the womb, the tissue of this organ, and the presence of the hymen, have been considered as so many particulars belonging exclusively to the human

(1) Cuvier, *Ann. du Muséum*, vols. iii. and ix.

race; but this is false in regard to the hymen, which has been found well developed in several other mammalia, or at least is always indicated by folds.(1) The other two characters are more valuable: 1. In fact the womb of most mammalia is not single and pyriform both externally and internally, like that of the female; but it has two horns, and frequently is completely divided into two cavities. 2. It has also a distinct red layer of muscular fibres, which is attached to the internal membrane only by a loose cellular tissue, and its parietes are very thin in proportion to its cavity, while the fibrous texture of the human uterus is developed only during pregnancy; even then the fibres of this organ do not assume the peculiar appearance of those of the muscles: it is difficult to separate the internal membrame from the rest of its tissue; and its cavity is always very small in proportion to the thickness of its parietes.

Neither are these conditions exclusively peculiar to the human race; for they are found in almost all the edentata and tardigrada; besides, the womb of the apes and makies differs but little from that of woman.

§ 30. The principal character of the human species is drawn then from the large size of the brain, from the inferior development of the organs of sense, and their almost uniform development.

It is in this sense only that we can admit the proposition of Herder(2) so often repeated by others, that man is but a species intermediate between those beings above and below him.

§ 31. From the many particulars already mentioned, and from those which remain to be examined, may be deduced a fundamental characteristic of the human species, viz., that *originally, and from his very nature, man was formed for the erect posture.* The ancients understood this law perfectly well, and showed more sagacity in developing it than many modern writers have in opposing it.(3)

§ 32. X. Notwithstanding the peculiarities of conformation which prove that man, like every other organism, forms a separate species, daily observation demonstrates that, under any relation, all the individuals are not exactly alike.

The principal difference, which extends to the whole species, is the distinction of this species into two sexes,(4) *male* and *female.* This in fact does not exist, or is not marked so distinctly, in the early periods of fetal existence; and as the resemblance of the organism to itself is much greater the nearer it is to the time of its origin, so at this period

(1) Cuvier, *Anatomie comparée*, vol. iv.

(2) *Ideen zur Philosophie der Geschichte der Menschheit*, Carlsruhe, 1790, vol. i. p. 103.

(3) Compare Moscati, *Delle corporee differenze essenziali che passano tra la struttura de'i bruti e la umana*, Milan, 1770; and against his assertions, G. Vrolik, *De homine ad statum gressumque rectum per corporis fabricam disposito*, Leyden, 1795.—G. Bakker, *Natuur-en geschiedkundig onderzoek aangaande den oorspronglijken stam van het menschelijk geslacht*, Harlem, 1810.—The opinion of Moscati has been maintained by Schelver and Doornik, and contested by Blumenbach, Herder, Vrolik, and Bakker.

(4) Hufeland, *Sur l'égalité numérique des deux sexes dans l'espèce humaine*, in the *Jour. compl. du Dict. des Sciences Méd.*, vol. vi. p. 361.

all the organisms appear formed more exactly after the same type But this difference soon begins to show itself, and although the sexual characters in the general form are not well marked until after the fourteenth year, nevertheless the form of some organs, as the genitals, in the regular course of development soon assumes the characters of the male or female. The two sexes differ from each other both in the size of the body in general and of the organs in particular, and also in the proportion either between these organs themselves or between them and the whole body, as in regard to *their external form and texture, physical properties*, and *the position of their parts*.

1st. *In size.* The male is usually taller than the female. Some organs are proportionally larger in the male, and others in the female. Besides the differences in this respect between the different parts of the genital organs, for the mammæ of the male are less developed than those of the female, and the uterus is larger than the prostate gland, and again, the testicle is more voluminous than the ovary, and the penis than the clitoris: independently, we say, of these differences, the *heart*, *lungs*, and *organs of voice* are larger in the male, while the liver, and the brain considered proportionally to the nerves and the whole body, are larger in the female. The hair of the head is more developed in the female than in the male; in the latter there is a strong beard, and the whole body is hairy, which is not the case in the female, except on the head and pubis.

2d. *In the external form.* The number of parts is the same in the female, but they differ somewhat in form, for if the stomach in the female is more oblong, and in the male rounder, the form of the body of the female, and usually that of all the organs, is rounder than in the male where the outline is sharper and more angular.

In fact all the parts of the genital apparatus correspond in the two sexes; but their external forms vary so much that it seems at first impossible to believe that the genitals of the two sexes are only modifications of the same primitive type. In this respect the distinguishing characteristic is the predominance of length in the male, and of breadth and thickness in the female. It is seen both in the form of the genital organs and in that part of the body which contains them. Thus the male pelvis is narrower, more contracted, and deeper, than that of the female; the penis is longer and narrower than the vagina and clitoris, the vasa deferentia are longer than the Fallopian tubes. The two sexes differ also as respects their constancy of form, which is much greater in the male than in the female.

3d. *In texture and physical qualities.* The body of the female is usually more delicate, softer, and less firm than that of the male.

4th. The *situation* of the parts is the same in both sexes, if we except those organs which relate to the generative functions. The principal difference in this respect between the male and female is, that the parts are external in the male, but internal in the female. The testicles are situated externally, and the ovaries internally, the prostate is at the outlet, and the uterus within the cavity, of the pelvis; the penis extends along its external face, while the clitoris and vagina are placed within its cavity.

§ 33. Besides this grand fundamental difference, which divides the human species into two halves, there are others less striking which are common to both of these halves, which distinguish the species, not into sexes, but *races*. They are called, *differences of races.*(1)

The characters employed to establish the principal divisions of the human family may be very different, but the suitable track to follow is that which embraces the whole organization, and is not confined to the consideration of only one or another of its peculiarities, as, for example, the color, size, the proportions of the different parts of the body, &c.

Buffon was the first who proceeded in this manner, and divided mankind into six races, viz. the *Hyperborean*, or *Laplander*, which includes the polar nations: 2d, the *Tartar*, which is the largest, and inhabits central Asia: 3d, the *Southern Asiatic*, which embraces also the South Sea Islanders: 4th, the *European*: 5th, the *Ethiopian:* and 6th, the *American:*(2) but, finally, he reduces these six races to five only, considering the Laplanders as degenerated Tartars, and indicating very precisely the tribes which make the transition from the Tartar race properly so called, to those imperfectly developed nations who live under the poles.

After this correction, the five races established by Buffon, correspond to those of Blumenbach, as the Laplander and the Tartar of the first are the Mongolian of the second; the Southern Asiatic corresponds to the Malay, and the European of Buffon is the Caucasian of Blumenbach; the similarity of names identify the other two.

§ 34. The principal characters which distinguish the *European*, or the *Caucasian*, race from the others, are as follows:

A white skin, but in the people of the south it is brownish yellow; cheeks red, but they have little or no color in the other races. The color of the hair varies, from a light yellow to a deep brown, and even black. The eyes, that is to say, the irides, are blue, gray, brown, and rarely entirely black. The form of the face is oval, neither very flat nor very angular. The bones are no where very prominent; neither do the cheek bones ever project much. The forehead is arched, but never retreating; the nose narrow, the mouth moderately large. The lips do not project much; the lower projects beyond the upper. The teeth are perpendicular to the two jaws. The chin is full and rounded.

(1) The principal work on this subject is that of Blumenbach, *De generis humani varietate nativâ*, Goettingen, 1795. Consult also, besides the work of Herder quoted above, A. G. Zimmermann, *Geographische Geschichte der Menschen und der allgemein verbreiteten Thiere*, Leipsick, 1778–1783. G. Josephi, *Grundriss der Naturgeschichte des Menschen*, Hamburgh, 1799.—C. F. Ludwig, *Gundriss der Naturgeschichte des Menschenspecies*, Leipsick, 1796.—J. J. Virey, *Histoire naturelle du genre humain*, Paris, an IX.—Id. *Recherches sur la nature et les facultés de l'homme.*—C. Gross, *Magazin fur die Naturgeschichte des Menschen*, Leipsick, 1788--1791.—S. S. Smith, *An essay on the causes of the variety of complexion and figure in the human species*, in the *American Museum* 1789, p. 30, et seq.—C. Meiners, *Untersuchungen über die Verschiedenheiten der Menschennaturen*, Tubingen, 1811.

(2) *Histoire naturelle*, vol. iii: *Histoire naturelle de l'homme. Variétés dans l'espèce humaine*, p. 37.

The *Caucasian* race represents, in some measure, a centre, on each side of which are varieties. In fact, the head, and to a certain extent, the whole body becomes either broader or narrower. The Mongolian and American races are marked by greater breadth, while a lateral compression is seen in the Ethiopian and Malay races.

The principal characters of the *Mongolian* race, are a yellowish or olive color, between that of wheat and boiled quinces or dried lemon peel; hair black, short, thin, stiff, and straight; head almost triangular; face broad and flat; cheek bones high and prominent; forehead very broad and flat; small flat nose; cheeks almost round, and plump; eyelids half closed. The proportion of the skull to the face, is a little less favorable than in the Caucasian race, being about one tenth less. The stature of the northern nations of this race is very low; the extremities are very short, even in the countries at some distance from the north, which probably depends in part on artificial habits.

The *American* race is distinguished from the others by a copper or cinnamon color; hair fine, black, straight, and thin; forehead low; eyes sunken; nose slightly flat, although projecting. The face is broad; the cheek bones are generally prominent, but the different features are not both flat and depressed; they appear, on the contrary, very full, especially on a side view.

In the *Malay* race the skin is brown; the hair is soft, curled, and abundant; the head narrow; the forehead prominent; the nose broad, diverging, and thick at its apex; the mouth large. The upper jaw projects considerably; but on a side view the features are well proportioned.

The *Ethiopian* race is farther removed from the Caucasian in many respects. The color is more or less black; the hair is short, thick, woolly, fine, hard, glossy, and elastic: it does not extend itself gradually towards the neck, but terminates suddenly, like a wig. The eyebrows are also curled and thinner; the eyelashes are much more arched and thicker than in the other races. But these peculiarities are not seen at all periods of life, for at birth the color is whitish, and the hair is long and curled, but not woolly, and on the back part of the head it continues insensibly to the neck; this latter is stronger, and the occiput is more feeble; the occipital foramen is placed a little farther forward and is larger; the head is narrow and compressed laterally, whence the forehead appears sloping. The cheeks project forward, but not on the sides; the upper jaw is constructed after the same type, and the cheek bones project, evidently, from this arrangement. Hence the alveolar processes appear narrow and long. The upper incisors are directed obliquely forward. The bones of the skull are very strong and very thick. Of all the human races, the Ethiopian is that in which the proportion between the face and skull is least advantageous to the latter, for the facial angle is only seventy degrees, while in the Mongolian race it is seventy-five, and in the Caucasian, eighty. The surface of the face, compared to that of the skull, is one fifth larger in this race than in the Caucasian. The nerves, especially those of the first, second, and fifth pairs, are also more voluminous, in proportion to the brain. The brain is firmer. We could discover no difference in its color, and the various opinions among authors on this subject leave it doubtful. The lips, especially the upper, are thick and turned upward; their color is not purely red, but they are bluish black, or at most a dirty rose-red. The chin is more or less retreating. The nose is very thick, and is almost blended with the upper jaw, and it is, moreover, flat, even in young fetuses. The eyes are very prominent, and often so black that, in many nations of this race, we cannot distinguish the iris from the pupil. The aperture of the eyelids is generally smaller than in the Caucasian race, but the globe of the eye is larger, and blackish to about half a line round the cornea, while the rest is yellowish. The rudiment of the third eyelid is greater than in the other races. The external ear is rounder, more analogous to that of the ape, and stands out farther from the head. The muscles of the mouth are more developed; hence the temporal fossa is deeper, and the semicircular line on the side of the skull is more distinct and prominent. The anterior orifice of the nasal fossæ is extremely large, and the surface of the pituitary membrane is increased by some irregularities within the nose. The anterior palatine foramen is broader. The teeth are very large and very broad. The pelvis is narrower than in the Europeans. The hands and feet are well proportioned, but flat; the fingers and toes are long.

The genital organs in this race present some general peculiarities, and some characters which belong only to certain tribes. They are chiefly characterized by their great development; in males, this is seen in the size of the penis, and in that of the clitoris in females.(1) The nymphæ are sometimes (2) excessively lengthened, and sometimes, in different nations, even new parts seem to be developed, certain accessory organs, which serve to enlarge the external genital apparatus.(3) All these peculiarities are very remarkable, because they resemble the structure of the ape. In fact, the Ethiopian race seems to form the transition from the Caucasian race, to the quadrumani.(4)

§ 35. The number of races can be restricted still farther, by referring to a single type, those which are separated in the same manner,

(1) *Vaillant's Travels in the Interior of Africa*, in the *Mag. merk. Reisebeschr*, vol. 2. p. 308.

(2) Péron and Lesueur in the *Anatomie Comparée* of Cuvier vol. iv.—Barrow in Voigt's *Magazin für die Naturlehre*, vol. iii. p. 4. p. 792. Barrow, however, pretends that the parts found in the Boschisman woman are prolongations of the nymphæ.

(3) The exhibition of a Boschisman woman at Paris as a *Hottentot Venus* who died there, proved that Péron was deceived in admitting a special organ. The pretended apron, very inproperly stated in regard to the Hottentots, (as the true Hottentots are deprived of it, and it belongs only to the Houzouanas, or Boschisman women,) is a prolongation of the nymphæ, developed, if we may so speak, at the expense of the labia externa, which are hardly visible. Cuvier has shown, that the upper part of the two fleshy lobes which compose this apron, are formed from the prepuce and the summit of the nymphæ, while the rest is only an extension of the nymphæ. See his Memoir on this subject, in the *Memoires du Muscum*, vol. iii. p. 259.—Flourens, *Notice sur la Vénus Hottentote*, in the *Journal complémentaire du Dictionnaire des sciences médicales*, vol. iv. p. 145.—G. Sommerville, in the *Med. Chirur. trans.* vol. vii. p. 154.

F. T.

(4) See S. T. Sœmmerring, *Ueber die Kœrperliche Verschiedenheit des Negers vom Europœer*, Francfort, 1785.

from the middle term of the formation peculiar to the Caucasian race. We should then have only three races. This classification is more convenient, as it is favored by the similarity of customs. Finally, the different races not only pass from one to the other by imperceptible shades, but still it sometimes happens that certain individuals belonging to one race, resemble others in many essential respects, and especially in the form of the head. We have before us, at the present moment, the skulls of several Germans, so strongly marked with the characters of the Ethiopian race, that it would be difficult to distinguish them from the skulls of negroes.

The form of the whole body, and especially of the head, evidently proves, that the Caucasian race, is that, in which the human character, the predominance of the brain, is seen most perfectly, and on the contrary, the Ethiopian race most resembles the apes. The other races form intermediate degrees between the Caucasian race and the other mammalia. But we have no proof, nor is it even probable, that the Ethiopian race can in time be perfected, and that the other races have already possessed their form, than that the human race has once been formed more perfectly, of which form it is now deprived. On the contrary, there is every reason to think, that the species man was formed last, and that all other beings are so many attempts of nature, before making him. We cannot decide, whether the different races are consecutive modifications of a single primitive trunk, or if the differences be original, and if the number of primitive races, which perhaps appeared at the same time, be not infinitely greater than that of the races afterwards formed, by including several, similar to each other, in some large families; the second hypothesis however, is more probable than the first;(1) nevertheless, it does not prevent us from reducing the five races, actually admitted by naturalists, to three.

§ 36. Besides the differences of sexes and of races, the human formation presents others of a third kind. These latter are separate from the first, and are common to the whole species, and are found indiscriminately in both sexes and in all the races, although they may be more frequent in one sex, or race, than in another: they are called *abnormal formations*, or *deviations* of *formation*. In fact, the whole body, as well as each particular system, possesses an external as well as an internal form, which recurs oftener than any other, and which may therefore be considered as the *rule*. This regular form, is, at the same time, if not always, at least in most instances, *the most suitable*, because it is the most favorable for the performance of the functions. It may then be called *the healthy form*, or the *form in harmony with the health*. On the contrary, those which vary from it should be called *morbid formations;* first, because they often disturb the functions of the organ, and, according to the nature of the organ, and the manner and degree of the aberration, may even prevent the continuance of life; and secondly,

(1) See the memoir of Rudolphi *On the distribution of animals*, in the *Beitræge zur Anthropologie und allgemeine Naturgeschichte*, Berlin, 1812.

because the cause of those aberrations from the normal state, is evidently a disease, as most of the *alterations of texture* result from morbid affections.

These anomalies form the subject of *pathological anatomy*. Nevertheless, it is impossible to separate completely the study of the regular from that of the irregular structure; so that general anatomy ought to embrace, also, the most important considerations arising from anomalies of texture.(1)

All the abnormal formations are essentially the same; in the end, they consist in the *rarity*, and consequently, in a deviation from the rule. Nevertheless, these formations may be distinguished from each other, either from the size and importance of the organ, or from the influence of the anomaly on its function, or according to the degree of the anomaly. But the differences they present in relation to the qualities of the organs, and to the manner in which they are themselves developed, are still more important.

Many of these anomalies, in fact, affect only the external form of the organs; others their internal structure, their tissue, chemical composition, and physical properties. Many arise during the course of life, and are *accidental*, while others are *primitive*. *Alterations* of *texture* are the most frequent, but they are not always accidental. The *defects* of *formation* are *congenital* when they do not depend upon mechanical injury, or on previous alterations of texture.

§ 37. The *anomalies of form*, whether appearing primitively, or after the period when the part affected has its regular form, refer, 1st, to the *number*, 2d, to the *volume*, 3d, to the *situation*, and 4th, to the *form* of the organs.

1st. In the first respect, an organ may be entirely or partly deficient; sometimes the defect is original, but it is often, also, only accidental, resulting from morbid actions, which, either mechanically, chemically, or dynamically, have partially or totally destroyed the organ. Thus compression and irritation, arising from tumors, or from the teeth which are cutting, cause even the hardest bones, the milk teeth, to disappear; by the want of extension, as consequent to a ligature, the blood vessels are obliterated as high as the first branch, furnished by the trunk, in which the circulation is impeded. The acids destroy the most solid parts by solution; the testicles vanish without leaving the least trace, and often without any known sufficient cause, &c.

We cannot always determine with precision, if a part which is deficient, has existed previously, and has been destroyed, since numerous observations demonstrate, that parts, existing at first, partially or wholly disappear, not only morbidly, but normally. (See page 46.)

(1) These considerations, however, can be pointed out only very briefly, when treating either of general or of descriptive anatomy. We have made them the subject of a *separate* treatise, called *Handbuch der pathologischen Anatomie*, Halle, 1812-15. 3 vols. in 8vo.

Neither is there an instance of the defect of any part whatever which has not been differently explained by different observers.

The reverse of *defect* or *absence*, is a *plurality* of parts, in which we observe numerous gradations commencing with multiplications of the small parts. This defect of formation is always congenital, or at least the power of the human organism to produce supernumerary parts, is extremely limited, except during the period when the normal parts are forming. In truth, all these parts are not formed at once. (See p. 45.) But if we except those which appear regularly after the others, the organism never produces parts in any manner composite, and similar to those which exist in the normal state, unless in conditions analogous to those which the formation of a new organism requires.

2d. *Aberrations in regard to mass and volume*, are also congenital or accidental. In this case, the mass and volume is greater or less than in the normal state, and the increase or diminution in mass and volume does not necessarily take place in these two respects at the same time. An organ may become much larger than usual, without an increase, and even from a diminution in its mass when its tissue is considerably dilated or extended. This is proved by the swelling of the bones and the dilatation of the hollow organs.

The *abnormal stricture* (*strictura*, *coarctatio*) of the hollow organs, may even entirely efface their cavities ; this is called *obliteration*, or *atresia*, which has been badly divided into *true* and *false*.

3. *Anomalies of situation* are accidental more frequently than congenital. In this point of view, first, sometimes a part is found on the side opposite to that where it is generally placed ; or, second, higher or lower than usual. Third. Sometimes it is perpendicular when it should be oblique, or oblique when it should be perpendicular. Finally, it may exist outside of the cavity within which it is commonly found. When this part has only left its usual situation, it is called a *hernia*, or *luxation* (*luxatio*). Hernia is when a part usually inclosed in one of the three large cavities of the body, escapes from it. *Luxation* is when a bone leaves its articular cavity. *Inversion* is when the internal face of a part is turned outwardly. Inversion sometimes produces an *intussusception* or *invagination*, when the inverted part, or those which envelop it, pass into another cavity, as happens for instance in the intestinal canal, and sometimes it causes a *prolapsus*, when these same parts project more or less externally. Every prolapsus is, at first, for a longer or shorter time, only a simple intussusception, which sometimes lasts only an instant ; but an intussusception does not always become a prolapsus.

4th. Anomalies in form, are produced in various ways ; since the varieties of which the form is susceptible depend on the particular character it possesses in the normal state. Thus a rounded part can be oblong or more angular, and *vice versa*. A single part may be divided into several others, and parts usually united may be separate and distinct. The deviations of formation most often found, are the *abnormal separation* of parts usually united, and the *abnormal union* of parts generally separated. But abnormal separation may often, although not always, be referred to defect, or absence, as for example, in fissure of the palate, or of the abdomen. So too with abnormal union, as the fusion of the two eyes into one, the union of the two auricles, or of the two ventricles of the heart, &c.

The anomalies of this class also are accidental, or congenital; in the latter case, they are probably for the most part primitive or original.

The anomalies of the first kind, besides those already mentioned, are the lobed structure of the spleen and kidneys, the fissure of the vagina, of the womb, and of the bladder, &c.

Those of the second kind, are the different accidental solutions of continuity, as *lacerations*, *wounds*, and *fractures*, which may depend on an infinity of causes; the accidental union of parts originally separate, as in anchilosis, &c.

§ 38. We have already said that aberrations of form are sometimes congenital, and sometimes are not developed till after birth. But even if one of those anomalies exists when an infant is born, it does not thence follow, that it is *original*, that the altered organ has not been well formed at a former period, and that the monstrosity it presents does not result from a morbid cause acting upon it before birth. Nevertheless, irrefutable arguments unite to demonstrate, that *congenital* aberrations of the external form, are also usually *original*. We can refer these arguments to the following, which make us acquainted at the same time with the most essential and most remarkable conditions of original deviations of formation.

1. The nature of the deformities announces that they are original. In fact,

a. Most of them can be explained in no other manner. Such, for instance, as the inversion of all the organs, or of some one only, the result of which is, that on the right side we see parts which are usually found on the left, and *vice versa*; and much more, when the inversion takes place, not only in situation, but also in form; the increase in the number of certain parts, as of the fingers and toes; irregularities in the distribution and origin of the vessels, &c. The attempts which have been made to account for these anomalies mechanically, are so monstrous, that they refute the hypothesis imagined to explain them. Organogenesis proves that many deviations of formation, are original; since it can be demonstrated that they depend on the fact, that the organ has remained stationary at one of those degrees, through which, in its normal progress, it successively passes.

b. The sides of the body seem to differ a little, one from the other, in regard to the frequency of deviations of formation presented by them. In fact, most are found only on the left side. Thus, for instance, the vertebral artery rarely arises, except on the left side, from the arch of the aorta. We see, too, anomalies in the renal vessels of the left side, more commonly than in those of the right. To express this law more generally, we may say that the regions and the parts which are but imperfect representations of parts better developed, or to produce which, the formative power seems habitually to employ less energy, are also those which vary the most from the rules laid down, and which are formed with less constancy. Thus the sternum differs so much in respect to the number and size of its osseous nuclei, that we can scarcely establish any thing certain in regard to them, while anomalies in the vertebral column are very rare. So too, varieties in the vessels of the lungs, the most noble and most important organ, and which appears very early in the animal series, are less numerous and rarer than those of the renal vessels.

Nevertheless, this law has exceptions. Thus, for instance, the distribution of the vessels, varies more frequently in the upper than in the lower extremities, although the latter appear later than the former. But this exception is perhaps only imaginary, as the inferior members in the progress of life soon become larger than the superior.

c. Some systems are more subject to deviations of formation than others. The greater part of the nervous, osseous, and muscular systems, present anomalies more rarely than the other systems, particularly the vascular. Among the apparatuses, those of voice and respiration are less subject to derangement, than those of generation, digestion, and of the urinary passages. The last two, with the vascular system, are those which are most frequently anomalous. In this respect, there is a remarkable contrast in the nervous system between the brain, spinal marrow, and their nerves on one part, and the great sympathetic nerve on the other. The difference we have pointed out between the different organs certainly depends on this contrast, at least in part, since the organs which receive their nerves from the brain or the spinal marrow, are distinguished from the others, by the constancy of their forms. These organs in which the form is most *constant* are, at the same time, more *symmetrical*, so that these two conditions seem to depend on the same principle. In fact, there is here only a simple difference of relation, since symmetry is to the individual, what constancy is to the species.

d. Anomalies of the same organ are similar. Thus, when two tongues exist, they are not placed side by side, but one above the other. Anomalies in the large vessels arising from the trunk of the aorta, vary much, in truth, but each resembles itself. Thus, for instance, if the right subclavian artery does not come from the arteria innominata, it arises, most usually, above that of the artery of the left side, and there is not merely a division of the trunk of the innominata. When the vertebral artery forms a separate trunk, it is always the left which presents this irregularity, and it usually rises from between the large trunks of the left side, instead of implanting itself below the corresponding subclavian artery, although in the preceding anomaly, the origin of the right subclavian artery is placed lower even than that of the last. The perforation of the septum of the heart, the division of the urethra, the contraction of the stomach, always occur in one determined place.

e. In the anomalies of an organ there is a gradual transition from one to another. We can establish a series from the slightest anomalies of an organ, to the greatest disfigurement of the whole organism. Thus the doubling of the whole organism commences by the multiplication of the toes, the heart, the head, and is arrested when two bodies are united by the head, the chest, the abdomen, &c. So too, in monstrosities of an opposite character, there is a perfect gradation from the approach of the two eyes, to the existence of only one on the median line, with which the anomalies attending it in other parts of the head, coincide. We can also trace this transition from the inversion of the inferior limbs, to the existence of a single pelvic member, which is also central, and developed very imperfectly. This law does not contradict the preceding; it only restricts it to a certain extent, and the more, as the different degrees of the anomalies of the organs present themselves not merely once, but frequently exist in different individuals of the same and different species.

f. The deviations of formation are bounded by certain limits. To whatever extent the form of an organ, or of the whole organism, may be abnormal, it can always be recognized, even when the organism is deformed by several simultaneous deviations of formation. Thus the heart is never seen on the back, the lungs in the abdomen, the cranium between the lower extremities, &c. These organs then are never anomalous to such a degree, that heterogeneous parts should be blended in one mass; for instance, the nerves with the vessels, the aorta with the esophagus, &c. This is one of the strongest arguments against the hypothesis, that monstrosities depend on mechanical influences.

g. Slight anomalies are much more frequent than large deviations, both as regards the relation of the volume of the parts, and the influence of the anomaly on the functions. The small branches and ramifications of the vessels vary much, while the large trunks are more constant. It is much more common to see the radial artery arise from the brachial artery in the region of the axilla, or the left vertebral artery coming directly from the trunk of the aorta, than to see the right subclavian artery arising below the left, or the aorta divided completely or incompletely into three trunks. The rarest anomalies in the circulatory system are those which allow a mixture of the pulmonary blood with that of the body, and those which affect the health: as the perforation of the septum of the heart, the origin of the pulmonary artery from the aorta, of the aorta from the right ventricle, or of the pulmonary artery from the left ventricle. This law may be expressed in a general way by saying that an anomaly is more frequent the less the arrangement of the parts varies from the normal state; but thus expressed this law is not correct: for instance, the perforation of the septum of the heart is a normal formation during the first periods of fetal existence, and nevertheless it exists much more rarely than varieties in the distribution of vessels, which are never normal.

2. The relations which connect deviations of formation to other conditions not dependent on the misformed organs themselves, prove that these anomalies are original.

h. The simultaneous existence of several anomalies in the same organism. Although but one organ is usually abnormal, a circumstance which is connected with the preceding law, nevertheless we sometimes find in the same body many which vary from the normal formation. The anomalies then present sometimes the same and sometimes a different and even an opposite character. Thus, in certain cases all the imperfectly symmetrical organs are inverted: those of the right side are found on the left, and those of the left side on the right. Again, several systems are deformed by a defect of development: often, and in fact most usually, some parts are deficient, while others are immoderately developed. But we rarely or never find supernumerary organs in a body where the general form is characterized by an excessive activity of the formative power: for instance, a double-bodied monster has never more than five fingers and toes. Thus, generally speaking, the formative powers appear not to employ more energy upon one part unless at the expense of another; and one part remains deficient only because another is too much developed.

i. The simultaneous existence of several misformed fetuses, or the coexistence of a monstrous fetus with one that is well formed. We sometimes meet with twins or triplets which present similar deviations of formation in the same organs, almost always ascribable to a defect of development; and it is more common to find two or three together which are monstrous on account of some fault in their development, that is to say, in general by defect. A singular relation sometimes exists in this respect between one pregnancy and another: a finger, for example, which is deficient in one child is found in excess in the next. This law is the same as the preceding, but applies to other objects.

k. Monstrosities of the same kind are hereditary in some families. This does not cease even by marriages with other families, although it sometimes disappears for several generations. The best known examples of this are those families with supernumerary fingers. But the hare-lip, fissure of the palate, hypospadias, &c., are equally hereditary. Sometimes a tendency to produce anomalies is transmitted rather than an anomaly, although usually the species of aberration is then the same. The predisposition does not often extend except to one generation; nevertheless, we may ask if cases of this kind have been well observed, and if, when such a tendency is developed in one generation, it is not transmitted at least to the following generations, as certain diseases are developed sometimes under favorable circumstances, and have now become contagious.

l. The influence of sex. We may state as a principle that anomalies are more common in the female. This phenomenon seems to us to depend upon the eighth law, since the organization of the female results from the development being arrested at an inferior degree. Hence it follows also that deviations of formation absolutely opposite in their nature are more common in the female than in the male. Nevertheless certain organs may be exceptions to this rule. Thus, several anomalies of the heart(1) and of the bladder(2) are found more frequently in the male than in the female.

m. Most deviations of formation are analogous to what is seen in animals. The organs of man do not present a single anomaly which is not similar to what is seen in animals. A whole book might be written on this subject, and exact observation would multiply to infinity the facts we could now mention in favor of this law. It is founded on another law, that the human fetus while developing passes through several formations, and that those monstrosities which are formed essentially by the development being arrested in one or another of these formations, are the most common because they were normal in the first periods of its existence. Nevertheless we trace a resemblance with the organization of animals in certain anomalies which have never been normal, such as the inversion of the least symmetrical organs, and most of the varieties of the vessels. This law then can be expressed in general terms as follows: All the organisms have one primitive fundamental type: hence one may be transformed into another.(3)

n. The spontaneous appearance of similar phenomena during life, which do not result from the effect of an external lesion. The alterations of texture and all new formations are usually developed spontaneously. Why, then, is it not probable, after this, and setting aside too the arguments hitherto adduced, that, by a stronger reason, congenital monstrosities are original, and do not depend on external influences? But it is a peculiar anomaly which favors this opinion. In several animals, especially in the class of birds, the female habits and female desires are so effaced by age, that, although the genital organs remain the same, yet in these particulars the bird belongs to the male sex. It is true that at first sight these phenomena appear to oppose the doctrine of original monstrosities, as they show the possibility of a total change; but in truth they favor it, as they combat the opinion which ascribes these monstrosities to the influence of mechanical causes. To us it does not seem very unlikely that some parts originally well formed in the first periods of life should afterwards assume of themselves an abnormal form; that, for instance, some parts at first single should afterwards become double, instead of merely acquiring an abnormal volume, since the inferior organisms, which the fetus so much resembles, have the power, not merely of enlarging, but of increasing the number of their

(1) Schuler, *De morbo cœruleo*, Muhldorf, 1810, p. 29.

(2) See Duncan's paper *On the malformation of the urinary organs*, in the *Edin. Med. and Surg. Jour.*, vol. i. p. 132.

(3) This law has been perfectly developed by J. F. St. Hilaire, who has endeavored to demonstrate that the *organization of vertebrated animals* may be referred to a uniform type, *i. e.* that the materials of all these are the same; but they vary in size, forms, and uses, and form the organization according to the wants of the animal and the medium it inhabits. Although their forms and size change, their connections always remain the same, their relations are invariable. The same materials being given, and animated by a sum of life nearly uniform in each class, a greater development of one cannot take place unless one or more of the parts adjacent suffer. Such are the principles of the truly philosophical theory which J. F. St. Hilaire long since brought forward (*Philosophie anatomique*, 1818) as the *Theory of analogies.* F. T.

parts, under the same circumstances which in the superior animals are at most attended only with an increase of volume.

§ 39. Thus almost all the congenital deviations from the normal form are primitive, or at least do not result from mechanical causes.(1) The classification most convenient for their study is that which views them in their essence. In fact it is not impossible that the formative power when producing them differs only in degree from its normal state; and this proposition, although at present unproved, is not at least unlikely. Monsters may then be classed according as they are anomalous in *quantity* or in *quality*. The first class comprehends, 1st, monsters by defect, (*monstra per defectum*,) their essence is a want of energy(2); 2d, monsters by excess, (*monstra per excessum*,) which are characterized by an excess of formative power.(3) The second are divided into those which depend upon the union of the characters of both sexes in the same individual, or the hermaphrodites, (*monstra androgyna*)(4), and 2dly, those which cannot be referred to any of the preceding classes, (*monstra per fabricam alienam*.)

To the first class of the first section are referred the defect, smallness, and too long continuance in the forms or proportions of early youth; to the second, the plurality, excessive volume, and too rapid development. The objects of the second section are expressed generally by the definition itself. As to the classes of the first, it appears that, besides the first two conditions, which are common to all the organs, the same kind of anomaly presents as many differences in each organ as naturally occur in its normal form and development. Besides the differences relative to the frequency of the anomalies, which we have before mentioned, we may remark that we find more deviations in formation in those organs which while developing pass through the greatest variety of forms; because this circumstance increases the number of temporary forms in which they can stop. Perhaps there are organs peculiarly predisposed to one or another class of deviations of formation; this would certainly seem to be the case: thus, for instance, the abnormal multiplication is observed particularly in the limbs, but seldom in the internal organs or in the trunk. We may establish then, as a general law, that an increase of the formative power is directed rather to the surface, and diminution inwardly. Nevertheless there is

(1) J. F. St. Hilaire has settled this important proposition also, (*Des monstruosités humaines*, Paris, 1822.) Monsters have given new support to his doctrine of the unity of composition in vertebrated animals. In fact he has observed that these anomalies are usually marked by the excess or deficiency of only one of the parts which form the being in its proper state, but that the parts themselves are often equal in number, and their relations are always the same. Although these observations have been confined to monstrosities of the head, they are sufficient for us to conclude, by induction, that all others enter into this common law, and that their origin is truly dynamic and vital. F. T.

(2) We have given the complete history of these deformities in our *Handbuch der pathologischen Anatomie*.

(3) The general laws and particular conditions of these anomalies have been mentioned in our *Commentarius de duplicitate monstrosâ*, Halle, 1815.

(4) Besides several treatises on hermaphrodites, some of which are excellent, as those of Ackermann and Burdach, consult the second volume of our *Handbuch der pathologischen Anatomie*.

only a difference in degree, as nothing is rarer than monsters from defect of the external parts.

§ 40. *Alterations of texture* extend to all qualities connected with the intimate composition, that is to say, principally, 1, to the *color*; 2, the *density*; 3, the *number* and the *composition*, *of the particles which contribute to form the whole part*; and finally to the *chemical composition*.

Alterations in texture, considered generally, consist essentially in the formation of a tissue different either in one or in all parts from the normal tissue.

1. The abnormal colors are very often accidental and foreign to the tissue which presents them. This takes place when, as in jaundice, cyanopathia, &c., the color of this tissue arises solely from the morbid state of other organs, or when it is not situated in the tissue, but in the fluids it contains; it then disappears as soon as the disease which caused it is cured. On the contrary, the color is rarely or even never normal when the tissue varies from the rule in another relation: in this case it is darker, brighter, or entirely different. Generally it becomes more clear when the morbid alteration is not caused essentially by an excessive development of the vessels.

2. The *density* is sometimes greater and sometimes less. In the first case, the organs are *hard* and *firm*, in the second, *loose*, *soft*, *brittle*, and *fragile*.

3. Usually the morbid tissue is less distinct and more uniform; the number of vessels is often increased, and often also diminished, &c.

4. The *chemical composition* also varies much. Here applies all that has been said above with regard to its intimate texture.

We should observe in general that the texture of the organs changes in two different ways. Sometimes an organ whose conformation is regular is partially or wholly changed into an abnormal tissue. Sometimes a new and anomalous tissue is developed near it, entirely different from the old tissue, which disappears as the former increases. Nevertheless this difference is only apparent, for even in the latter case the new tissue is unlike that whose place it supplied, and is only the change of another, ordinarily of the mucous tissue, which has assumed an abnormal state.

The most general condition of the alterations of texture, and the most general cause of their production, is *inflammation*, which may be defined a state in which the blood flows in greater abundance towards a part of the economy, and attempts a new formation.

Even the alterations of texture are either the repetitions of a tissue which already exists in the normal state, or formations entirely abnormal, which do not exist in the regular state.

All the parts are not anomalously produced, nevertheless this is the case with almost all, and especially the most simple. Thus we see the cellular tissue abnormally produced, which then contains fluids of a different nature; the tissue of the bones, and even enamel, that of the cartilages, the fibro-cartilages, the fibrous tissue, the skin, and several parts of the epidermoid tissue, especially the horny parts and the hairs: the serous texture, which, like the cellular, contains different fluids, the synovial tissue and the mucous tissue.

As the vessels and nerves enter more or less evidently into the formation of several of these tissues, we may say they are reproduced in an abnormal manner, whether they do or do not arise from vessels and nerves previously existing.

The muscular and glandular tissues are those only which appear not to be formed anew.

These repetitions of the normal formations take place principally in two different circumstances: sometimes to repair a loss of substance, and consequently at the place where the organ usually exists; sometimes accidentally, and in other places. This difference is merely accidental: the proof is, that those parts which are easily and perfectly reproduced after having been destroyed, or those which grow more than once in the normal state, are those also which are most completely and frequently developed as anomalies in other parts of the economy. Here are included the mucous tissue, the bones, the teeth, the hair, and especially the epidermoid tissue.

On the contrary, the muscular and the glandular tissues are never reproduced.

The most essential characters of the new formations of this kind, resemble those of the parts of which they are repetitions: their texture and chemical composition are the same: they pass through the same periods of development, and exercise no injurious influence on the health and life unless from their mechanical effects, or because they divert the formative power from other organs. The accidental differences found in parts which are produced abnormally, are a less perfect form, a chemical composition which is often not exactly the same, while their duration is shorter.

It is difficult to class the abnormal formations which are entirely new, because they differ only by insensible shades. Generally they have this in common, that at first, they are more solid than the organs in which they are developed, or which are changed to them, which destroys them and those organs; and that in all those and particularly during the latter periods of their existence, they have a marked propensity to pervade the whole organism.

§ 41. XI. The organic form every where presents traces of a formation in accordance with the purpose to be attained. It is impossible not to perceive that an intellectual power, whatever may be its relations to matter, has governed the formation of the organized bodies. This is especially confirmed by those mechanical arrangements which we find in a multitude of places, and by the greater protection given to the organs essential to life. Among the phenomena of the first class, we shall mention the valves established in those vessels which have no immediate power of impulse, as the veins and the lymphatics, and the multiplicity of these valves, either at those points where the friction is greatest, as in the small veins and in the lymphatic vessels generally, or in those where there is no mechanical impulse, as in the lymphatic system. On the contrary, there are no valves in those veins where the different trunks anastomose together. In other parts of the vascular system, also, as at the base of the aorta and pulmonary artery, between the ventricles and auricles, we find valves which oppose the reflux of the blood. A similar arrangement exists also when it is required to separate parts of the same cavity in which different functions are executed: for instance, at the union of the stomach with the small intestine, and of the latter with the large intestine, &c.

As to the phenomena of the second kind, we see that the organs most essential to life, as the brain, spinal marrow, and lungs, are wholly or partially inclosed in large cavities, the skull, vertebral column, and the thorax, which are also particularly remarkable, on account of their circular form. So, likewise, the veins are situated less deeply than the arteries.

The duplication of most of the organs deserves also to be regarded in this point of view, since it allows the continuance of the function, even when an organ, or a portion of it, is destroyed. Sometimes the remaining organ increases in size, as happens, for instance, in the kidneys; while, sometimes, the sound portion redoubles its activity, as in the brain, lungs, &c., although in fact one half can never be perfectly replaced by the other.

The texture and external form of all the organs seem to harmonize with the final end of the organism, since most anomalies soon suspend its functions.

§ 42. Each organ has its peculiar functions. Nevertheless, there are certain conditions, in respect to which the functions of some organs agree together better than in regard to certain others. On this is founded the classification of the functions. The first, and most general division is that which divides the organic actions into functions which are related with consciousness, with the spiritual existence, which connect mind and the external world, the *animal functions* properly so called, and into those which immediately concern the material existence, the preservation of the substance, which are accomplished without *consciousness*, the *vegetative functions*. These functions unite and constitute, the first, the *animal life*, the second, the *vegetative*, *organic*, or *automatic life*, a division to which Buffon,(1) Grimaud,(2) and Bichat(3) have called the attention of physiologists. The latter has assigned to the two lives, and among other things to the forms of their organs, peculiar characters which have been adopted by modern writers,(4) and are reduced to the following:

1. *The organs of animal life are symmetrical, those of organic life are unsymmetrical.* To the first class are referred, 1, the brain and spinal marrow, with their nerves and appendages, or the nervous sys-

(1) *Histoire des Animaux*, Paris, 1709, vol. ii. ch. 1.
(2) *Memoire sur Nutrition*, St. Petersburg, 1789, p. 3.
(3) Bichat, *On Life and Death.*
(4) Sprengel, *Inst. Med.* vol. i. p. 197, 198.

tem of animal life ; 2, the muscular system ; 3, the osseous system ; and 4, the organs of voice. The second comprises, 1, the vascular system ; 2, the great sympathetic nerve ; 3, the digestive apparatus ; 4, the respiratory apparatus ; and 5, the urinary apparatus. This difference, as respects symmetry, is seen even in the anomalies, which appear on both sides at once in the first class, and exist on one only in the second.

Lately, some have wished to establish between the different systems of the animal life, differences founded upon the greater or less perfection of the symmetry, and still more recently, it is pretended that the osseous system exceeds all others in this respect.(1)

2. *The organs of animal life are formed in a type more constant than those of vegetative life : hence anomalies are as frequent in the latter as they are rare in the former.*

3. *The influence between the form and the activity of the organs in the two lives, is entirely different.* An anomaly in the form of an organ of animal life, instantly deranges its functions, while the most considerable aberrations in that of an organ of organic life are not attended with bad consequences. The normal condition of both halves of the organs of animal life is especially necessary in order to the regular performance of their functions ; for every derangement in one of them is followed immediately by an interruption in the whole function. On the contrary, one part of an organ of vegetative life may be diseased without incommoding the function, if the other portion supplies its place. And again the symmetry is such, that one half of an organ of animal life may be diseased, while the other remains in a state of perfect health ; while the disease of one half of an organ of vegetative life deranges the functions of all.

Although these characters are true to a certain extent, yet they are too general. It is true, and the remark has already been made, (§ 23,) that the organs of animal life are disposed more symmetrically and more constantly than those of vegetative life. But this difference is only in degree, and is not a direct contrast. Neither are the organs of animal life entirely symmetrical, and when we consider what has been before stated, the symmetry of the organs of organic life seems still more perfect. This difference, too, has no general value, since comparative anatomy demonstrates that it is not observed in the great majority of animals, for, in most of them, the organs of organic life are not less symmetrical than those of animal life, although Bichat seems to admit the contrary. Besides, even in man, the genital system is disposed with as much symmetry as any system of animal life, while that belongs only to vegetative life. It is true that Bichat separates it from these organs, saying that it does not relate to the individual : but he is mistaken, since the essence of the functions fulfilled by this system, corresponds perfectly to that of the other organs of vegetative life. It is not true that the anomalies of the organs of animal life exist on both sides at once, and that those of organic life are found on one side only. We

(1) Bartels, *Physiologie*, Freyburg, 1809, p. 21.

have almost always found varieties in the distribution of the vessels of the upper extremities, of the kidneys, &c., on both sides at the same time, while anomalies of the muscles and of the bones are frequently found only on one side. That the osseous system is more symmetrical than the other systems of animal life, is also false. The same system demonstrates, also, the too great generality of the proposition which states that the type of the formation is more constant in the organs of animal, than in those of vegetative life, since we meet varieties of form in the bones, as often at least, as in the vascular system. Finally, the greater frequency of anomalies in the organs of vegetative life depends on the greater number of stages through which they pass. When these stages are numerous, as in the osseous system, and especially in some of its parts, deviations from the normal form are also very frequent.

The third proposition, especially, is too general. All the truth it contains, is, that deviations in the form of organs affect their functions, if these functions depend in any measure on mechanical arrangement. It is of no consequence whether the kidneys are lobed or not, united or separated; whether the stomach or heart is on the right or the left side, &c.; but when the kidneys are too small, or when one kidney is deficient, when the ureters are obliterated, when the stomach is contracted in its centre, when the valves of the heart are deficient or adhere, when there is only one ventricle instead of two, when the aorta arises from both of these cavities at once, &c., the derangements are certainly more important than when the brain is oblique, when one side of the skull possesses more wormian bones than usual, or when a muscle is attached to an unusual number of ribs.

This pretended difference is then without foundation, and both for this reason, and because that duplication has been confounded with symmetry, the propositions mentioned by Bichat in his third law absolutely contradict each other. The normal arrangement of two parts of an organ of animal life is necessary only when, by their structure and relations with external objects, they form a single organ, and when their external form is connected with their functions, as happens, for instance, in the organs of the senses. When this is not the case, a deviation in formation of one of the portions has no bad effect, because it is replaced by that which is not mal-formed. The disease of one half of an organ of vegetative life does not always affect the function of the whole. When one kidney is diseased, the other enlarges. It is true that the disease in a part of an organ of vegetative life affects the function of the rest, but only when the different organs are parts of one whole; thus, a disease of the liver affects digestion, because the liver forms part of the digestive apparatus.

§ 43. So far in regard to the general conditions of the human form: before we pass to the general description of the individual organic systems, let us attend to the general conditions of the *chemical composition*, and the *actions* of the human organism.

§ 44. The human body, like all other organized bodies, is composed of proximate and remote chemical elements, even as it contains proximate and remote elements of form.

Among the remote elements, there is no one which is peculiar to it; all are met with in the general organism. It contains, on the contrary, some of the elements found in nature, but not all.

The union of several remote elements produces the immediate elements which belong particularly to organisms. We find especially oxygen, hydrogen, carbon, azote, and phosphorus, in almost all the immediate elements. The predominance of one or another of these principles distinguishes the materials from each other, as that of azote and phosphorus characterizes the chemical composition of animals, and consequently of man. Some of the immediate elements are more generally diffused, and concur to form more of the solids and fluids than others which are found only in certain parts.

Those which exist most generally are ***albumen***, ***fibrin***, ***gelatin***, a peculiar substance, ***mucus***, which resembles gelatin very much, and was long confounded with it, *fat*, and several ***salts***, which also occur in other than organized bodies. Fibrin, gelatin, and albumen, are only modifications of one and the same substance; they may be converted into each other by art: so too the most varied forms may be finally reduced to a certain number of simpler terms (§ 5).

The immediate elements which every where exist are, with the exception of gelatin,(1) contained in the common nutritive fluid, the blood. The blood is composed of globules (*cruor*, ***globuli***) and of a coagulable fluid: the latter consists of ***serum*** and ***fibrin***, the primitive elements of form.

The *fat* is a substance generally diffused, which does not enter into the composition of organs, but only envelopes them.

The immediate principles which are found only in certain parts are ***acids*** and ***salts***, or other compounds, which appear principally in the secreted fluids, to which they impart their peculiar characters.

These immediate principles concur in different proportions to form the different organs and the different fluids; and even viewed chemically, they may be considered as the proximate elements of the organism.

All the organic combinations, with a very few exceptions, take place contrary to the usual laws of affinity; hence sooner or later after death they form other compounds, which obey the laws of affinity, and which differ from those above-mentioned, principally because they contain fewer elements, because they are more simple.

Although the solids and fluids differ from each other by the excess of an immediate principle more or less properly belonging to them, and this peculiarity depends in its turn on the predominance of an immediate principle, still they may all be divided more or less easily into two classes, opposite to each other in this respect, that there is an excess of free acid in the first, and of free alkali in the second: a contrast which is also developed by electricity in the heterogeneous fluids.(2)

(1) Bostock, in *Med. Chirurg. Trans.* London, 1809, vol. i.—Marcet, *ibid.* vol. ii. —Berzelius, *ibid.* vol. iii.

(2) Besides the general works of Thomson and Thenard, we may consult on animal chemistry J. J. Berzelius, *Foerelaesningar i Djurkemien*, Stockholm, 1802-6,

§ 45. The organisms possess *dead* and *living* forces, which differ from each other inasmuch as the latter do not belong to them except for a certain period called *life*, during which only they may be considered as organisms enjoying a separate existence. Nevertheless these dead forces themselves differ very much during life and after death, for they depend on the form and chemical composition of the parts: so that the change death brings in this form and composition ought necessarily to produce other phenomena.

The living forces of the organisms may be referred to three, according to the different phenomena of action presented: 1, productiveness, (*productivitas*); 2, motivity, (*motilitas*); 3, sensibility, (*sensilitas*).

All the phenomena arising from these forces can also be reduced to two classes, according to the principle which forms the basis: these are the *material* and the *intellectual*: for we observe that the substance changes in the phenomena of formation and motion; but this is not seen in those of sensation.

The phenomena of formation essentially consist in the production of a peculiar substance, formed at the expense of another which is unlike it. The formative power shows itself in preserving the normal state, or in bringing to it the abnormal state. If this abnormal state be so changed to the normal state that a new part forms in the place of that which has been destroyed, the phenomenon is called *regeneration* or *reproduction* (*regeneratio*, *reproductio*); so too the preservation of the normal state of the species by the formation of a new creature is called *generation* (*generatio*). The substance which produces all these new formations is the common nutritious fluid, the *blood*, which is itself formed from heterogeneous substances, in accordance with the same laws by which all organic products are derived from it. The quantity of nutritious fluid increases then in a local or general manner, in order that each new formation may take place: and this state may be generically termed *inflammation*.

The essence of the phenomena of motion is an alternate change in the degrees of cohesion and form, which increases the volume in one direction at the expense of the same volume in another direction. When a part endowed with this power contracts and shortens, it swells, and becomes thicker; when it lengthens, it seems more and more thin. But in the first of these two states it is also much harder than in the second; either from this circumstance, or because the first state is the immediate result of an irritation acting on the part, it is called the *active state* of the organ susceptible of motion. We are certain that, although the volume and the mass are the same in the two cases, nevertheless the nature of the two states is entirely different, even when the chemical composition of the part should not be modified, and the difference should consist only in a change of cohesion.

2 vols.—Id., *Ueberblick über die Zusammensetzung der thierischen Flüssigkeiten*, Nuremburg, 1814.—Id., *Uebersicht der Fortschritte und des gegenwaertigen Zustandes der thierischen Chemie*, Nuremburg, 1815.—J. F. John, *Chemische Tabellen des Thierreichs*, Berlin, 1814.

This vital motivity differs much from similar dead forces, particularly from that of elasticity, although it is somewhat analogous to them. Neither should we confound it with the *extensibility* and the *contractility of tissue* admitted by Bichat, who represents them as principles of peculiar phenomena, which are either phenomena of formation or merely those of elasticity.

The phenomena of motion have also been classed either from the manner in which this motion is manifested, or from the relation between it and the cause on which it depends. Thus they are distinguished into *voluntary* and *involuntary* motions, or into *animal*, which are considered as belonging to animals only, and into *organic*. The latter have also been divided into *sensible* and *insensible*. But if the first classification, founded on the relation of the phenomena to their remote causes, be correct, the second is not, since the insensible organic motivity depends only on the phenomena which become active probably in another manner.

Sensibility is the power of receiving and of propagating impressions. It belongs to the nervous system, which should be considered as the organ of the internal principle, or *organ of the soul*, since it is in one of those parts that the spiritual principle experiences, from the impressions received by its periphery, the spontaneous changes afterwards transmitted to other organs by the conducting portion of the system.

As all the nerves do not propagate the impressions they receive even to that part of the nervous system in which the changes relative to the intellectual phenomena take place, or which immediately cause them ; and again as all the intellectual changes are not transmitted to the same organs, the sensibility may be distinguished into *animal* and *organic* ; and although this difference relates only to the nerves, we may extend it to the organs themselves : so that some are organs of animal and others organs of organic sensibility. Nevertheless, we would ask, if to establish this distinction too much latitude be not given to the idea of sensibility, or if that be not wrongly confounded with that of susceptibility in general. Then the animal sensibility alone would be called *sensibility*, and those parts destitute of it would be called insensible. The phenomena alledged in support of the hypothesis of sensible or insensible organic sensibility, do not prove its reality ; even as, on the other hand, those which they assure us demonstrate the presence of a pretended sensibility purely organic in certain parts, are not sufficient to justify the admission of this hypothesis.

GENERAL ANATOMY.

PART II.

DESCRIPTION OF THE INDIVIDUAL ORGANIC SYSTEMS.

§ 46. We have already stated, (§ 15,) that the different systems composing the organism, are divided into general and particular. The general systems, the *mucous*, the *vascular*, and the *nervous* systems, exist in all parts of the economy, and every where unite to constitute the body; and form, more or less perceptibly, the basis of all the other systems. They differ, however, in their extent: that of the nervous system is much less than that of the vascular, and the latter cannot be demonstrated in many parts where the mucous tissue is evident. The mucous tissue, then, is the most general, and, in fact, is the matrix of all the organs. It also is the first to appear. We ought, then, to mention it first.

SECTION I.

OF THE MUCOUS SYSTEM.

§ 47. The *mucous system*,(1) or *cellular tissue*, (*tela seu textus mucosus, cellulosus, cribrosus*,) is one of the two elementary forms to which, in ultimate analysis, the whole organic formation may be referred. It is the coagulable fluid coagulated. It is generally described(2) as an

(1) D. C. Schobinger, *De telæ cellulosæ in fabricâ corporis humani dignitate*, Goettingen, 1748.—Thierry, *E. in celluloso textu frequentius morbi et morborum mutationes*, Paris, 1749, 1757, 1788.—Hunter, *Remarks on the cellular membrane and some of its diseases*, in the *London Med. Obser. and Inquiries*, vol. ii. p. 26.—Th. Bordeu, *Recherches sur le tissu muqueux ou cellulaire*, Paris, 1767.—J. Abadie, *Diss. de corpore cribroso Hippocratis, seu de textu mucoso Bordevii*, Montpelier, 1774.—C. F. Wolff, *De telâ, quam dicunt cellulosâ, observationes:* in the *Nov. Comment. Petropol.*, vol. vi. vii. and viii.—Detten, *Beytrag zu der Lehre von der Verrichtung des Zellgewebes.* Munster, 1800.—Lucæ, *Anatomisch-physiologische Bemerkungen über den Zellstoff*: in the *Annalen der Wetterauer Gesellschaft für die Naturkunde*, vol. ii., 1810.—G. R. Treviranus, *Ueber die organischen Elemente des thierischen Koerpers*: in *Vermischte Schriften*, vol. i. 1816, p. 124.—Felici, *Cenni di una nuova idea sulla natura del tessuto cellulare*, Pavia, 1817.—Heusinger, *System der Histologie*, Eisenach, 1823, Part II. p. 121.

(2) This is the view taken by Haller, Bergen, Schobinger, and Thierry. This opinion was adopted by Bichat, and recently by Béclard and Blainville, and is now generally received in England, France, and Italy. Bordeu's opinion, which Meckel follows, has been defended in Germany by Wolff, Autenreth, Prochaska, Blumenbach, Rudolphi, Treviranus, and Heusinger. F. T.

assemblage of numerous layers, and of soft and white fibrils, which, varying constantly in their arrangement, produce cellules of different sizes and forms. All these cellules communicate, so that the whole tissue forms but a single cavity which is infinitely subdivided, from which circumstance its most common name, *cellular*, is derived. But when closely examined, it is perceived that this assertion is at least too general, and that the mucous tissue is a cohesive, homogeneous, viscous, shapeless, and but slightly solid substance. It appears thus in the inferior animals, and in the commencement of all formations. In fact, we see at first only this homogeneous semi-fluid mass, in which globules afterwards appear, and concur to form the whole organism. There exists primitively between it and these globules, and afterwards between it and the organs, the same relation as between the shapeless portion of the fluids, and the globules which swim in them.

We may be convinced of the exactness of this representation at all periods of life. Neither layers, fibres, nor cells, are perceptible to the naked eye, even when aided by a microscope, and we see only the substance spoken of by us, without the least opening. This substance appears to be composed of fibres and layers only because its viscidity causes it to assume that form when it is extended, and with or without a microscope these layers and fibres may be seen to form under the eyes of the observer. When, for instance, we separate two muscles or muscular fasciculi, the homogeneous substance between them becomes at first uneven, and appears filled with channels, without always losing its cohesion. But if this traction be continued, or if more force be used, it tears and produces filaments or small cylindrical columns, which become very long if the extension be sustained. If we cease to extend it, so that the space occupied by the substance is diminished, the filaments first shorten and finally unite anew in a coherent mass.

When the mucous tissue is extended, air sometimes accidentally penetrates it and produces vesicles of different sizes and figures. But this air escapes when the tension ceases and the tissue then assumes its primitive form. The cellules which arise in this manner are not always the same, for if these parts be again separated the air penetrates anew, but the cells now formed are very different from the first both in size and form. When these cells remain by continued extensions, the air is confined only by the contraction of the mucous tissue at the moment when the traction ceases, so that, when renewed, cells of the same form are naturally produced. When air penetrates into the mucous tissue, it can be pushed in every direction; we can divide or reunite the vesicles to which it gives rise, and thus vary their form to infinity.

The facts which Bichat(1) regarded as proving that the mucous tissue is an assemblage of filaments and laminæ, demonstrate only that, when properly considered, this substance can assume this form, whenever the circumstances are favorable. Thus, for instance, it is pretended that the distension of a part of the mucous tissue of the scrotum would

(1) Bichat's *Gen. Anat.* vol. i. p. 114.

demonstrate its lamellar and fibrous structure, because it then appears as a transparent membranous layer, presenting many irregular filaments, which are seen when more force is used, as the spaces between them are then enlarged. But this experiment only proves that whenever the homogeneous mucous tissue is distended, it can assume the lamellar and the fibrous form.

Accordingly, then, as we simply extend the part, or at the same time inflate it with air, and as the substance is more or less viscid, we obtain in the same part either vesicles of different sizes, or filaments, or, finally, both vesicles and filaments, at the same time we then see simple meshes, or true permanent cells.

Nor does the cellular structure obtained by congelation prove that this arrangement is original. As the mucous tissue is always filled with liquids, the interstices they occupy must become permanent by freezing.

These pretended fibres have also been called absorbent or exhalent vessels, because they are discovered only in those portions of the mucous tissue which have been formed into membranes by extension, and have not been observed in those parts which have a cellular form from the introduction of the air. But it is easily perceived that this difference also depends on the process employed; for traction ought necessarily to produce fibres; while distension by air, which acts in every direction at once, gives rise only to laminæ and vesicles.

The color of this semi-transparent substance is grayish. The white tint commonly attributed to it does not belong to it, but results only from the reflection of light from an infinite number of surfaces when laminæ and filaments have been artificially formed. The term *mucous* tissue already adopted by Bordeu, is then more exact than that of *cellular* tissue which is generally used.

§ 48. All the phenomena presented by the mucous tissue are explained with as much, and even with more facility, by the hypothesis of this structure, than of that of the formation usually attributed to it.

The most remarkable property of this tissue is its *penetrability* or *permeability*. Foreign substances which are accidentally introduced, or which are abnormal only from their great abundance, are frequently seen in parts the most distant from where they entered; or when they form a coherent mass, they sometimes extend through the whole tissue and sometimes are expelled only by one opening.

Here we may mention,

1st, The migrations of those firm solid bodies which have penetrated into the organism. Thus, pins which have been introduced into the stomach proceed to the fingers, the toes, or the other regions of the surface of the body, as the loins, sides, &c. Often too they are carried from the surface into other parts, and move from the arm towards the chest—from the hand towards the upper part of the arm, &c.

2d. The facility with which general emphysema is produced by blowing air into any portion of the body, and the ease with which the air passes out from a single opening.(1) Air, if introduced under the skin penetrates, not only below the cutaneous organ and the parts covered by it in the whole body, but also within the interstices of the muscles and into the substance of all the viscera. The same thing happens after wounds of the lungs; the air which is constantly renewed by respiration, passes, first, through all the branches of the bronchial system in its mucous tissue, and from thence into every part, so that the body often resembles a large bladder distended by air.

3d. The ease with which collections of pus point at a distance. The pus of abscesses developed in the chest burrows a passage to the feet through the mucous tissue which fills the interstices of the organs. Urine, which filters through a wound in the bladder, penetrates the cellular tissue of the abdomen, and even of the chest. The blood from a wounded artery spreads itself through the cellular tissue of an entire limb, &c.

4th. In a general anasarca all the serum sometimes escapes by an accidental or artificial opening, if the nature of the fluid will permit.

These phenomena are commonly attributed to the continuous communication of the cellules with each other; but they may be explained as well by the softness and semi-fluidity of a cohesive substance. All these unusual passages are but temporary, and it is evident that many of the above mentioned phenomena, as the migrations of foreign bodies, and of collections of pus, favor the hypothesis of the cellular structure of the tissue less than that of its mucous structure, for it is not probable that these bodies would follow the direction of the cellules. They burrow, removing, destroying, and separating, purely mechanically, the mucous tissue before them: in the former case the tissue is reproduced, or collapses when they have passed; in the latter case the disease, which at first was slightly developed, is now extended. If we be incorrect, how do bodies which have been swallowed descend from one cavity to another? How do pins proceed from the intestinal canal into the vessels? Why is the mucous tissue altered at all points where it contains pus? None of these phenomena demonstrate a cellular structure, and many prove the contrary.

§ 49. The relations of the mucous tissue with the organs are of two kinds; it forms, or does not form, one of their essential parts. In the first place it may be called the *internal* or *special mucous tissue*, in the second, the *external*, or *general mucous tissue*.

The former contributes to form the organs, either alone or combined with nerves, vessels, or a peculiar substance which pervades it: the second is found between the organs, and fills the intervals between them. But at the same time both unite; for the external mucous tissue gradually blends with that which properly belongs to the organs.

(1) We have seen several of these general emphysemas which so commonly follow wounds of the lungs, and which sometimes result from the rupture of a cartilaginous ring of the trachea. Air penetrates into the mucous tissue very rapidly, but when a large opening is made for it, but little escapes, even when we press around the wound. Most probably, then, it is absorbed, rather than expelled. F. T.

As the mucous tissue of the organs penetrates all their substance, the distinction between the internal and external mucous tissue is not very strict, and the whole body is imbedded in mucous tissue. The most essential difference between these two tissues relates only to the functions. The internal mucous tissue contains the different substances which form the organs, while the external includes only the *fat* and *serum*, which are necessary for their continual reproduction, and also for their constant activity.

§ 50. The *external mucous tissue* may, nevertheless, be considered as forming, in some measure, a separate system: for in the different regions of the body it is connected with the internal mucous tissue less intimately than with its own peculiar parts. Setting aside both this internal tissue and the organs it assists to form, it represents an uninterrupted system, which is a duplicate of the form of the whole body, but which, in certain parts, differs considerably in regard to *quantity*, *cohesion*, and the *nature* of the fluids it contains. Besides the general connections between all the portions of the mucous tissue there are places where those of the principal regions, which correspond with the principal regions of the body, pass more particularly and imperceptibly from one to the other. Although these details may belong strictly to special anatomy, they should be anticipated here, since we must know them to acquire a complete idea of the mucous system.

The mucous tissue exists but in a small quantity within the vertebral column and the skull; the cavity of the spine contains more than the skull, especially between the dura mater and its bones: and there also it contains an abundance of fat, which is not found in the cranium. This phenomenon is very remarkable, since in several animals, particularly in most fishes, a very considerable mass of fat is found within the cranium between its parietes and the brain which is small in relation to the capacity of the cavity, so that the substance scattered between the organs, as nutrition in reserve, exists at least where the brain is still very imperfectly developed.

On the contrary, much mucous tissue exists around the vertebral column, and there is always more before than behind, and also around the head.

In the trunk this tissue abounds, not only around the vessels which proceed along the vertebral column the aorta and the vena cava, in the thoracic and abdominal cavities, in the neck around the carotid arteries, the jugular veins, the pneumogastric and sympathetic nerves, and the esophagus, but it accumulates in great quantities in several parts of those regions. On the sides of the neck, at its upper part, it surrounds the numerous lymphatic glands and the salivary glands, and below, the vessels and nerves of the upper extremities as they emerge from the thorax. It abounds in the chest in the two mediastina and around the large vessels: and without this cavity, especially at its superior part, it exists around the mammary glands, and also between the two pectoral, and the serratus magnus, muscles. There is more in the abdomen than in the chest, particularly around the kidneys and at the entrance of the vessels into the abdominal viscera, between the folds of the peritoneum, and especially in the mesentery. But in no part is it more abundant than in the pelvis, around the rectum, the internal organs of generation and the bladder, and it thus favors the great enlargement of the parts within this cavity. It accumulates also on the outside of the pelvis and principally forward in the external genital organs, the scrotum, and the labia pudenda. On the external surface of the skull there is less than in the face where large masses exist in the orbits of the eyes, between the muscles of the face, in the cheeks, and around the mouth.

In the limbs its quantity is in a direct ratio with the extent of motion in the different regions. It is most abundant in the axilla and in the groin; and there is more in the former than in the latter: less is found in the succeeding articulations. There is not so much between the muscles of the arm and of the thigh, as between those of the fore arm and the leg, and of the hand and the foot.

The masses of internal and external mucous tissue communicate together in the different regions of the body, principally by the openings of these regions and the spaces between them. These are then the points through which abnormal substances pass from one region to another.

The mucous tissue of the cavity of the spine, communicates with that which covers the spinal column externally, principally by the intervertebral foramina; and the mucous tissue of the cavity of the skull is connected with that of the exterior of the skull and of the face by openings for the passage of the nerves, as also by the great and small emissary veins. That of the face is continuous, particularly on the sides of the lower jaw, with the mucous tissue of the neck: this mucous tissue of the neck unites with that of the thoracic cavity, in the place where the vessels and nerves of the arm emerge from the thorax; this proceeds to the abdomen along the large vessels, especially the aorta, and along the esophagus also, passing through the openings in the diaphragm designed for the passage of these canals, and gliding at the same time through the smaller perforations in this muscle. The mucous tissue of the abdomen communicates with that of the organs of the pelvis by the inguinal ring, the crural arch, the sciatic notch, the foramen ovale, and the lower cavity of the pelvis.

§ 51. The mucous tissue immediately connected with the organs, for which we cannot find a better term than *special*, also divides into two parts: the external serves to envelope each organ, continues itself imperceptibly with the general mucous tissue, and forms the transition from the general to the special mucous tissue: the internal, on the contrary, concurs with the materials coming from the other systems to form the organs.

The external portion of the special mucous tissue forms around each organ a layer which separates it from the rest. We may say, then, with Bordeu, that this tissue represents a kind of atmosphere. This separation, as a layer, is produced, first, by the peculiar life of the mucous tissue; secondly, by the fat and serum with which it is filled.

The most important organs, then, are generally imbedded in the largest masses of this tissue, whenever they are not insulated by other modes; although, in certain cases, this result is produced by the two arrangements united.

In the organs formed of several superimposed layers, as the alimentary canal, the bladder, &c., a proper layer of mucous tissue always exists between the different coats, which may be regarded as forming the transition of this to the internal mucous tissue; since, if it is internal in regard to the whole organ, it is also external in relation to each of its different layers.

Partly on account of these atmospheres of mucous tissue, the adjacent organs and the superimposed layers of an organ, escape for a time the diseases which attack one or more of them. Nevertheless, the mucous tissue does not insulate them perfectly, so that, in general, the disease of an organ or layer finally passes through it, and attacks the organ or layer adjacent; and again it only serves to concur in the insulation of the diseases of the organs which depends principally on the peculiar structure of each part, and on the differences of the life it enjoys. This proposition seems at least very probable, when we remember that, although the nerves and vessels are not lined with this tissue, they often escape disease, although all around may have been destroyed by suppuration: the character of the disease itself has also some influence, for some maladies extend to the surrounding parts more readily than others.

Further, these atmospheres of mucous tissue relate also to the motions of the organs, and hence are found abundantly around parts which are very movable.

§ 52. Usually it encompasses the respective parts in their whole extent, except the skin, where it is found only on its internal face. Hence the skin has been compared, in this respect, to the serous and mucous membranes, and even to the vessels; but the comparison is incorrect, since all the hollow organs are enveloped in all parts with the mucous tissue. In fact their internal surfaces are not lined with it, so that, when opened and drawn out to reduce them into flat membranes, they are analogous to the skin. And will not all the other organs present the same phenomenon if they are also treated in this manner? Finally, the skin is no exception to this rule, as the epidermis, which covers it, may be considered as an indurated mucous tissue, and as an external envelope or capsule.

§ 53. The proper substance, the vessels, and the nerves, of the organs, are situated within the special mucous tissue, which may itself be divided into two other parts. Each branch of a vessel, of an excretory duct, or of a nerve in the interior of an organ, has its layer, its proper cellular sheath, which is more solid than the rest. Between these sheaths we find a looser mucous tissue. The fasciculi and the fibres of a muscle are surrounded with proper sheaths, which are arranged, in regard to the looser mucous tissue in their spaces, in the same manner as is the capsular mucous tissue of a whole organ in regard to the general mucous tissue. The final element, which possesses a definite form, is also enveloped with mucous tissue.

Thus, in final analysis, the mucous tissue represents a cavity constantly folding from without inward, which closely envelopes the whole body, and all the organs, and even their minutest portions.

We cannot perceive with the naked eye in all the organs, that the quantity of the mucous tissue is in an equal ratio with the other compound elements included by them; many seem even entirely destitute of it. Thus we find little in the brain, spinal marrow, bones, tendons, &c., while there is much more in the muscles and the lobate glands.

§ 54. Although some vessels and nerves of large and small caliber, wind into the mucous tissue, we cannot consider them as its component parts, since they pass through it only to go to the organs and form with it their bases. But the most delicate ramifications of the exhalent and absorbent vessels,(1) undoubtedly enter into its organization, and very probably have no proper parietes distinct from the rest of this tissue.

As regards chemical composition, the mucous tissue belongs to the class of organs formed principally of *gelatine.*

§ 55. The mucous tissue is highly elastic, so that it may be extended to a great degree, and contracts in the same proportion; its elasticity, however, is diminished by the effects of inflammation and other morbid changes, and it becomes fragile.

The plastic or formative power, is developed in it to a great degree; hence its facility of prompt and complete reproduction, when it has once been destroyed; and hence too it replaces those parts which cannot be reproduced in perfection, as the muscles and the tendons. All reproduction then commences by the formation of mucous tissue. This tissue is destroyed with difficulty. The other vital phenomena, irritability and sensibility, are not observed in it; at least it possesses the former only in certain regions, and in a feeble degree; and even the phenomena which lead to this conclusion do not positively prove it, since they may occur in the muscular system or in the cutaneous tissue, as well as in the mucous system.

§ 56. The mucous tissue includes two different fluids, a *serum*, analogous to that of the blood, and *fat.*

The serum, unlike the fat, exists in all parts, but not always in the same quantity, which seems to be inversely as that of the fat; thus it abounds in the scrotum and eyelids, which normally contain no fat, and it collects there more readily than in other places; an accumulation of it constitutes *anasarca.* The serum of the mucous tissue, like all the

(1) Absorbent and exhalent vessels do not exist. They have never been seen, but have been imagined, to account for the phenomena of exhalation and absorption. Before they were thought of, these phenomena were well explained by transudation and imbibition. Physiologists owe this doctrine to Magendie and Fodera. Fodera thinks that exhalation and absorption depend on capillarity of the tissues, that this double phenomenon can exist in all parts, and that the liquids which they contain may be carried either by the lymphatics or by the arteries and veins. See his *Recherches experimentales sur l'absorption et l'exhalation*, Paris, 1824. F. T.

serous fluids, contains an abundance of albumen combined with a small quantity of coagulable mucilage and salts. If we may judge from experiments made upon the serum which is collected abundantly by blisters between the cutis and epidermis, the ratio of the animal matter to water, is less than in the serum of the blood.(1)

§ 57. The fat(2) is yellowish and less fluid than the serum of the mucous tissue. This substance occurs in masses of various forms, composed themselves of regular, rounded globules or vesicles arranged more or less compactly, one against another. The masses and vesicles are formed of mucous tissue, which contains the fat, but is not connected with it, and which unites them altogether. Their size varies, although Wolff pretends it is always the same in man, for the small masses which they inclose, differ much in volume. The largest are generally situated internally, and continue diminishing as they approach the circumference, where they are also more compact. Nevertheless small masses are found among the large. These have the same volume in all the regions of the body, although that of the masses varies infinitely.

In regard to chemical composition, fat differs from all other animal substances, as it contains but very little azote: by distillation it is resolved, for the most part, into water and carbonic acid, and a small quantity of ammonia. A peculiar acid, which Krell believed he had discovered in fat, seems not to exist; as is the case too with the salts and acetic acid mentioned by Thenard,(3) while the peculiar acid he thought he discovered in fat, is benzoic acid,(4) according to Berzelius.(5)

The quantity and nature of the fat is not the same every where.

This substance presents itself in two states loose, and in combination.

There are parts of the body which contain no loose fat, as the interior of the skull, of the brain, of the eye, of the nose, of the organ of hearing, the lungs, the intestinal canal, and the glands.

Much is found, however, under the skin, except in the penis, eyelids, and scrotum. It abounds in the face, the neck, the abdomen, the groins,

(1) Marcet, *A chemical account of various dropsical fluids*, in the *Medico-Chirurg. Transac.*, vol. ii. p. 34-384. Bostock, *On the analysis of animal fluids*, in same journal, vol. iv. p. 53.

(2) Malpighi, *De omento, pinguedine et adiposis ductibus;* in his *Epist. anat.*, London, 1686, p. 33.—Jansen, *Pinguedinis animalis consideratio phys. et pathol.*, Leyden, 1784.—Wolff, *De adipe*, in *Nov. Act. Petrop.*, vol. vii. 1789, p. 278.—Reussing, *Diss. de pinguedine sanâ et morbosâ*, Jena, 1791.—Allmer, *Diss. sistens disq. anat. pinguedinis animalis*, Jena, 1823.

(3) *Ueber die Fettsaure*, in Scherer's *Allgem. Journ. de Chemie*, vol. viii. p. 127.

(4) *Ueber die Fettsaure*, in Gehlen's *Journ. für Chemie und Physik*, vol. ii. p. 275.

(5) Chevreul has recognized in it, as in many other fatty bodies, two portions, a fluid called *elain*, and a solid called *stearin*; this latter very much resembles the fat of tallow, but is distinguished from it, as by saponification, we have margaritic but not *stearic* acid. It is white and has but little lustre; when fused it crystalizes on cooling in small needles, the mass of which is terminated by a plane surface. As to elain, it is colorless, and resembles an oil; it is liquid even at four degrees below zero, and begins to form an acicular mass at several degrees below this temperature. It is inodorous, or nearly so; its taste is sweetish, and when fresh is not disagreeable. F. T.

the upper parts of the extremities, the palms of the hands, the soles of the feet, between the voluntary muscles and among their fasciculi and even their fibres, around certain membranes, as the peritoneum and its prolongations especially the omentum and mesentery, in the pelvis, beneath the internal layer of the pericardium, consequently on the surface of the heart, around the origins of the large vascular trunks, in the mediastina, around certain glands, as the salivary glands and kidneys, around the nerves penetrating between their fasciculi in considerable quantity, and finally within the bones, especially the long bones, where it is called *marrow*. (1)

It accumulates in those parts especially which execute extensive and frequent motions, and in those where it is necessary that the heat should be concentrated. It is deficient, on the contrary, in fat persons, where it would incommode the functions, and where its existence might affect even life.

The fat, combined with the other immediate materials of organized bodies, exists in several places where it is rarely found in a loose state, and where even it is never uncombined, as particularly in the brain, (2) which, like the nervous system in general, contains a considerable quantity of the two different fatty substances.

The fat does not exist in the substance of the fibrous organs, in the cartilages, bones, or serous membranes, either in a loose state or in combination; although it sometimes collects in considerable quantities around those parts.

The fat has not the same consistence every where: thus, it is very hard around the kidneys, but softer on the heart and in the orbits of the eyes.

G. Hunter was led to conclude, from the constant deficiency of the fat in some parts of the body while it abounds in others, from a greater accumulation of serum or air in parts destitute of fat in persons affected with edema or emphysema, while, whatever degree of obesity occurs, fat never accumulates in these parts even when they are so situated that a fluid contained in the mucous tissue would collect in them from the fact of its gravity alone, as the scrotum; from the difference observed too, even in the most extensive anasarca, between those parts of the mucous tissue filled with water and those which before contained fat; and from another circumstance, that the fatty portions of the mucous tissue do not yield at all to pressure, as do those which contain an excess of serum, and that the fat usually cannot pass from one place to another: all these facts, we say, led G. Hunter to conjecture that the fat is secreted by a peculiar glandular apparatus, distinct from the common mucous tissue, and composed of vesicles. (3)

(1) *Analysis of the marrow* by Berzelius, in Gehlen's *Journal für Chemie und Physik*, vol. ii. p. 287.

(2) Vauquelin, *Analyse de la matière cérébrale de l'homme et de quelques animaux*, in the *Ann. du Muséum naturel*, vol. xviii. p. 212–239.

(3) Wolff was the first to state that the molecules of fat are contained in the spaces of the mucous tissue in which they are placed, and not in special cells. Heusinger

Most probably, however, this special apparatus does not exist, and the adipose cellules are all produced simply by fatty globules, which penetrate the mucous tissue as the fat forms. Our opinion is founded too on the circumstance of the fat appearing in the form of globules independently of the mucous tissue, of which we may be easily convinced by destroying a lump of it.

Riegel's opinion is still less probable: this physiologist thinks that fat is formed in all the glands, but principally in the renal capsules.(1)

Fat has several uses. Its unctuous nature facilitates the motions of the organs; it is a bad conductor of caloric, and hence it protects them from cold by opposing the dispersion of the animal heat. Finally, it serves particularly as a reserve of nutriment, although, as it contains no azote, it is but feebly animalized. Farther, as its formation is favored by rest, so those organs which remain for a long time unused, even the muscles among the rest, are transformed into fat; on the contrary, fasting, intellectual and bodily labor, and debility from any reason, cause it to disappear. The facility of its production doubtless depends on its slight degreee of animalization: hence the reason why it appears, not only in the circumstances above mentioned, but also to replace those parts which are wasted, and which have been removed: as, for example, the testicle in the scrotum or the eye in the orbit when they have been extirpated.

§ 58. The mucous tissue and the fluids it contains differ very much in several respects at different periods of life. Like all other parts, they are more fluid in proportion as the organism is younger. The mucous tissue appears at first absolutely homogeneous, very soft, and differs but slightly or not at all from serosity, from which it is afterwards distinguished by its greater solidity. Hence the reason that during the early periods of life we can easily separate parts which afterwards become inseparable; this is seen particularly in those parts which are formed of several superimposed layers united by mucous tissue.

The mucous tissue is more abundant the younger the organism is. The organism originally, when homogeneous, is formed of this tissue alone; even after the organs are developed, its proportion is still much greater, as it contains few substances which are peculiar to it. This is proved by the muscles, whose fasciculi are small in proportion to the mucous tissue, and by the glands, which are composed of several lobes, united by a loose mucous tissue, and easily separable from each other.

The fat is more liquid, thinner, more transparent, and whiter, the nearer the organism is to the time of its origin. Nor is its quantity the same at all periods of life. In the early periods of fetal existence

adopted this opinion; but Beclard has rejected it, and, faithful to the old doctrines, admits a special adipose tissue, even as he adopts the opinions of Bichat's school, in regard to the structure of the mucous tissue. F. T.

(1) *De usu glandularum suprarenalium in animalibus, necnon de origine adipis, disquisitio anatomico-physiologica*, Copenhagen, 1790. Riegel has explained the uses of the fat very clearly, although his little work contains many arbitrary assertions wholly unproved, partly true or entirely false.

it is deficient in those organs which afterwards contain the most. It begins to appear at the fifth month under the skin in small isolated masses. It exists in masses in this place only, even in the fully grown fetus; for the internal parts, even those where it afterwards abounds, as the epiploon, the heart, the surface of the kidneys, the muscles, &c., have none or but very little, while it is formed in abundance near the surface of the body. This arrangement resembles that in the cetaceous animals, where little is found internally, but enormous masses exist near the external surface of the body. It gradually increases also internally; but, generally speaking, this occurs only towards the middle of life. At puberty the fat diminishes externally, as it does in the hibernating animals, in proportion as the semen is secreted with more activity,(1) and in the same manner also, as in insects, the genital organs develop themselves at its expense, so that the neuters and those which lose their sex are fatter than the others.

Finally, the fat not unusually disappears in all parts of the body at an advanced age, and the subject actually wastes. The extremities of life then are alike in this respect. Nevertheless, the body of the old man differs from that of the infant, in that, although the layers of fat diminish in him, the organs are still provided with it, and consequently the body always possesses it in a large quantity. A severe and long continued dropsical affection can alone remove it entirely, which depends doubtless on the fact that the abundant formation of the serum prevents that of the fat.

§ 59. The mucous tissue forms the basis not only of the regular but also of the irregular tissues. The history then of all the alterations of texture might be given in this place, since they develop themselves near it and in it; but as these alterations present peculiar characters, as they appear in the mucous tissue of some organs rather than in that of others, we had better mention them when speaking of those organs of which they are repetitions, or in which they are developed.

The *induration* of the mucous tissue is rather a common morbid alteration, and occurs most frequently in very young children. It attacks particularly that found under the skin. The fat and serum seem to participate in it also, for if we cut into the indurated mucous tissue, a yellowish fluid escapes.

The serum of the mucous tissue accumulates morbidly in general *anasarca*. In this disease the fat disappears more or less completely, and is converted into a mucous substance analogous to gelatin.

The fat itself often varies from the normal state, principally as respects its quantity. We have already pointed out in a summary

(1) H. Reeve, *De animalibus hyeme sopitis*, London, 1803.—Idem, *An essay on the torpidity of animals*, London, 1809.—Mangili, *Saggio di osservazioni per servire alla storia de' i mammiferi soggetti al periodico letargo*, Milan, 1807.—Idem, *Mémoire sur la léthargie périodique de quelques mammifères*, in the *Annales du Muséum*, vol. x. p. 234.—J. A. Saissy, *Recherches expérimentales, anatomiques, chimiques, etc., sur la physique des animaux mammifères hibernans*, Paris, 1808.—Prunelle, *Recherches sur les phénomènes et les causes du sommeil hivernal de quelques mammifères*, in the *Annales du Muséum*, vol, xviii. p. 20.

manner the circumstances of its excess or deficiency. Its general or local accumulation is sometimes enormous. Generally speaking, it increases in those parts where it is found in a state of health rather than in any other, although in other places the ordinary proportion exists: we have observed this particularly in the great epiploon. The same may be said of the surface of the heart and mediastinum. Thus, it is in the epiploon that *lipomata* are most frequently formed. But we must not confound these congestions of fat with the lardaceous tumors, which do not deserve this name, as they are simple condensations of the cellular tissue, or repetitions of other regular tissues, or finally peculiar morbid tissues.

The lipomata almost always perfectly resemble the normal fat; we rarely find them surrounded with a proper cyst; they are connected intimately with the adjacent fat, although from their size and prominence they are immediately discovered. Those below the skin may be confounded with other diseases, especially with hernias, when they are developed in those parts where the viscera appear after leaving their cavities; of this we have seen several instances, and have some preparations in our cabinet.

Fat, however, develops itself sometimes irregularly where it does not exist in a natural state: as first in the ovaries, then on the internal face of the mucous membrane of the intestinal canal, and rarely within the skull. In the ovaries we often find hair developed with the fat; and as in the normal state the mucous tissue contains both fat and serum, so collections of the latter fluid are almost always found in those ovaries which are overloaded with fat.

SECTION II.

OF THE VASCULAR SYSTEM.(1)

§ 60. The *vascular* system (*systema vasorum*) is composed of numerous flexible ramifying canals, formed of several membranes, in which the fluid of nutrition is perfected, and carried to all the organs and to all the parts of the body, and reconveyed from all the organs. As the blood constantly returns to the place from which it started, that is, as it *circulates*, this system is also called the *circulatory*. The first name is derived from its form, and the second from its function. It comprises

(1) There are but few general works which embrace the whole of the vascular system, because it is formed of so many different portions, and so many views have been taken of it, both generally and particularly; both in its outer and inner form, we study its properties, functions, and its changes whether regular or irregular. We may however mention the following as the principal works on the normal structure and functions of the whole vascular system: Sœmmerring, *Lehre vom Baue des menschlichen Kœrpers*, vol. iv.—Bichat, *General Anatomy*, trans. by Hayward, vol. i.—Beclard, *General Anatomy*, trans. by Togno, p. 237. For the properties of this system see Haller, *Mémoire sur la nature sensible et irritable des parties*, Lausanne, 1756, sect. xi., and in *Op. min.*, vol. i. nos. 13, 14, 15.—Verschuir, *De*

three principal parts, of which two, the *arteries* (*arteriæ*) and the *veins* (*venæ*), contain perfectly formed blood, which is carried by the former to the organs, while the latter takes it back from them. These two systems of vessels meet in a common centre, the *heart*, a hollow organ with thick muscular parietes, from which the arteries originate, and where all the veins empty themselves. The third principal part is the *lymphatic* or *absorbent* system, (*systema lymphaticum*, *vasa absorbentia*;) its vessels do not carry blood, but are filled with the product of digestion, the *chyle*, or with the residue of the processes of nutrition, the *lymph*. In several respects this system is only an appendage of the venous system.

§ 61. The arteries, the veins, and the heart itself, are also divided into two separate systems. The veins of the one, called for this reason the *veins of the body*, carry back all the blood from the organs; and, as the lymphatics terminate in this system, to which they are only appended, they carry the chyle and the lymph to the right or anterior portion of the heart. The different veins of this system unite in three trunks, the upper and lower venæ cavæ and the large coronary vein of the heart; these open separately into the *right auricle*. From this cavity the blood passes into the *right ventricle*, thence into the *pulmonary artery*, which carries it into the lungs, where it is subjected to the influence of the atmospheric air.

The ramifications of this artery carry it to the *pulmonary veins*, whence it passes to the *left auricle* of the heart, then into the *left ventricle*, and it is afterwards conveyed to all the organs. Harvey, in 1619,(1) first demonstrated the complete circulation of the blood, which had already been discovered in some parts by Servet, Colombo, Levasseur, and Cesalpin. As this fluid has peculiar qualities in the veins of the body, in the right portion of the heart, and in the pulmonary artery; as it also possesses properties equally peculiar in the pulmonary veins, the left portion of the heart, and the arteries of the body,

arteriarum et venarum vi irritabili et inde oriunda sanguinis directione abnormi, Groningen, 1776. On the motion of the blood consult Harvey, *Exercitatio de motu cordis et sanguinis in animalibus*, Oxford, 1628.—Haller, *Experimenta de motu cordis a stimulo nato; De motu sanguinis sermo, quo experimenta continentur; De motu sanguinis sermo, quo corollaria experimentorum tradantur*, in *Op. min.* vol. i. p. 60–241.—Spallanzani, *De' i fenomeni della circolazione osservata nel giro universale de' vasi*, Modena, 1777. For the morbid alterations of different parts of the vascular system, although they are treated of very imperfectly, see Baillie's *Morbid Anatomy*, § 1, 2, 3.—Voigtel, *Handbuch der pathologischen Anatomie*, vol. i.—Baillie, *Of uncommon appearances of disease in blood-vessels*, in the *Trans. of a soc. for the improvement of med. and surg. knowledge*, London, 1793, vol. i. no. 9.—Sandifort, *De rarissimo cordis vitio*, in *Obs. anat. pathol.*, book i. no. 1.; *De cordis et valvularum aortæ nonnullis vitiis. ibid.*, no. 2.; *De notabil. vasor. aberrationibus, ibid.*, lib. iv. no. 8.—Corvisart, *Essai sur les maladies organiques du cœur et des gros vaisseaux*, Paris. 1806. Burns, *Observations on some of the most frequent diseases of the heart*, Edinburgh, 1800. These last works, however, treat only of the sanguineous system. The *Anatomie Médicale* of Portal, vol. iii., art. *Angiologie*, gives a complete history of the whole vascular system, both in a healthy and diseased state.

(1) Harvey, *Exercitatio de motu cordis et sanguinis in animalibus*, Francfort, 1628. —G. Kerr has recently denied the reality of the circulation, (*Observations on the Harveian doctrine of the circulation oj the blood*, London, 1819,) but all his objections are easily refuted.

while its qualities in all parts of these two opposite systems are the same; finally, as the structure is similar, and differs only in an analogous manner in the corresponding portions of each in relation to the functions they fulfil, we may with Bichat consider both of them as separate systems, of which the first is that of black blood, and the second of red blood; even as two circulations were long since admitted, viz., the great circulation, performed by the latter system, and the small, of which the first is the agent. Each of these two systems is composed of a central part, the corresponding half of the heart, of a second portion, through which the blood passes to arrive at the first, and of a third, through which it passes after leaving the heart. These two halves of the heart belong, in situation, connections, and structure, the auricle to the carrying system, and the ventricle to the bringing system.

The three principal parts of the vascular system, the arteries, veins, and lymphatics, present peculiarities of structure which distinguish them from each other; but they have also certain common characters, which identify them as belonging to one and the same system.

ARTICLE FIRST.

OF THE VASCULAR SYSTEM IN THE NORMAL STATE.

A. THE VASCULAR SYSTEM IN GENERAL.

§ 62. I. *The external form of the vascular system is that of a tree.* On leaving the heart, it gradually divides into trunks, branches, twigs, and ramuscules, which continually diminish in caliber. If we suppose all these divisions united in a single canal, the form is not a cylinder but a cone, whose apex is at the heart, while the base rests on the surface of the body, where it is formed by the union of the orifices of the smaller vessels. We know not the exact relation between the base and summit of the cone; nevertheless, we imagine, from the numerous subdivisions, that the difference is very considerable.(1) Thus, although the vessels diminish in caliber as they recede from the heart, this diminution occurs in the branches, and not in the whole system; and even, in each particular case, *the orifices of the branches, if united, are always broader than that of the trunk from which they come.* But the branches do not diminish much in caliber in their passage, and preserve the same breadth as long as they do not furnish twigs: we may be convinced of this by observing vessels which proceed a considerable distance without ramifying, as the spermatic arteries. Thus, although the whole system represents a cone, its parts considered separately are cylinders.

(1) See several different calculations on this subject in Haller, *De fabr. et usu,* vol. i. p. 151-163.

§ 63. The number of divisions in all parts of the vascular system is not the same; a vessel, however, rarely offers more than twenty.

§ 64. Neither are the angles formed by these divisions always the same, although the calibers of the vessels have no marked influence upon these angles. Ordinarily they are more or less acute, and in this respect vary very much. The spermatic vessels are perhaps those which are given off at the most acute angle. Almost all the vessels of the extremities also arise at acute angles.

On the contrary, the trunks coming from the arch of the aorta, the cœliac artery, the superior mesenteric, the renal, most of the intercostal, and the diaphragmatic arteries arise by almost right angles.

The superior intercostal and the recurrent arteries of the extremities describe an obtuse angle with their trunks. The more modern assertion, therefore, is entirely false, viz. "that the branches of the vessels every where rise at acute angles;" and some anatomists still admit, quite erroneously, the differences of the angles above mentioned only according to measurements made on dry arteries.(1)

§ 65. II. Notwithstanding these divisions, there is an uninterrupted communication between the different parts of the vascular system, not only by the union of all in common trunks, but also by the connections between most of them. This latter arrangement is called *anastomosis;* it differs considerably in its form and its greater or less frequency in the different parts of the same section of the vascular system.

1. The most usual case is when two vessels anastomose to form an arch, while the place of union is not exactly known, and from this arch vessels of a smaller caliber arise, as happens around the articulations and near the intestinal canal.

2. The communication of two vessels by a small transverse branch of little extent is more rare. This arrangement exists, for instance, between the two umbilical arteries, where they enter the placenta; they are observed frequently between the umbilical arteries of twins. We find an instance too in the anastomosis of the anterior with the posterior cerebral arteries, giving origin to the vascular circle of Ridley. The umbilical vein unites with the vena cava in the same manner, by the venous canal. This kind of anastomosis is very common in the veins of the limbs, especially in those of the superficial layer.

3. It is still more rare to see two vessels unite at an acute angle to form one, the direction of which is between that of the two trunks which have produced it. This is the mode of union between the pulmonary artery and the aorta in the fetus by means of the arterial canal, and between the two vertebral arteries, to give rise before to the basilar, and behind to the anterior spinal artery.

In the last species of anastomosis the two vessels which unite are almost equal in volume, while in the other two they often differ very much in this respect.

(1) Walthers, *Physiologie*. vol. ii. § 399. p. 49.

With regard to the frequency of anastomoses, we may say, in general, that they are very frequent between the small vessels particularly, and that they increase the farther the vessels are from the heart; so that the smallest form a very complex network. Anastomoses between the large vessels are rare; they are most common in the intestinal canal and the extremities. The largest, that between the pulmonary artery and aorta, is only temporary. They facilitate the course of the blood, and diminish the inconvenience of obstacles to the circulation, and even those which might arise from the destruction of the principal large trunks; as then the anastomosing canals, already very large or at least very dilatable in the normal state, permit the blood to arrive at the parts. Hence the reason that even the large trunks, as the aorta,(1) vena cava,(2) internal jugular vein,(3) and the thoracic canal,(4) have been found partially contracted or obliterated, and the subject has not suffered from this anomaly.

§ 66. III. *The direction of the vessels is usually straight.* This axiom is true particularly in regard to the trunks and branches; as for the smaller divisions, they are somewhat tortuous: but, in general, the the course of the vessels presents differences in this respect independent of their caliber, which arise from the nature of the organs. In fact the vessels of those organs which change very much in volume are very tortuous. This arrangement is well marked in the uterine vessels during pregnancy, where the curves are so numerous and so considerable, that acute angles often result. We observe it also, although in a smaller degree, in the vessels of the stomach, of the intestinal canal, of the face, of the lips, and particularly in those of the iris, the tongue, and the bronchia. This arrangement allows the blood to circulate uniformly when the organs are collapsed as well as when they are dilated; for in the latter case these vessels lengthen and extend. In those organs which are not subject to these changes in volume, but which are liable to changes in situation, similar, for instance, to what the limbs experience in flexion and extension, this tortuousness of the vessels is replaced by their elasticity.

There are also other instances, where the course of the vessels is not straight, but very much curved: this is the case with the arteries of the spleen and those of the brain. The purpose of this anomaly appears to be slightly to retard the course of the blood.

(1) Paris, in Desault's *Journal de chirurgie*, vol. ii.—Scarpa, *Sur l'Anévrisme*, trans. by Delpech, Paris, 1809.—A. Cooper and B. Travers, *Surgical works.*—Graham, in *Medico-chirurg. trans.* vol. v.—Th. Goodisson, in *Dublin Hospital reports*, Dublin, 1818, p. 194.

(2) Haller, *De gravior. quibusdam aortæ venæque cavæ morbis*, Goettingen, 1794, § viii.—Baillie, in *Trans. of a society for the imp. of med. and surg. knowledge*, vol. i. no. 8. p. 127.—Wilson, *ibid.*, vol. viii. no. 6. *An instance of the obliteration of the vena cava inferior by inflammation*, p. 65.—Hodgson, *Diseases of the arteries and veins.*

(3) G. Lardner, *Case of the obliteration of the internal jugular vein*, in *Edinb. med. and surg. journal*, vol. viii. no. 28. p. 407.

(4) Sir A. Cooper, in *Med. records and researches*, London, 1813.—Flandrin, *Journal de médecine*, vol. lxxxvii. 1791.

There are other vessels in which these curves exist only at certain periods of life, and are observed when the organs are developed in a part which they afterwards leave. Thus, the vessels of the testicles are very crooked while these glands continue in the abdominal cavity, but they afterwards become straight.

§ 67. IV. The vascular system, considered in a general manner, is symmetrical, that is, the right and left sides, the superior and inferior portions, and to a certain extent the anterior and posterior parts of the body correspond in this respect. Nevertheless, even the symmetry of those parts which are most similar, the right and left sides, is much less than that observed for instance in the nervous system. Thus, the heart is not perpendicular, nor situated so that its axis corresponds to the median line, neither are the unmated trunks of the arteries, veins, or lymphatics, placed upon this line. Finally, the corresponding vessels of the two sides are not arranged in the same manner: thus, for instance, the arteries of the head and superior extremities arise from a common trunk on the right side, while on the left they come off from the aorta by separate trunks. In fact the symmetry seems a little greater when we consider the vascular system as a whole; for then we find, for instance, the trunk of the veins of the body on the right side, that of the aorta on the left, and that of the absorbents in the centre; but the symmetry is, at the best, very imperfect. In animals, particularly those far removed from man, and in the fetus, the arrangement is more symmetrical.

§ 68. V. *The distribution of the vascular system presents numerous and very considerable differences,* since the origin and distribution even of the largest vessels varies. This system is undoubtedly that in which we find the most anomalies. When an anomaly exists on one side, a similar or analogous one is usually observed on the other. These anomalies frequently add to the symmetry, but often also they render it less evident.

Neither is it rare that anomalies of the same kind are observed in the upper and lower parts of the vascular system. Thus, we have met with two instances where in the same subject the left renal artery divided, and the vertebral artery arose immediately from the aorta.

On the contrary, the anomaly of one portion of the vascular system has usually no influence on the course of the others. Hence the reason why anomalies of the arteries are so common in all the parts of the body while the veins do not vary, and *vice versâ.* The anomaly of one part often approximates it to the normal formation of another; an effect which is produced, for instance, by the development of large anastomoses or of the large superficial vessels in the arterial system.

§ 69. With regard to its internal form or its texture, the vascular system in almost every part is *composed of several layers.*

The internal layer is the most essential, as it exists in every part of the system, and passes uninterruptedly from one to another of its principal divisions. This membrane is very thin, whitish, more or less transparent, homogeneous, and has no trace of fibres; but it differs very much in regard to its thickness, extensibility, and solidity, not only in different portions, but also in different parts of each principal portion. It is loosely attached to the inner and outer surface of the membrane next to it, and may easily be detached, and represent a separate organ. The serous membranes are those with which it seems the most analogous, and perhaps it connects them with the mucous system.

Does it secrete? We find an unctuous fluid in the vessels of the cadaver, even in those parts which contain no blood, as the arteries; but this fluid may perhaps be the serum of the blood or the result of transudation after death. Bichat,(1) who considers the internal membrane only as an epidermis to protect the vessels against the blood, thinks this fluid is not produced by the vital action of the arteries, founding his opinion on this fact, that the internal surfaces of the arteries when deprived of blood adhere intimately. But this phenomenon proves nothing against the opinion, since the example of the serous membranes announces that the fluid to which it refers may be the agent of this adhesion, and because we find adhesions in the mucous membranes.

In several parts of the internal membrane are folds called *valves* (*valvulæ*) which project within the vessels. Usually the form of these folds is semi-elliptical, adhering by their convex edge, while the straight edge is unattached. Their arrangement is always such as to oppose the reflux of the blood when its course is impeded by any cause; because the retrograde motion of this fluid separates them from the parietes of the vessel, and adjusts them to each other. On the contrary, when the column of fluid moves uninterruptedly, it forces them against the sides of the vessel. We almost always find several of these valves in the same part; this arrangement, while it increases the obstacles to the reflux of the blood in the first case, impedes it much less in the second.

The only membrane outside of the internal membrane which is common to the whole vascular system, is that called the *cellular* or *nervous tunic* (*tunica cellulosa seu nervea*); but in all the arteries and in the large veins, between this and the internal tunic, we find another, called the *fibrous*, *muscular*, or *fleshy tunic*, (*tunica fibrosa*, *muscularis*, *seu carnea*.) The çellular coat blends insensibly with the mucous tissue disseminated through the organs; it consists only of a thicker and denser mucous tissue, the resistance of which is so great that it forms a cylinder different from the rest of this tissue. The line of distinction between this and the fibrous tissue being as distinctly drawn, we ought to consider it as a peculiar membrane belonging to the vascular system.

Scarpa asserts that we should not regard the cellular tunic as belonging to the vessels, as it only covers them externally, to keep them in place, and to unite them to the parts adjacent, and that it is the soft and extensible mucous tissue of these latter. But we cannot agree with him, since the cellular coat of the vessels is more closely united to their fibrous membranes than to the adjacent mucous tissue, from which it appears to be distinct. Vessels are every where found

(1) *General Anatomy*, vol. i. p. 313.

surrounded with this funnel-like layer, which is attached to the fibrous membrane by a thin layer of loose mucous tissue, and which is evidently distinct from the mucous tissue found between the organs. If we divide an artery, taking care to cut the fibrous membrane only in a part of its circumference, we can easily raise the dense and whitish cellular tunic in the form of a continuous membrane, and with the blade of a scalpel can neatly detach it from the subjacent cellular tissue.

It is principally to this external membrane that the curves in the vessels are to be ascribed, which disappear as soon as it is cut. There is no fat in its interstices, nor does it furnish any serum. It does not penetrate internally between the other membranes.

§ 70. The vascular system contains the common nutritious fluid of all the organs; but its own proper substance is supplied by peculiar vessels (*vasa vasorum*) which are distributed in it. This arrangement is not confined to that portion of the vascular system which carries an imperfect nutritious fluid; it extends to all. The vessels which compose it arise from those near, and rarely or never from the artery to which they belong. They divide and anastomose in the cellular membrane before penetrating the internal tunics. Almost all their ramifications are appropriated to the fibrous membrane, at least the internal coat receives very few; the arteries and veins reciprocally accompany them there.

The existence of the absorbent vessels is very probable; but it has not been demonstrated:(1) although blood has not been diminished in a portion of a vessel comprised between two ligatures.(2) This experiment proves only that the action of the absorbents does not extend into the cavity of the vessels.

§ 71. The nerves of the vessels are not numerous;(3) they generally form a network on their surface. The nervous system of organic life furnishes twigs to most of the vascular system, but not to the whole, since those of the vessels of the extremities come from the nervous system of animal life.(4)

§ 72. The most delicate branches of the vessels are called the capillary vessels, (*vasa capillaria.*) This term is applied both to the final ramifications of the arteries and to the origins of the veins. Ought we to con-

(1) It seems to be demonstrated, not only by the microscopical observations of Malpighi and Leeuwenhœck, and by the injections of Ent, but also by those inflammations where there is no blood effused, and where the lymphatics are gorged with it. In this case, the excess of this fluid which distended the blood-vessels has been absorbed by the absorbents. This explains the utility of means to quicken the absorption in inflammation. See Cruikshank, *The anatomy of the absorbent vessels*, ch. x. p. 20.—E. A. Lauth, *Essai sur les vaisseaux lymphatiques*, Strasburg, 1824, sect. ii. p. 12.—Alard, *De l'inflammation des vaisseaux absorbans lymphatiques, dermoïdes, et souscutanés*, &c., 2d edit., Paris, 1824. F. T.

(2) Bichat's *General Anatomy*, vol. i. p. 321.

(3) The nerves of the vessels are very numerous, especially in the thoracic and abdominal cavities. F. T.

(4) Wrisberg, *De nervis arterias venasque comitantibus*, in *Sylloge comm.* Goettingen, 1800.

sider the capillaries as a separate system, distinct from the rest of the vascular system, in which the arteries terminate, and from which the veins and the exhalent and absorbent vessels arise? Bichat has adopted this opinion. Autenrieth goes still further, for he pretends that the capillaries, even as regards their form, constitute a system intermediate between the arteries and veins, saying that the final ramuscules of the arteries anastomose with the first twigs of this system, and that these unite in trunks which afterwards ramify a second time; so that according to him the form of the capillary system is the same as that of the vena porta.(1) But this form which Autenrieth assigns to the lymphatic system does not depend upon positive observations. The most minute injections demonstrate only two series of ramifications, and not four. On the other hand, Bichat has too widely separated the capillary system from that of the arteries and veins. He has extended the limits of this system too far, in saying that it furnishes all the vessels designed to nourish the organs. Nutrition ought necessarily to be carried on without the cavity of the vascular system, and cannot take place unless the nutritious fluid leaves the vessels which contain it. It is not true then, even in this respect, that the organized body should be considered simply as an assemblage of vessels.

§ 73. Nevertheless, the capillaries differ in several respects from the larger divisions of the vascular system:

1. In the nature of the fluid they contain. Blood is not found every where, as in the large branches of the arteries and veins; the small vessels also carry other colorless fluids, particularly serum.

2. The heart has less influence on the motion of the fluids they contain. This is demonstrated by the absence of pulsation in the venous system, which is in a great measure explained in this manner: by the arbitrary increase in the activity of these vessels in inflammation, which is seated principally in them, or at least takes place much more rarely in the large vessels; and finally, because those secretions which are performed in the limits of the capillary system are independent of the heart's action, to a certain extent.

§ 74. The capillaries do not extend equally far in all parts, neither is there every where the same proportion between the blood and the other fluids they contain. We rarely can demonstrate the presence of very minute vessels in the cartilages, in most of the fibrous organs, the epidermis, the nails, the hair: those which we sometimes find there when in their normal state never contain blood. The bones, the skin, the glands, the parietes of the vessels, the serous membranes, and some fibrous organs, are furnished with capillaries, some of which contain blood, and others colorless fluids. By means of fine injections, and sometimes even during life, as after certain irritations from diseases, &c., we see parts, which at first view seem entirely destitute of vessels, covered suddenly with a vascular network. In other organs, as the

(1) *Physiologie*, vol. ii. p. 138.

muscles, the capillaries appear to carry red blood only; nevertheless, we must observe that the coloring substance is found also outside of the vessels.

Finally, the relation between the blood and the colorless fluids is no where always the same. The examples mentioned of the blood penetrating parts usually colorless furnish already one proof. Nor ought we to rely upon the injection of colored liquids to discover the true limits of the blood in the capillaries, since, when it succeeds, and fills even the smallest vessels, it tinges red, parts which, like the serous membranes, are colorless, or at most but very slightly colored during life.

§ 75. The vascular system contains the fluid of common nutrition, carries it to all the organs, and sends it into all. How does this fluid escape from its cavity? How does it penetrate into them? We must observe first, that absorption and exhalation take place very probably only in the most delicate twigs of the vascular system, because all the vessels are provided with smaller vessels, conductors of the blood which is distributed to their parietes, because these vessels ramify infinitely, and finally because there are no plausible reasons for admitting the contrary opinion.

But how do these fluids enter into these most delicate ramifications, and how do they come from them? Are the terminations of the arteries and the origins of the absorbents closed or open? Neither in the smallest nor in the largest vessels has observation demonstrated chasms in their parietes, or orifices at their extremities. Nevertheless, constant openings probably exist, but their diameters vary with the degree of vital activity they possess. At least these openings exist necessarily where the fluids enter and depart. But absorption and exhalation are never interrupted, and it is impossible to demonstrate that the substance is destroyed and reproduced alternately, in infinitely small spaces, at the extremity of the vascular system.

§ 76. It is still less probable that the different portions of the vascular system every where form closed cavities which do not communicate with each other. We have already (§ 60) said that the absorbents are only an appendage of the venous system, from which they arise by several large trunks: there can be no doubt in any respect in regard to this. That the final twigs of the arteries and veins communicate is less certain.(1) Nevertheless, the opinion of those who refuse to admit this communication, and who think that the blood is effused between the two orders of vessels, either into the substance of the organ or into special cells, or who believe that the arterial blood is

(1) Among the moderns who do not admit this communication are Doellinger and Willbrand. The former thinks that the terminations of the arteries have no parietes, that the blood moves freely in the solid substance of the body, which he terms mucous, and partially continues its course, to pass into the venous and lymphatic vessels arising from this substance, as the arteries terminate in it. According to Willbrand, all the blood changes into organs and secretions, and these organs, becoming in a measure fluid, are formed again into venous blood and lymph, which continue to circulate. F. T.

changed at the extremity of the arteries into the substance of the organs, and that the venous blood itself is formed from all parts at the expense of this same substance, this opinion, we say, is at least very improbable; for,

1. Some substances although coarse, provided they are sufficiently warm and consequently fluid, pass easily from the arteries into the veins of a part whose temperature is also properly elevated.

2. Microscopic observations made on the transparent parts of living animals, as the bronchiæ of the salamander, the mesentery and the swimming membranes of frogs, the tails of fishes, &c., demonstrate clearly the uninterrupted continuance of the arteries with the veins.

3. This phenomenon is often observed under the microscope in the same transparent parts when they have been well injected.

But these anastomoses are always very narrow. They suffer only one globule or a very small number of globules of blood to pass at once, and those admitted by certain anatomists between the arterial and venous branches of a large caliber, as for instance between the spermatic arteries and veins,(1) have been long rejected by reasonable men.(2) In one part of the body only, the lungs, does the system of red pass to that of black blood in a manner opposite to that which is usual. It is true that large anastomosing branches exist between the arteries and pulmonary veins; but they are rather anastomoses between vessels of the same kind, since the small branches of the pulmonary artery carry red blood.

The transition from the arteries to the veins does not every where take place in the same manner, either as respects the size of the vessels, or the other conditions of the phenomenon. Sometimes the artery only folds upon itself, and thus becomes a vein, and again small branches are detached, which empty into the vein adjacent. But very probably in this case the union takes place by a small intermediate branch, of which consequently one half is venous, the other arterial.

§ 77. The relation of the vessels to the organs may be considered in several points of view: 1st, in regard to the quantity of nutritious fluid which arrives at the organs and which returns from them, and consequently, other things being equal, in regard to the greater or less size of the vessels; 2d, to their number; 3d, to their direction; 4th, to their divisions and anastomoses; 5th, to their place of origin; 6th and lastly, to their length.

§ 78. 1st. *Abundance of vessels and abundance of nutritious fluid are not synonymous*, since an organ which has many vessels of a small caliber, as a bone, may nevertheless not receive abundance of nutritious fluid. The secretory organs are those in which the vessels are proportionally the largest. Next comes the muscular system, the nervous system, the bones, and finally the fibrous organs and the cartilages.

(1) Lealis Lealis, *De partibus semen conf.*, Leyden, 1707.

(2) G. Martin, *Reflections and observations on the seminal blood-vessels*, in *Med. essays and obs. of Edin.*, vol. v. no. 19.

The cuticle, the enamel of the teeth, the amnion, and the tunica arachnoidea, receive no vessels, at least in man.

2d. *Every organ is usually supplied with several vessels.* The unmated organs, formed of two halves more or less intimately united on the median line, as the brain, the nasal fossæ, the thyroid gland, the larynx, the stomach, the liver, the uterus, the bladder, and the penis, not only receive two vessels of the same name—the one on the right side, and the other on the left—but also each organ, without regard to volume or its importance, in more than one point receives vessels which often arise from very remote parts of the sanguineous system, and which usually anastomose near, or within this organ. Thus the internal carotid and vertebral arteries proceed on each side to the brain, and there anastomose with each other and with those of the opposite side. The spinal marrow, besides the posterior and anterior spinal arteries, receives a great many vessels from the aorta, which pass through the intervertebral foramina. The thyroid gland receives on each side two arteries, a superior and an inferior, which anastomose with each other, and with their congenitals. So four arteries are given off to the stomach, two to the intestines, four to the uterus, and an equal number of veins arise from these organs. The kidneys receive two, or even a greater number of arteries, more frequently than one; and the number of those belonging to the renal capsules is very considerable. All the muscles and bones are supplied with vessels which enter in several points. In certain organs, possessing but one vessel, as the eye, which receives only the opthalmic artery, we find an equivalent for this arrangement in the number of anastomoses. But one vessel is rarely so much larger than the rest, that we have reason to say with Walther,(1) that each important organ receives but a single principal vessel.

3. The vessels *generally* proceed in almost straight lines. When we find exceptions to this rule, the curves of the vessels are attended with a change in their caliber, or in their form, as in the hollow organs, and then consequently are not constant; but they sometimes depend on other circumstances of which we are ignorant, and are then constant as in the brain.

4. *A vessel never enters or leaves an organ, unless it be more or less divided.* Of this we may be convinced by looking at the brain, the eye, the tongue, all the organs of secretion, and the muscles. The vessel is generally divided near the organ, but sometimes at a certain distance from it. The muscles furnish an instance of the latter. In this respect we do not always find the same arrangement, and the elongation of the branches makes the vascular trunks more numerous, as we can easily perceive in the kidney. These branches almost always anastomose together. We have before mentioned the differences in regard to the number and size of the anastomoses.

(1) *Physiologie*, vol. ii. p. 55.

5. *The vessels do not always arise from the same point*, as we have already stated, (§68,) and it matters little, either to the development or the function of an organ, from what point its vessels arise, whether they proceed directly from the aorta, or the vena cava, or come from secondary trunks. Thus the left vertebral artery often detaches itself from the arch of the aorta; the inferior thyroid artery is anomalous in the same manner, or presents other variations. The renal artery arises sometimes from the primitive iliac, or even from the internal iliac artery; the three branches of the cœliac artery come directly from the aorta in some subjects; in others their trunk unites to that of the superior mesenteric artery, &c. All these facts prove that the importance and individuality of an organ are not lessened because its vessels belong to those of the second order, as Walther says.(1)

6th. The origin of the vessels is generally not very remote from the place where they enter the organ to which they belong; and we rarely see one passing through any considerable space, unless it sends off branches to those parts before which it passes. When the contrary takes place, as in the ovaries, the testicles, the brain, the contradiction is but apparent, and explains itself easily, by the primitive situation of those organs: thus the testicles and ovaries are formed very near the place from whence the spermatic arteries arise; and in the early periods of life, the neck is so short that the brain rests immediately on the point from whence its vessels are derived.

§ 79. We can make but few general observations on the activity of the vascular system, because, like the structure, this varies in its different component parts. We can only say, it is to a certain degree elastic, extensible, and contractile, and insensible in the healthy state. A dispute still exists, whether it be susceptible of vital contraction, or in other words, if it be irritable. The heart and the absorbents certainly possess irritability,(2) but observations on the arteries and veins as well as the results drawn from them are contradictory. Haller has never seen stimulants produce contractions, except in the trunks of the venæ cavæ, although he does not deny the irritability of the arteries exactly for that.(3) This subject will be better discussed at the end of the remarks on each of the three portions of the vascular system; for, in regard to this, the phenomena are not the same in all.

§ 80. The vascular tissue is composed of several parts entirely different from each other; hence, this very complex form is one principal cause why it varies so much at different periods of life. The principal parts in the history of its development are the inquiries, 1st, if certain parts of the system appear before the rest, and what these parts are; 2d, the investigation of its mode of origin; 3d, the study

(1) Walther, *loc. cit.* p. 54.

(2) Verschuir, *Diss. de arter. et venar. vi irritabili*, Groningen, 1766.—Hastings, *Diss. de vi contractili vasorum*, Edinburgh, 1820.

(3) *Mém. sur la nature sensible et irrit. des parties*, Lausanne, 1756. Sect. xi. *De part. corp. hum. præc. fabr.* vol. i. p. 140. 236.

of the relations which exist at different periods of life between the systems of red and black blood, and between the large and small circulatory systems; 4th, that of the mutual relations of the vessels, as respects number and capacity, at different periods of existence.

§ 81. 1st. We are deficient in exact observations relatively to what parts of the vascular system are formed first, either in man or in the mammalia. Nevertheless, we may admit, as almost certain, that the veins appear before the arteries, and that the first are those of the umbilical vesicle; for it is proved, in birds, that the vitelline veins, and particularly the omphalomesenteric, are soonest developed; now the umbilical vesicle in man corresponds exactly with the vitelline sac of birds.(1)

Nevertheless, it is not improbable that, in the body of the human fetus, the principal trunk of the arterial system, the aorta, arises at least at the same time as the veins, or perhaps before them. This conjecture acquires some weight, when we regard: 1st, the arrangement of the vascular system in the acephalous monsters; and 2d, the manner in which this system is formed in the animal kingdom. In supposing it to be true, there is first formed on the anterior face of the vertebral column a long canal which ramifies at its two extremities, and which blends above, in the place where the heart afterwards exists, with the vena porta, with which it probably communicated before, only by small twigs.(2)

2d. As to the mode of development of the vessels, we learn the following from observing what occurs in the egg.(3) When at some distance from the embryo, we see in the membrane of the yolk, which is at first homogeneous, certain rounded, circumscribed rents, which are filled with a mass more fluid. These rents are, at first, entirely separated from each other, and appear like islands in the rest of the mass. New lacunæ are gradually formed in the substance of the membrane of the yolk, which increase the number of islands, and give rise to a fine network of vessels which ramify exceedingly; these soon contain real blood instead of the clear thin fluid which first filled them. This vascular network is the commencement of the

(1) We do not hesitate to use this expression, (notwithstanding the celebrated Osiander (*Goetteng. Anz.* 1814. part 163, p. 1627.) has declared the umbilical vesicle to be a morbid abnormal formation, inasmuch as it is never found in the well-formed fetus, but only in monsters,) because we have hitherto found it, by careful examination, in every fetus where it had not disappeared, and all these fetuses were well formed. That the formation of the fetus has no effect on the existence of this vesicle, is shown by the observations of the best anatomists, of whom we shall mention only Albinus, Hunter, Wrisberg, and Blumenbach, who all observed it in the perfectly normal embryo.

(2) We only mention these as probable conjectures, and, to prevent all false interpretations, we would have them understood as such.

(3) Among the modern authors on this subject, we would distinguish Rolando, *Sur la formation du cœur et des vaisseaux artériels, veineux et capillaires*; in the *Journ. complément. du Dict. des Sciences Médicals*, vol. xi. p. 323, and vol. xii. p. 34.—Pander, *Mémoire sur le développement du poulet dans l'œuf*; same journal, vol. xiv. p. 306.—Home, *Observations on the changes of the egg during incubation*, with notes by Prevost; in the *Archives générales de médecine*, July, 1823, p. 451.—Prout, *Experiences sur les changemens qui arrivent dans les principes fixes de l'œuf pendant l'incubation*; same Journal, September, 1823, p. 119.—F. T.

omphalomesenteric vein; its trunk is not the first portion formed, but the ends of the vessel appear soonest; these gradually unite into branches, and finally produce the trunk. At first, the vessels have no proper parietes which are distinct from the rest of the substance, and represent only lacunæ, channels hollowed in this substance; but this insensibly accumulates still more around them, and then their parietes appear, the structure of which is slowly and gradually developed.

3d. When the omphalomesenteric vein is thus once formed, the rest of the vascular system produces itself as follows, concluding always, as we are obliged to do, from the results furnished by the organogenesis of birds. The vein bends from below upwards, and dilates on the anterior face of the body of the fetus to form the heart. From this the trunk of the arteries of the body arises, which carries the blood to the organs, and after this we see the accompanying veins. The omphalomesenteric artery next appears. We do not yet know positively, whether the umbilical veins, like the omphalomesenteric veins, are formed before the umbilical arteries, or if the reverse be true; but the former is more probable.

In examining the thing more attentively, this is the progress of formation. The vessel into which the omphalomesenteric vein opens, or to speak more exactly, into which it is changed, is the vena porta. This, which at a later epoch, finds itself simply inclosed in the general system of the veins of the body, constitutes, at present, the principal trunk, and, at its upper part, produces the heart. The heart appears, at first, like a half ring lying loose; the portion first seen, is the left ventricle. Immediately after, the trunk of the aorta shows itself, appearing as a considerable dilatation. A little later the upper extremity of the vein dilates, then contracts before the venous trunk, and thus produces the auricle. These three vesicles are, at first, separated by folds, very long in proportion, of which one, that between the ventricle and auricle, is called the auricular canal, (*canalis auricularis.*) These folds soon disappear, and the three vesicles approach each other. All the parts which are finally double, are still single at this period.

At the same time the arrangement of the rest of the vascular system is perfected. The vena porta reunites to the umbilical vein, with which it ramifies in the liver. It is only then that the blood it contains commences to circulate there and reaches the heart by passing through the hepatic veins. Nevertheless, during the period of fetal existence we can trace in the venous duct (*ductus venosus*) the primitive arrangement of the vena porta, and the important part it at first performed. The venous duct extends from the umbilical vein and vena porta, on the inferior face of the liver, to the inferior vena cava, and consequently conducts a part of the blood immediately into this last. We sometimes see the primitive arrangement preserved even through life, when the whole trunk of the vena porta opens directly into the vena cava.

While these phenomena take place, the heart continues to develop itself. Of all its parts the auricle first becomes double ; an imperfect septum descends from its circumference, and floats in its cavity, so that the two parts communicate, at first, by a very broad opening. The interauricular canal, and the common trunk of the veins of the body, the umbilical vein, and the vena porta, opens into the auricle at the place of this septum. The doubling of the ventricle does not take place in the same manner, but it depends in some measure on gemmation, and is produced by the prolongation of the primitive portion at its upper part. The right ventricle appears, first, as a small tubercle, which gradually extends itself towards the summit of the heart, and communicates with the left ventricle, not only when it first appears, but even after. This communication takes place at the upper part of the two ventricles, because, at first, the left cavity only prolongs itself. Hence, why the aorta arises, at first, from both ventricles. The pulmonary artery is the last to detach itself so as to constitute a distinct trunk, but it was indicated before along the aorta. In fact, at first, this latter, which arises solely from the heart, divides, at some distance from this organ, into two branches at least, which soon unite to form its descending portion. As the aorta is blended gradually with the ventricle, the bifurcation is depressed also, and when one of the two branches separates itself entirely from the other, by completing the formation of the opposite portions of their circumference, the pulmonary artery appears forming a distinct trunk. But as all the cavities of the heart communicate, the pulmonary artery continues not only at first, but during the whole of fetal existence, with the aorta, of which it constitutes the second root. Nevertheless, as it also divides at the same time into two branches, which proceed each to a lung, the continuation of its trunk, properly so called, that portion between the point where it bifurcates, and that where it is implanted in the aorta has been particularly termed the *arterial canal*, or the canal of Botal. (*Ductus arteriosus s. Botalli.*)

The vascular system is then formed at its commencement, at least, of parts which do not afterwards exist. On the contrary, during the latter periods of fetal life the number of these parts is greater, and several exist then which disappear after birth. The circulation is at first single, and even after the different systems are formed, the line of distinction between the systems of red and black blood is not drawn with precision. Some of these supernumerary parts which latterly are effaced, trace the primitive formation when the parts were not so numerous as in the perfect state: all relate to the connections of the fetus with external objects. The arrangement of the vascular system causes a circulation entirely different from that seen in the adult; it varies from the latter, particularly in this, that all the organs do not receive blood from the same source ; the small and large circulations are not yet completely distinct from each other. In fact, the vena cava inferior during the whole period of fetal existence, opens more into the left than into the right auricle, so that it pours immediately into the former cavity the blood of the umbilical and omphalomesenteric veins, mixed with that of the inferior parts of the body; from the left auricle the blood, mingled with that which comes from the pulmonary veins, passes into the left ventricle, which then sends it through the aorta into the carotid and subclavian arteries. One portion goes to the lower part of the body. From these organs the blood returns to the right auricle by the jugular and subclavian veins; from the right auricle it passes into the right ventricle, where it arrives at first alone, but afterwards, when the orifice of the vena cava inferior also opens into the side of the right auricle, it mixes with the blood from this last vessel. The right ventricle causes it to pass by the pulmonary artery, partly into the lungs, and partly also by the arterial canal into the descending aorta, where it mixes with that which comes from the trunk of the aorta; from thence it goes into the lower part of the body, which is larger than the upper portion. The descending aorta divides at its inferior extremity into two large trunks, the umbilical arteries, which, arriving at the umbilical cord, go to the chorion of the ovum, and at a later period principally to the placenta, where they are continuous with the roots of the umbilical vein.

Thus, the head, neck, and arms continually receive almost all the blood which returns from the placenta by the umbilical vein, but they receive it mingled with that which returns from the lungs and the inferior part of the body. On the contrary, the blood which circulates in all the other parts, has already circulated in the preceding, and contains only a small portion of that which arrives at the right auricle, and which, passing from there into the aorta, is not propelled by it to the superior parts of the body. Although the blood which returns from the placenta does not arrive at the first organs pure, they receive, however, a quantity greater than the others.

When the formation of the vascular system is finished after birth, the systems of red and black blood are totally separate; they communicate only by their extremities, in the lungs on one side, and in the other organs in another, and no part of the blood can arrive at these organs, unless it has passed through the lungs. But the blood of the pulmonary veins does not mingle, except with that which goes to the upper part of the body; and before this fluid has arrived at the lungs, the arterial canal removes most of that which the right ventricle throws into the pulmonary artery, even as the insertion of the vena cava inferior into the left auricle causes the blood which returns from the lower parts of the body to flow almost entirely into the aorta, while a small portion only goes to the lungs. The pulmonary artery receives but a small portion of the blood which comes to the right ventricle. The small circulation then does not form a separate system; it is only an appendage of the large, since the arteries of the lungs arise from a vessel which carries its blood to other parts also; and its veins unite with the inferior vena cava, which receives the blood from other organs. The arterial canal has been called, also, the *derivative canal,* because it turns aside the blood before it arrives at the lung.

These differences depend principally on the inaction of the lungs, since after birth the small and large circulations are not separated, except on account of the changes which the blood experiences in the organ, and which are caused by the air which rushes there. Probably the lung is replaced to a certain extent in its functions by the placenta, so that the umbilical arteries and veins may be compared to those of the pulmonary system. But the small circulation, which is carried on through the placenta, is not separate from the large, since the umbilical arteries arise from the descending aorta, the umbilical vein and stomoses, directly and indirectly, with the vena cava inferior; and the blood which comes from the placenta mingles, both in the auricles and at the union of the pulmonary artery with the aorta, with that which returns from the organs of the body. Thus, in the fetus, the blood which returns from the placenta, and that which comes from the organs, is not pure in any part of the circulation. On account of this peculiarity, and doubtless because the lungs are very imperfectly replaced by the placenta, there is no marked difference between the arterial and venous blood, either in the human fetus, or in those of the other mammalia.

4. With regard to the capacity of the vascular system, and the number of vessels at different periods of life, we may say, generally, that when the vessels are once formed, their number and diameters are proportionally greater, in the early, than at subsequent periods. The heart of the fetus is unquestionably much larger in proportion to the rest of the body, the nearer it is to the period of its formation. How inconsiderable are the only ramifications of the umbilical vessels! The same remark applies to the small vessels. The latter, and generally speaking the whole vascular system, are much more easily injected in young persons, than in individuals advanced in life; and there are even parts, in which they cannot be demonstrated, unless in very young subjects. In fact, we find in the first periods of life some organs, which are then destitute of vessels, and in the place of which there are developed afterwards others, which possess vessels, thus the cartilages are replaced by bones. But this peculiarity disappears when compared with the enormous development of vessels in all other parts. This abundance of vessels is to be ascribed to the great necessity for them, since the number of the organs augments continually, they constantly require new nutritious fluids. Hence the caliber of the vessels is in direct ratio to the volume of the different parts of the same system.

These observations are true, especially in regard to the arteries, but are less applicable to the veins; for these are scarcely larger at the first than at subsequent periods, and at most have a caliber only equal to that of the arteries.

The specific gravity, both of the veins and arteries, is less in young men than in old persons; the vessels are then denser during the latter periods of life. In other respects, the difference is trifling; it is more perceptible in the arteries than in the veins.

§ 82. We may consider as sexual differences the greater thickness and power of the vascular system in males than in females, which is observed equally in its three divisions. The localities are no where different.

B. ARTERIES.

§ 83. The *arteries* (*arteriæ*)(1) differ from the veins in their external form and situation, and in their texture and properties.

They are usually *narrower*, *less numerous*, *more deeply situated*, and *more tortuous than the veins*. The branch near the heart is always larger than the branches which arise from it. The diameter is very constant in the same vessels whenever the parietes do not vary. In those places where the arteries divide, the largest branch almost always follows the direction of the trunk. Anastomoses are rare among the arteries of a large caliber, and in general there are fewer anastomoses in the arterial than in the venous system; nevertheless they are more common than is usually supposed. We cannot consider them as a sign of imperfection in the formation of the arteries, and as indicating that they are degraded to a level with the venous system, as Walther(2) has said, since in the normal state they belong no less to the arterial than to the venous system. They are developed to such an extent in this system that the largest trunks may be obliterated by ligatures, or in any other manner, and the circulation nevertheless continued by the anastomoses, which are dilated. Thus a dog, in which the two carotid, the crural, and the axillary arteries were successively tied, continued to live.(3) Surgeons at present do not hesitate to tie, not only the axillary and crural arteries, but the external iliac,(4) the internal iliac,(5) and the primitive carotid.(6) Even the

(1) Bassuel, *Dissertation hydraulico-anatomique, ou Nouvel aspect de l'intérieur des artères et de leur structure, par rapport au cours du sang:* in *Mém. prés. de math. et de physique*, vol. i. p. 23-55, Paris, 1750.—Belmas, *Structure des artères leurs propriétés, leurs fonctions et leurs altérations organiques*, Strasburg, 1822.—Ehrmann, *Structure des artères*, etc., Strasburg, 1822.

(2) *Physiologie*, Vol. ii. § 399. p. 43.

(3) *Dissection of a limb on which the operation for popliteal aneurism had been performed by A. Cooper;* in the *Medi. chirur. trans. of London*, vol. ii. p. 259.

(4) *Case of femoral aneurism reaching as high as Pouparts ligament, cured by tying the external iliac artery, by J. Abernethy;* in *Edin. med. and surg. journal*, vol. iii., p. 46.—*Case of inguinal aneurism cured by tying the external iliac artery*, by W. Goodlad, *same journal*, vol. viii., no. 29., p. 32.—*An account of the anastomosis of the arteries at the groin, by A. Cooper, in Med. chirurg. trans.*, vol. iv., p. 425.

(5) *A case of aneurism of the glutæal artery cured by tying the internal iliac, by Stevens; in the Medico-chirurg. transactions*, vol. v., p. 422.

(6) A. Cooper, *A case of aneurism of the carotid artery;* in the *Med. chirurg. transact. of London*, vol. i., no. 1.—*Second case of carotid aneurism; same journal*, no. 17.—*Case of aneurism from a wound in which the left carotid artery was tied* by A. Macauley; in *Edinburgh Medical and Surg. Journal.* vol. x., no. 38., p. 178.—*A case of aneurism by anastomis in the orbit, cured by the ligature of the com-*

abdominal aorta has been tied(1) or found obliterated,(2) without causing any bad effects. We cannot admit a resemblance between the venous and arterial systems, except when extraordinary anastomoses are formed between the arteries.

The arterial is more symmetrical than the venous system in some parts, and less so in others. Thus the two spermatic arteries arise from the aorta, while of the two corresponding veins the right comes from the vena cava, and the left from the renal vein. On the contrary, the right subclavian and right carotid arteries have a common trunk, and those on the left side have separate trunks, while the jugular and subclavian veins unite on each side in a single trunk.

§ 84. The arteries are usually considered more constant in their distribution than the veins,(3) but we think wrongly. If the veins offer greater varieties in their branches, twigs, and secondary trunks, the difference is only apparent; it is because these vessels are more numerous and larger. In those parts of the system where the arteries equal the veins in number, the number of their anomalies is the same. In fact, every artery, even the origin of the aorta, is sometimes divided; the three large vessels which arise from its arch, present, at least, nine or ten varieties, in relation solely to their origin. On the contrary, we know only one anomaly of the vena cava superior, where the right and left trunks were not united, which, in fact, corresponds solely to the division of the aorta at its base, but which we are obliged to compare also with the other anomalies of the large trunks, arising from its arch, since the vein offers no other. But how common are anomalies in the arch of the aorta! and how uncommon is a division of the vena cava descendens!

The arrangement of the renal vessels has been adduced as a remarkable exception. On the contrary, these furnish the strongest argument in favor of the rule just established.(4) In fact, the renal veins vary less frequently than the arteries.

mon carotid artery; in *Med. chirurg. trans.*, vol. ii., no. 1.—Finally, Valsalva had already tied without inconvenience both carotids on dogs, (Morgagni, *Ess. an. med.*, xiii. a. 30). Baillie and Hunter had also advised this operation, when it is indicated, (*Trans. of a society for the improvement of med. and surg. knowledge*, vol. i., p. 125.) and Cooper had performed it, but unsuccessfully, although he failed from accidental circumstances. (*Med. chirurg. trans.*, vol. i., no. 1.)

(1) A. Cooper, *loc. cit.*, vol. ii., p. 260.

(2) *Case of obstructed aorta*, by R. Graham; in *Med. chirurg. trans.*, vol. v., p. 287.

(3) "*I have found many more varieties in the division of the veins, the origins and number of their branches, than in the arteries.*" Haller, *De Fabr.*, vol. i. p. 255.—The branches of the arteries are generally more constant than the unions of those of the veins. Sœmmerring, *Gefaesslehre*, p. 77.—Walther even asserts that the greater constancy of the course of the arteries proves they are the most noble vessels (*Loc. cit.* vol. ii. § 404.) Bichat has been more exact in saying the arrangement of the branches and twigs in the veins is at least as variable as in the arteries.

(4) Haller, *El. phys.* vol. iii. p. 260. The renal arteries vary more than any, and even more than their accompanying veins. p. 266. "The form of the renal veins is much more simple and constant, than that of the arteries." The renal veins vary less than the arteries: Sœmmerring, loc. cit. p. 419. Voigtel was, then, mistaken in saying (*Path. Anat.* vol. i. 6. 480.) their anomalies equalled those of the arteries.

In the extremities, the veins always follow the same course; and although we have often seen the brachial artery divided much higher than usual, the arrangement of the corresponding veins was normal among all the anomalies of the arteries, while variations in the venous trunks are rarely found, unless there are corresponding anomalies in the arteries.(1)

§ 85. The internal structure of the arteries presents, also, several peculiarities.(2)

The internal membrane is much thicker, less transparent, harder, and more brittle, than in other parts of the vascular system. It is not very elastic, and is very solid. In dogs, the other membranes have been raised, and, although in several instances the adjacent parts did not protect the arteries, still it was neither torn nor distended.(3) This membrane differs also in different parts of the arterial system. It is thickest in the left ventricle, less thick in the aorta, and thinnest in the pulmonary artery. In the arteries themselves, it seems to be almost uniformly thick every where, although it is thicker in the aorta than in the other branches. It is smooth in almost the whole extent of the arterial tree, and is not larger than the external membrane. In the places only where the great trunks arise from the heart, it forms three valves, by expanding and folding on itself. These valves, called *sigmoid*, or *semilunar* (*valvulæ sigmoideæ seu semilunares*) from their semicircular form, are attached by their inferior edges to the circumference of the arterial orifice: their upper edge, which is loose, forms two fissures, which unite in a central process of a cartilaginous nature, called the *tubercle* (*nodulus.*) These valves, and the portions of the arteries which correspond to them, form sacs closed towards the heart, which open outward. The parts of the circumference of the vessels which correspond to them, are dilated, and project outwardly; while within, are corresponding hollows, called *sinuses*. The valves and the tubercles of the pulmonary artery, like the other portions of its internal membrane, are thinner than in the aorta. But in both vessels, these folds prevent the reflux of blood to the ventricles; for when the fluid takes a direction contrary to that which it ought to follow regularly, they leave the parietes of the artery, approach its axis, and join so that their edges touch. The tubercles fill up the void which may be left between them.

(1) For particulars on this subject see J. F. Meckel, *Ueber den Berlauf der arterien und venen.* In *Deutschen Archiv. f. die Physiol.* 1815. vol. i. No. 2. p. 285.

(2) Ludwig, *De arteriarum tunicis*, Leips. 1739. *rec. in Haller's coll. diss.* vol. iv. No. 1.—A. Monro's *Remarks on the coats of arteries, their diseases, and particularly on the formation of aneurism.* In *med. essays and observ. of a society in Edinburgh*, vol. ii.—De Lasonne, *Sur la structure des arterès*, in *Mém. de l'ac. des sc.* 1756. p. 166-210.—Mondini, *De arteriarium tunicis*: in *Opusculi scientifici*, Bologna, 1817. Béclard, *Sur les blessures dés artères*; in the *Mém. de la soc. med. d'émulation*, vol. viii. Paris, 1817.

(3) Home, *An account of Mr. Hunter's method of performing the operation for the cure of popliteal aneurysm.* In *Transact. of the society for the improvement of med. and surg. knowledge*, vol. i. No. ix. p. 144-145.

§ 86. The internal membrane of the arteries, and of the arterial portion of the heart, in the system of red blood, has a great tendency to ossify.(1) This tendency is strongly seen in the arteries, although it is usually developed at an advanced age; it is then so frequent, that, in some countries, after the 60th year,(2) or even, as Stevens says,(3) after the 30th, we find the arteries ossified more commonly than unossified. Bichat says, of ten subjects, there were, at least, seven which presented the osseous incrustations, after the 60th year.(4) Cooper is not then altogether wrong, in regarding this degeneration as a normal state, and in calling it morbid only during youth.(5) Nevertheless, it is not an inseparable attribute of advanced age, for we have found no traces of it in very aged persons, whom we have dissected expressly for this purpose. Perhaps, in this respect, differences exist which may be referred to the climate, or manner of living. Ossification is extremely rare in the arterial portion of the system of black blood. We have never met with it, and we know of but few examples cited by authors, except those cases where the valves of the pulmonary artery have been found ossified, and adherent even at an early age,—circumstances which contribute powerfully to aggravate cyanopathia.

§ 87. The fibrous membrane of the arterial system, is firm, hard, dry, somewhat elastic, yellowish red, and evidently formed of transverse fibres, or to speak more precisely, of fibres a little oblique. These fibres form several layers, rarely separable from each other, but which unite differently together, as do also the fibres of each layer, so that we can, at least in that respect, consider them as so many distinct tunics, since their structure is absolutely the same, and their number depends on the greater or less attention used to separate them. This membrane is commonly known as the *muscular tunic*, (*tunica carnea*,) from its fibrous structure and reddish color; but its fibres differ from muscular fibres, by their greater elasticity, firmness, fragility, dryness, flatness, and finally by the entire want of mucous tissue in their interstices.(6)

This membrane is the thickest of the arterial tunics, and on it the great force of the arteries principally depends. Its internal layers are more solid and closer than the external. Its absolute thickness diminishes much, as its distance from the heart increases. It is also much

(1) This inner coat never ossifies: ossification of the arteries depends on an accumulation of calcareous salt in the cellular tissue, which unites their internal to their fibrous tunic: hence these layers can be easily insulated from the tunics between which they are deposited, and ought to be regarded rather as calculous concretions than as real accidental bones. F. T.

(2) Baillie, *Of uncommon appearances of diseased blood-vessels*; in the *Transac. of a society for the improv. of med. and surg. knowledge*, vol. i. no. 8. p. 133.

(3) In Med. Chirurg. Transact. vol. vi. p. 433.

(4) Bichat, General Anatomy, vol. i. p. 314.

(5) *Philos. Transact.* no. 299. p. 1970.

(6) Hence a separate tissue has been made of this fibre called the *elastic tissue*; this tissue, as it is represented, exists also in the parietes of the air passages; it surrounds certain excretory ducts; it forms the envelope of the corpus cavernosum and of the spleen, and the yellow ligaments of the vertebræ; it constitutes also the posterior cervical ligament in certain animals. See Hauff, *De systemate telæ elasticæ*, Tubingen, 1822. F. T.

greater, and from this, too, the fibrous structure is much more apparent, as the arteries themselves are more voluminous, while the proportional thicknesss augments in an inverse ratio ; for the parietes become much stronger, in regard to the orifice and caliber, as the arteries diminish. We also observe that the membrane becomes redder in the same proportion, and, if we may judge of it from experiment, proportionally more irritable also.

But the thickness of this membrane differs also considerably, either in the different parts of the same artery, or in the different parts of the arterial system. In the first respect, it is always more considerable at the convexity than at the concavity of the curve of the arteries, and also in the angles of their divisions, than in other parts. As regards the second point, we must remark :

1st. That the thickness of the arteries within the viscera is proportionally less than within the muscles, and in the points where these vessels are loose, than where they adhere to other parts.

2d. That the arteries of the brain differ much from the others, by the thinness of this tunic, which is even so slight, that formerly its existence was doubted, but wrongly.(1) Hence, the cerebral arteries collapse when they are empty, are more subject than the other arteries to break during life, and the blood is more clearly seen through their parietes. This layer is much thinner and more extensible in the pulmonary artery, than in the system of the aorta.

Some anatomists admit internal longitudinal fibres in the arteries, either from applying to man what is observed in animals, or from erroneous observations, or finally, in order to agree with ideas purely theoretical ; these fibres do not exist.

§ 88. The cellular tunic is very thick, very solid, and perfectly distinct from the fibrous. It is much more extensible than the internal tunic.(2)

§ 89. The arteries receive some considerable nerves.(3) In general, these nerves are more numerous in the arteries of the vascular system of red blood, than in the pulmonary arteries. They are also, proportionally speaking, more numerous and larger in the small than in the large arteries. The trunk of the aorta and of the arteries of the neck, of the chest, abdomen, and skull, receive their nerves only from the nerves of organic life. They form a very complicated plexus on their surface. The arteries of the extremities, on the contrary, receive filaments from the adjacent nerves of animal life. Some pretend there are two kinds of the latter : that some of the largest are expanded only in the cellular tissue ; that they furnish none to the fibrous membrane, inasmuch as they have still an inconsiderable size; that they are pulpy, flat, and soft, at their origins, and that they are insensibly lost in the cellular tissue ; they add, that the others are smaller, and penetrate to

(1) Boerhaave, *Prælect*, vol. ii. no. 234.

(2) J. S. Hebenstreit, *De vaginis vasorum*, Leipsick, 1740, *rec. in Halleri coll. dis.* vol. ii.

(3) Wrisberg, *De nervis arterias venasque comitantibus ;* in *Sylloge comment.* Goettingen, 1800, p. 363-407.

the fibrous tunics of the arteries; that they are cylindrical, harder, and more dense than the preçeding; that the distance between the trunks from which they arise and the artery is very small, and that they expand in the fibrous tunic, as a thin membrane, on which fibres are distinctly seen.(1) Nevertheless we have always seen that the internal, or the smallest nerves, are only the branches of the more voluminous, and they have never appeared to be rounder or firmer.

Finally, all the arteries are not accompanied with nerves.(2) We find none in the umbilical arteries, and probably those of the interior of the cranium are likewise destitute of them. They soon disappear in most of the viscera.(3)

§ 90. The arteries pass, first, into veins, as mentioned before; (§ 76) second, into roots of the excretory vessels in glandular organs; third, into exhalent vessels.

§ 91. The specific gravity of the arteries does not much exceed that of water. The relation is about as 106 : 100. They are proportionally lighter, and less dense, than the veins, being about as 25 : 26. Nevertheless, this ratio diminishes with age, and is often in advanced life as 140 : 139. This diminution in density is made up by the greater thickness of the parietes of the arteries. Nevertheless, the veins posssess more resistance, and are more difficult to tear than the arteries.

All the arteries have not the same force. Those of the secretory organs seem to resist much more than the others. Such, at least, is the case with the splenic and renal arteries, where the proportion is as 13 : 10.

§ 92. It is not easy to determine, from the phenomena presented by the arteries, upon what different forces these phenomena depend. However, most of these forces reside in the fibrous and cellular coats.

The arteries are highly elastic; hence they remain patulant, after having been divided, and they rebound when compression is removed. This elasticity resides especially in the cellular membrane.(4) The two inner membranes are more fragile, and hence are more easily ruptured; this is the reason why the two internal tunics of the arteries are torn, whenever ligatures are applied to those vessels.

On the contrary, the arteries are not susceptible of great extension, nor of great contraction; they extend and contract in the dimension of length more than in that of breadth. We must distinguish from these phenomena, the power of the arteries to enlarge, and to lessen.

(1) Lucae, *Quædam observationes anatomicæ circa nervos arterias adeuntes et comitantes*, Erfort, 1810.

(2) Lauth, jun. has, however, followed the threads of the great sympathetic nerve, surrounding the vessels of the liver, and losing themselves in their coats, even four inches within this viscus.—See Lobstein, *De nervi symp. hum. fabricâ usu et morbis.* Paris, 1823, § 33.—Compare *Journ. de la soc. des sciences, arts et agriculture du département du Bas-Rhin.*

(3) Wrisberg, *loc. cit.* § 30.—Scarpa, *Tabul. neurol. ad illust. nerv. card. hist. anat.* 1794. p. 25.—Lucæ, *loc. cit.* p. 28–29.

(4) We must, however, observe, that the poofs given by the author of the elasticity of the arteries refer it to the fibrous, and not to the cellular, coat; the utmost brittleness of the fibrous coat does not prevent it from being elastic. F. T.

When the circulation is impeded in a principal vessel, this vessel is gradually contracted and reduced to the size of a thread: the collateral branches dilate in the same proportion,(1) become more tortuous, and longer; but at the same time their parietes also thicken, but this is not always the case. The change then supervening in these latter vessels is not confined to simple dilatation. The principal trunk does not merely collapse; it diminishes also in volume, receives less nutrition, and is destroyed by absorption. Some time after the obliteration of a principal vessel, the number of enlarged collateral vessels is much greater than at a later period, for in time they diminish, and the circulation becomes more similar to what it was in the normal state. Further, several weeks are requisite for the dilatation of the collateral branches, and this enlargement is greatly hastened by the motions of the limb.

Sometimes there is dilatation rather than increase in mass, as is especially the case with the uterine arteries during pregnancy. So, too, after death, injections, if pushed with force, distend the arteries very much, rendering them tortuous, although they before appeared straight. The arteries of old people, particularly those of a large caliber, as the aorta and primitive iliacs, are almost always slightly curved, because, as they take a less active part in the circulation, the heart sends the blood into them with more force, and slightly lengthens them.

These phenomena result from a mechanical influence. They depend neither on a force of expansibility, nor on an effort to resist a state of expansion; they are not connected with the life of the artery. But it may be asked if the arteries have not, besides, the power of vital contraction or of dilatation?(2) They have not this power, at least they are not subject to the will; still it is incorrect to attribute to elasticity alone all the phenomena of extension, or of contraction, which they present.

This last opinion is that of Haller,(3) Bichat,(4) and Nysten.(5) Bichat, particularly, has supported it with many arguments, of which the principal are:

1st. Whatever may be the manner in which the artery is irritated, whether chemically or mechanically, internally or externally, or even by raising its fibres, layer after layer, it gives no sign of organic contraction. Cut longitudinally, it does not turn over on its edges, as do the irritable canals, the intestines, for instance, in similar circumstances.

2d. The artery does not contract when separated from the heart, or when a portion of it is comprised between two ligatures.

(1) This subject has been perfectly described by Jones, *On the process employed by nature in suppressing the hemorrhage from divided and punctured arteries*, London, 1808.—Cooper, *Diss. of a limb*, &c. in *Med. Chir. Trans. of London*, vol. ii. p. 251. *An account of the anastomosis of the arteries of the groin*, same collection, vol. iv. p. 424.

(2) Kramp, *De vi vitali arteriarum*, Strasbourg, 1785.—Parry, *An exp. inq. into the pulse and other prop. of arteries*, Bath, 1816: *Additional exp.* London, 1819.

(3) *Mémoire sur les parties irr. et sens.* sect. xi.

(4) General Anatomy, vol. i.

(5) This opinion is still maintained by Magendie. See his *Journ. de Physiol. exper.* April, 1820. F. T.

3d. Neither are contractions observed by irritating either the whole nervous system, or the proper arterial nerves. Even galvanism does not produce these phenomena.

4th. Opium, which destroys the motion of the irritable parts, has no effect upon those of the arteries.

But most physiologists, especially Van Doeveren,(1) Zimmermann,(2) Verschuir,(3) Sœmmerring,(4) and Hunter,(5) profess the contrary opinion. It may be objected, generally, to the arguments of Bichat, that, in fact, the artery does not always contract under the influence of an irritating cause, but the same thing occurs in very irritable parts. Also, that the arteries often contract when exposed to the action of stimulants. Zimmerman, Lorry,(6) and Verschuir,(7) have seen very sensible contractions produced by concentrated mineral acids.

Bichat(8) admits these facts, but says they do not result from contractibility; but from a horny hardening, which is observed as well after death as during life, and that the arterial tissue never returns to its natural state, after such a contraction.

But the circumstance alone, that this phenomenon is not constant, proves that it depends upon irritability.

Besides, what is observed in a dead body is not a true contraction, but a corrosion,(9) a state entirely different.

The arteries contract also under other influences than those of chemical agents; as when irritated by the point of the scalpel.(10) After being divided, they sometimes close, so that hemorrhage ceases spontaneously, notwithstanding the impulse of the heart. The impression of the external air is often sufficient to close an artery exposed to it, so that its cavity is entirely effaced,(11) or, at least, is much diminished; and this contraction, which does not every where exist uniformly, is always greater than that observed after death, even when the vessel contains no blood.(12) Sometimes, also, the arteries, when exposed, move with great vivacity, and very differently from the usual manner.(13)

The contraction, dependent on these causes, and which is often very considerable, ceases at death,(14) or during life when the irritating cause is removed.(15) It extends beyond the point acted on by the stimulus.

(1) Verschuir, *loc. cit.*, p. 22.
(2) *De irritabilitate*, Goettingen, 1751.
(3) *De vi arteriarum et venarum irritabili*, Groningen, 1766.
(4) *Gefæsslehre*, p. 67.
(5) *On the blood*, vol. i.
(6) Vandermonde, *Rec. period.* vol. vi.
(7) *Loc. cit.* exp. 1. 2. 7. 8.
(8) *General Anatomy*, vol. i. p. 332.
(9) Verschuir, *Exp.* 16.
(10) Ibid. *Exp.* 8. 14. 18.
(11) Hunter, *loc. cit.*
(12) Verschuir, *Exp.* 8.
(13) Ibid. *Exp.* 8. 22.
(14) Ibid. *Exp.* 8. 17.
(15) Ibid. *Exp.* 18

If after death we dilate the artery, which was thus contracted, it collapses, but much less than during life.

The electric spark also occasions strong contractions in the arteries.(1)

We may also mention against the assertion of Bichat and Nysten, that irritation of the nerves, by galvanism(2) or other means, as caustic alkalies,(3) causes contraction in the arteries.

There are no arteries, even those detached from the body, which do not truly move according to irrefutable proof.(4) In cold blooded animals, even when the heart is removed for hours, and even days, we not only see the motion of the blood, but a contraction and expansion of the arteries.

Finally, the circumstance that opium produces no effect upon the motions of the arteries would prove only that the irritability of these vessels is independent of the nervous system, but not that it does not exist.

To all this we must add :

1. That the arteries do not always and every where exhibit the uniform phenomena of contraction and expansion. Sometimes when a limb is paralized, the pulse is deficient in the diseased side, although it may be regular in the opposite side.(5) To explain this phenomenon we must admit, either that the artery, having lost its contractility, remains constantly in its greatest state of dilatation, or that the dilatation is a state no less active than that of contraction; for in either of these states there will be no pulsations.

On the other side certain arteries sometimes beat with extraordinary power. This certainly happens in the large arteries of an inflamed part; and also usually, if not always, in those of a small caliber. This phenomenon is observed also in the abdomen, from different causes, especially when the activity of the nerves is increased.(6)

Sometimes the number of the pulsations varies also in the same portion of the arterial system. Thus in a patient affected with aneurism of the pectoral aorta, the pulses were from 100 to 110 in a minute in the right arm, and only from 90 to 100 in the left.(7)

2d. The phenomena of irritability disappear after death in the arteries, but not immediately. This is proved by the experiments on the

(1) Bikker and Van den Bos, in Verschuir, *loc. cit.* p. 29.

(2) Giulio and Rossi, *Diss. de excitabilitate contract. in part muscul. involunt. ope animal. electric.* in *Mém. de l'ac. des sc. de Turin*, vol. iv. p. 50–52.

(3) Home has seen the carotid arteries beat for some time and violently in a rabbit, after touching the sympathetic nerve with caustic alkalies.

(4) Housset in *Mem. sur les parties irritab. et sens.* vol. ii. p. 404.

(5) Hoffman, *Ueber Empfind. und Reizbark. der Theile*, Mayence, 1792, p. 141.—Storer, Vicker, and Wells, have observed several similar cases. Storer, *Instances of the entire want of pulsation in the arteries of paralytic limbs*; in *Transact. of a soc. for imp. of med. and surg. knowl.*, &c., 1812, No. xxxii.—Marshall has witnessed the same phenomenon: *Case of suppression of urine from stricture succeeded by gangrene of the arm*; in *Edinburgh med. and surg. journal*, vol. iv. No. 36. p. 449.

(6) Armiger, *Case of Dysphagia produced by aneurism of the aorta*; in *Med. chir. Trans. of London*, vol. ii. p. 247.

(7) Alber's *Ueber Pulsation en Unterleibe.*—Burns, *On the principal derangements of the heart; On pulsations in the epigastric region.*

contraction of these vessels according as they had been divided, sooner or later. In many experiments of this kind, which have been made on the umbilical arteries, it has been remarked in observing the changes of their orifices, that they contracted three days after the placenta was detached, but that they possessed this power no longer.(1)

3d. The local application of certain irritants causes the arteries to contract, while others excite them to dilate. Ammonia contracts them so rapidly that they almost entirely disappear. The hydrochlorate of soda, on the contrary, causes them to enlarge their caliber almost as constantly. The rapidity with which this phenomenon takes place, its duration, and its power of being repeated, vary much as the subject is more or less robust.(2)

The arteries, besides elasticity, possess, also, irritability. The first property predominates in the large, the second in the small vessels. It is on account of its elasticity that the artery gapes, that it does not collapse, that it remains moderately extended, and that it increases the force of the blood sent forth by the heart. Irritability allows it to contract, to collapse more than when in a moderate state of extension, especially after it has been dilated by the efflux of the blood.

The arteries exhibit no sign of sensibility in their normal state, although they sometimes evince a little when carefully irritated by stimulants.(3)

§ 93. The arteries carry the blood from the heart to the organs. This function is demonstrated:

1st. By the swelling and sometimes the rupture of the arteries between the heart, and the part where they are tied or compressed.

2d. By the absence of blood in that part of the vessel situated between its periphery and the ligature.

3d. By the arrangement of the valves at the origins of those trunks which arise from the heart.

§ 94. With a few rare exceptions,(4) the artery moves regularly and uninterruptedly through life; it beats; it pulsates. Two questions are now presented: what change does the artery experience in pulsating? how is this change produced?

The first problem has been resolved in several different ways. Some physiologists admit that the dilatation of the arteries is necessary from the afflux of the blood, which the heart sends forth, and which is added to that they already contain; for, according to them, the arterial system is always full of blood. Others, on the contrary, adducing the small quantity of blood sent forth by the heart, which is not sufficient to dilate the arteries sensibly, pretend that the pulses are caused only by the displacement of the vessels. These two opinions should be united, for it is very probable that the same quantity of blood which

(1) Hunter, *loc. cit.* p. 256-7.
(2) Thomson's *Lectures on Inflammation*, Edinburgh, 1813, p. 75-89.
(3) Verschuir, *Exp.* 12.
(4) See a case of this kind in the *Mém. de l'ac. des sc. de Paris*, 1748: *Hist.* p. 87.

supports the arterial system should produce in it a marked dilatation also. Nevertheless, numerous observations made by us on the arteries of the umbilical cord lead us to think that the displacement contributes more than dilatation to produce the pulses ; in fact, we have always found the displacement very considerable, while the dilatation is scarcely perceptible.

The solution of the first question contains also that of the second, since it results from it, that the capacity of the arteries changes very little in their pulsations : the principal cause of the pulses, and hence of the circulation of the blood, is the contraction of the ventricles of the heart, which pushes forward into the arterial system a considerable quantity of blood. The artery remains passive ; it acts only at the second time, during which we see no motion, or at least but very little: it is then that it slightly contracts on itself. This theory is founded on the following facts :

1st. The contraction of the ventricles is cotemporary with the dilatation and displacement of the arteries.

2d. The arteries beat regularly, even when diseased; as, for instance, when ossified ; and when irregularities are observed, they take place because a morbid affection renders the dilatation, or the displacement of the vessel, more difficult.

3d. The arteries beat even after death when they communicate with the heart of a living animal ; and any flexible tube whatever will present the same phenomenon.

4th. The blood issues most forcibly from the wonnd of an artery during the contraction of the heart.

§ 95. Nevertheless the arteries concur also, though feebly, by their vital contractions, to push the blood forward ; as is proved :

1st. By the continual flowing of the blood from a wound in an artery, although it is more abundant during the contractions of the heart, than between them.

2d. By the circulation of this fluid in acephalous monsters which have no heart.

3d. By its motion and the alternate dilatation and contraction observed in animals which have no heart.(1)

§ 96. We may consider as sexual differences the greater thickness of the tunics in the male, which is to those of the female about as 11 : 10 ; a greater density and specific gravity, which is as 154 : 150 ; and, finally, their greater force, which is as 13 : 10. The narrow-

(1) For the part taken by the heart and arteries in the motion of the blood, we refer, in addition to the works of Harvey, Haller, Spallanzani, Sœmmerring, and Bichat, to Prochaska, *Controversiæ physiologicæ, quæ vires cordis et motum sanguinis per vasa animalia concernunt ;* in *Opp. min. anat. arg.*, Vienna, p. 1-58. This author thinks the arteries influence the circulation.—Araldi, *Della forza, e dell' influsso del cuore sul circolo del sangue ;* in *Mem. delle societa italiana*, Modena, 1804, vol. xi. p. 342-383., vol. xv. p. 2. 1810, p. 166-196. These are researches on the capacity of the force of the heart, tending to determine the extent of its influence on the vascular system.—T. Young, *On the functions of the heart and arteries;* in the *Phil. transact. of London*, 1809. This author attributes the circulation to the action of the heart alone.

ness of these vessels, compared to the veins, which, in the male, is greater than in the female, must be referred to the same.

§ 97. The arteries are much larger, more numerous, and softer, the younger the organism is, except in some points, such as the arch of the aorta, and the trunk of this vessel generally, where the force of the blood, in advanced age, causes an inverse arrangement; that is, an enlargement and thinness. After the middle of life, they become brittle, and lose their elasticity in a greater or less degree. Their internal membrane differs most at different periods of life; for it is frequently ossified (§ 86.) The number of the nutritious vessels, and of the nerves, especially of those filaments which go to the fibrous membrane, diminishes by age.(1)

C. OF THE VEINS.

§ 98. The *veins* (*venæ*) (2) differ very much from the arteries in their internal and external arrangement.

As regards their external arrangement, they offer the following differences, as to their *capacity*, *number*, *situation*, *direction*, *the relation of the trunks to the branches, and their anastomoses.*

The veins are more numerous andlarger than the arteries. They usually accompany the arteries, and are even intimately united with them. But besides the veins termed deep-seated, there are others also which arise from the capillaries in several parts of the body, proceed to the surface, and run immediately under the skin; hence they are called *cutaneous veins.* The latter form considerable trunks, sometimes even larger than the deep-seated veins, and correspond to no artery. They are seen particularly in the extremities. Farther, the deep seated veins which accompany the arteries are almost always double, although often of small caliber. Hence the capacity of the venous system evidently much exceeds that of the arterial system.

The difference is not equally great every where. In general it is much more marked in the vessels of the secretory organs than in others. Nevertheless we must not believe it as considerable as it seems after death; because then the blood accumulates in the venous system, from the inaction of the lungs, and continues to be propelled there by the arteries long after they receive none; and, finally, because the veins are very dilatable.

In some parts of the body, the number of the veins only equals that of the arteries, as in the stomach, intestinal canal, spleen, kidneys, testicles, and ovaries.

In other parts a single vein corresponds to two arteries, as in the penis, clitoris, gall-bladder, and umbilical cord. Still, even then the single veins are always larger than the several arteries whose blood they carry.

(1) Lucæ, *loc. cit.* p. 32.

(2) Marx, *Diatribe anatomico-physiologica de structurâ atque vitâ venarum*, Carlsruhe, 1819.

§ 99. *The veins generally accompany the arteries.* They issue from the organs at the same point as where the arteries enter, as is seen in the lungs, kidneys, muscles, intestinal canal, spleen, &c. But besides the superficial veins which exist in several parts, as we have stated above, independently of the deep veins, the arteries, and veins of certain organs, proceed entirely distinct from each other, and enter or emerge from different points. The liver and nervous system, especially the brain, furnish instances of this arrangement. The azygos veins have no corresponding arteries, unless they are considered as a compliment to the venæ cavæ, which is more admissible as they follow the aorta. Besides, this view of the subject appears well founded; for it is certain that the general type is strictly followed in the largest trunks of the two systems—the aorta and the vena cava. The right and left azygos veins, which are situated on each side near the aorta, correspond to those deep and sometimes very small venous trunks which immediately accompany the arteries, while the vena cava represents the larger superficial trunks.

§ 100. *The veins are, in general, more external and less concealed than the arteries.* We mention, in support of this proposition, the large subcutaneous veins which carry back most of the blood of the limbs, and also the situation of the deep veins which are placed at the side, and over the arteries they accompany, as the renal veins; and the arrangement of the veins of the brain, which, instead of rising from the base of the skull like the arteries, are, for the most part, united at its arch, so that they are still more exposed to injuries from external agents, as in children they are not in many places protected by bones.

The number of parts where the arteries are nearer the surface than the veins, is very small; in the pelvis, however, the iliac veins are situated more internally and farther backward than their corresponding arteries. When this arrangement exists, it has no effect on the security which they ought to have; for the situation and volume of the vessel is such, that every wound which would extend to the region it occupies would of itself endanger the life of the subject.

§ 101. *The direction of the veins is straighter than that of the arteries;* this facilitates the course of the blood within them very much. They ramify like the arteries, except that the relation between the branches and trunk is not so constant, that is, that the branches appear narrower: but this depends principally on the greater dilatability of the veins which allows the least cause to distend their small branches in one point or another so much, that their diameters equal and even surpass that of the trunk from whence they arise. The branches are broader than the trunk especially when the blood is forced to proceed a long period against its own gravity, as when we stand or when the arms hang down a long time.

§ 102. In general, a constant law of the arrangement of the veins is, that the branches and twigs are larger in proportion to the trunks than in the arterial system; so, too, the veins of one part, and even those of the whole body, never unite in so small a number of common trunks as that of the principal vessels which give rise to the arteries. The aorta and pulmonary artery come from their respective ventricles. On the contrary, the veins of the body arrive at their auricle in three trunks, the superior and inferior vena cava, and the large cardiac vein. The first receives a large vein just before entering the right auricle, the azygos. The pulmonary veins arrive at the left auricle four, sometimes five, and even six in number. At the side of one brachial artery we find four large venous trunks. The character of the veins then is to ramify, and that of the arteries to concentrate themselves.

§ 103. The veins present a character opposite to the arteries in regard to their anastomoses; these are more numerous and more general in the venous system: nevertheless, there is no contrast between these two laws, as the second is a consequent of the first.

In fact, the less degree of concentration in the veins renders the anastomoses more necessary, at least in part, in order to replace to a certain extent the common trunks which are not formed by the large branches.

Not only are the communications between the small branches as numerous as in the arterial system, but the large branches and the large trunks anastomose together more frequently than in that system. We see a remarkable instance of this in the subcutaneous veins of the extremities. But this law of the superficial veins is subordinate to another of a higher order: that the anastomoses increase in number wherever the course of the blood in the veins is more difficult, from a want of impulse and of powers which favor it. Hence their frequency in the subcutaneous veins of the limbs; in the spermatic veins, which are narrow, and very straight; and finally in the veins of the pelvis which are exposed to compression from so many different causes, and which frequently anastomose, to form a network so complicated, that it is difficult to follow the direction of the vessels correctly.

The number of the anastomoses in the venous system is also increased by this circumstance, that in many parts the veins form two distinct layers, the one superficial, the other deep. These two layers constantly communicate, as is seen in all the superficial veins of the limbs of the neck and head on the one hand, and the deep veins of the neck and arm, and the sinuses of the dura mater, on the other.

The great trunks of the venous system of the body communicate by a large anastomosis, the azygos vein, which arises directly from the vena cava inferior, or from some one of its ramifications, and empties itself into the vena cava superior.

This arrangement explains how the circulation continues, although it may be impeded by some very considerable obstacles; as, for instance, when the principal veins of the limbs are entirely obliterated, or when the vena cava inferior is compressed in its course behind the liver by the swelling of this gland.

§ 104. The venous system is more complex than the arterial, as regards its extent. The arterial system ramifies incessantly and uniformly after leaving the heart; both the aorta and the pulmonary artery represent each a single tree. But the venous system of the body embraces in the peritoneal cavity a second tree, that of the vena porta, which communicates as usual with the arteries of the abdominal viscera ; but which, instead of carrying its blood directly to the vena cava inferior, ramifies in an opposite direction in the liver, and thus represents two trees, one of which, the venous portion, carries the blood of the branches to the middle trunk, while the other, the arterial part, distributes it from this part to the liver, from whence it passes into the hepatic vein, to arrive finally at the inferior vena cava.

§ 105. The principal differences in the texture of the veins are the following.

The internal membrane is thinner, more delicate, but more extensible, and less fragile, than that of the arteries; at the same time it does not ossify in old age. This alteration of texture is a very rare phenomenon in the veins, while it is almost normal in the arteries, of aged persons. We improve this opportunity to observe, that in regard to this we should compare not only all the carrying vessels of the arterial system, considered as a whole, but also the pulmonary vein, the veins of the body, the pulmonary artery, and the internal membrane of the right ventricle, should be opposed to the left portion of the heart and the system of the aorta ; so that there is only the arterial portion of the system of red blood which has a marked tendency to ossify. The truth of this law becomes still more striking when we know the opening between the auricle and ventricle is the limit of ossification on the internal face of the left portion of the heart; and we seldom observe ossifications in the auricle, while they are very common in the ventricle.

§ 106. The internal membrane of the veins differs also very much from that of the arteries in its purely physical arrangement; for the valves (§ 69) are generally very common in the veins, while in the arterial system they are met with in only two parts.(1) The chief points in their history regard their form, direction, number, situation, and size.

1st. The form of the valves of the veins is that which valves generally possess. They are slightly parabolical; one of their edges is semicircular and attached—the other is loose and straight, or little fissured; both are slightly turned over. The valves and those parts of the circumference of the veins to which their similunar edges are attached, form sacs, the diameter of which is a little larger than that of the adjacent part of the vessel.

2d. Their direction is opposite to that of the valves of the arteries. Their loose edges, and the bases of their sacs are turned from the heart, so that the blood which runs from this organ distends them, and that which flows towards the heart presses them against the parietes of the vein.

(1) Meibomius, *De valvulis seu membranulis vasorum, carumque structurâ et usu*, Helmstadt, 1682, rec. in Haller's, *Coll. Diss.* vol. ii.—Th. Kemper, *De valvularum in corp. hum. naturâ, fabricâ et usu mechanico*, Jena, 1683, rec. *ibid.*

Their *number* offers several points for consideration.

a. They do not exist every where. There are none in the system of the vena porta, of the pulmonary veins,* the umbilical vein, the trunk of the vena cava inferior, in the veins of the brain, of the vertebræ, of the spinal marrow, of the heart, of the kidneys, and of the womb. Still these veins make the transition to those which possess many valves, since they are sometimes found in them but very rarely, and are always incomplete. The sexes seem to differ also in this respect; at least the spermatic veins of the female have no valves, while they exist in those of the male. There are none, or but few, in the anastomosing branches. Hence while there are many in the median vein of the arm, there are very few in the azygos vein.

b. Even in those parts of the venous system which possess them, *the number of valves varies.* Generally speaking, this number increases in the inverse ratio of the caliber of the vessels. Nevertheless the valves disappear entirely in the small veins; more are also found in the superficial, than in the deep seated veins.

c. The number of valves varies also in this point of view, that the number of these folds which close the orifices of the vessels is not every where the same. These valves are usually arranged in pairs, as is seen principally in the large trunks and large branches. Sometimes also they are insulated; this last arrangement takes place in the veins less than a line in diameter. Still we find also single valves in the large veins; as, for instance, at the opening of the vena cava inferior, and of the great cardiac vein into the right auricle. These single valves are proportionally larger than the others.

Sometimes also three, or even four and five valves are found where usually only two exist, but this state of things is rare, and is not constant.

4th. With regard to the position of the valves, we may say they are generally found in those parts where a subordinate vein unites with a larger one; sometimes there are none in these points, while we see them in others where no such union exists.

5th. The valves vary in size. They generally close the mouth of the vessel entirely. This closure is more perfect when there are two or three; but sometimes they are insufficient to shut up the passage entirely. Thus, in certain places we find only a slight projection the rudiment of a valve. Besides, particularly in the sinuses of the dura mater, there are transverse cords, incontestable marks of valves which are also observed in other veins, as, for instance, in the crural veins, (1) but not constantly.

* This assertion has recently been contradicted by Professor Mayer, (*Zeitschrift der Physiologie*, vol. iii. p. 155,) although hitherto admitted by all systematic writers on anatomy. Professor M. states, that the valves are large and numerous in the pulmonary veins, and always occur where a venous branch joins the larger trunks at an acute angle; and the more acute the angle, the more marked is the valve. Where the branches join at a right angle, however, no valve exists, as is the case in the other parts of the venous system. Hence the valves are fewer in the pulmonary than in other veins, because the ramifications of the pulmonary veins take place chiefly at right angles.

(1) Haller, De fabr. vol. i. p. 265.

We must here speak of the differences presented by the valves as respects their integrity. They are commonly entire, but sometimes they seem to be torn, especially on their loose edge. Doubtless this arrangement often results from a primitive formation, which has continued; but it may be consecutive also, and may then arise from compression or any other cause, as, during life, the valve at the orifice of the vena cava inferior, which is at first entire, is frequently changed into a network, or reduced to simple filaments, or disappears entirely. The valve placed at the orifice of the large cardiac vein often presents the same phenomenon. But these valves are precisely those most exposed from their situation to the influence of mechanical causes, and before birth they are always entire. When the reticulation of the valves is congenital, it marks the transition of the simple transverse filaments to real valves.

§ 107. The fibrous membrane of the veins differs also from that of the arteries.

1st. It is thinner. The difference between the two systems in this respect, is still greater than that mentioned when speaking of the internal tunic; since distinguished anatomists, as Vesalius, have not been able to see this fibrous membrane.

2d. Its fibres are less closely connected, and hence this layer is less dense and less compact.

3d. It does not exist in every part of the venous system. While in the arterial system it becomes even proportionally thicker in the small ramifications, it is only visible in the large branches of the veins. There is, however, between the large branches and trunks of the veins the same relation as respects the thickness of this membrane, compared to their caliber, as in the arteries.

4th. The fibrous membrane of the veins offers also other differences in regard to its thickness and even its existence.

a. It is always proportionally thicker in the system of the vena cava inferior, than in that of the vena cava superior; a remarkable difference which evidently coincides with the obstacle opposed by the weight of the blood to its progress in the former system of vessels.

b. It is also stronger in the subcutaneous than in the profound veins, which depends on the same cause; for the course of the blood not being favored in the former as it is in the latter by the pulsations of the adjacent arteries, the structure of the vessels should compensate for this unfavorable circumstance.

c. The fibrous membrane is evidently deficient in several parts, especially in the venous trunks, situated between the two layers of the dura mater, that is, in the meningœan sinuses. Most anatomists even suppose that there is no venous membrane in those parts, and that the blood runs directly on the dura mater. But Bichat(1) has proved this opinion to be false. In examining attentively the interior of the triangular space formed by the separation of the two layers of the

(1) General Anatomy, vol. i. p. 402.

dura mater, we discover a rounded canal, formed by the internal membrane of the veins. Now this canal continues on one side with the internal membrane of the cerebral veins which communicate with the sinuses of the dura mater, and on the other with that of the internal jugular vein, into which these sinuses open. The dura mater which slightly resembles the middle membranes of the vessels, here replaces it. As, however, the dura mater has no contractility, it would seem that the purpose of this absence of the fibrous membrane is to retard the course of the blood.

The veins which open into the sinuses of the dura mater, are all well provided with a fibrous membrane, but it is thinner in proportion there, than in the other veins of an equal volume.

5th. The veins differ also from the arteries in the direction of their fibres.

We have ascertained by the most minute dissections, that these fibres are all longitudinal, and there are none which are circular.(1) This difference between the arrangement of the arterial and venous fibres is remarkable, inasmuch as the two layers of longitudinal and transverse fibres which are observed in the whole extent of the intestinal canal, reappear also in the vascular system, which is but a development of the intestinal tube; but the membranes are separated and distributed each to one of the principal portions of the vascular system. This analogy is strengthened, as the external layer of the fibres of the intestinal canal is composed of longitudinal fibres, and the internal of oblique fibres, as the external is always feebler than the internal, and as the first is deficient, or at least is not very apparent in several parts, either of the circumference or of the length of the intestinal canal. Thus the longitudinal fibres are united in three distinct bands in the large intestine, and in the small intestine they are so thin, that, in many parts, they are indistinctly seen.

6th. The fibres of the venous membrane are redder, softer, more extensible, and less brittle than those of the arterial tunic.

7th. Their arrangement and their existence are more liable to variations than those of the arterial fibres, for they are very well developed in certain subjects, and are scarcely visible in others: a new point of relation between the fibrous membrane of the vessels and that of the intestinal canal.

§ 108. The cellular membrane of the veins is also thinner, less dense, and less solid than that of the arteries. Prolongations proceed from it to the fibrous membrane, which are not observed in the arteries: these extend even to the inner membrane. The veins of the brain have none.

§ 109. The veins receive fewer blood-vessels than the arteries, which is undoubtedly because they are thinner.

Their nerves, both those which come from the system of animal and from that of organic life, are equally less numerous than those of

(1) Bichat said correctly, "There are no circular fibres in the veins."—p. 403.

the arteries. This relation certainly exists between the system of the vena cava and that of the aorta.

§ 110. The veins are much more extensible(1) than the arteries. The latter tear when slightly distended; the veins resist much more, and often dilate considerably when the course of the blood is impeded by an obstacle. They are then less elastic than the arteries.

They are equally susceptible of vital contractions, although these have not been observed in every experiment.

The large trunks which possess very apparent fibres, are particularly irritable.

§ 111. The veins return the blood to the heart, and change neither in their diameter nor in their situation. They do not pulsate except in some rare and extraordinary cases.

The facts which prove that they really perform the above mentioned function are,

1. When tied, they swell between the surface of the body and the part to which the ligature is applied, while they are empty between this point and the heart. When these phenomena do not take place, it is on account of their anastomoses.

2. The direction of the valves.

3. In microscopical observations, the blood has been seen proceeding within them, from the surface of the body towards the heart.

D. LYMPHATIC VESSELS.

§ 112. The *lymphatic vesels* (*vassa lymphatica*) (2) form a system, which differs from that of the veins by the nature of the fluid it carries,

(1) The phenomena of erectility depend principally on the extensibility of the veins. Some have formed a special tissue of the corpora cavernosa of the penis and clitoris. This has been termed the *erectile* tissue, and to it have been referred the papillæ, mammæ, &c. Degraaf, Ruysch, Duverney, Boerhaave, Haller and his school considered it as a loose and elastic cellular tissue, forming cellules, and interposed between the arteries and the veins. Duverney, Mascagni, Cuvier, Tiedemann, Ribes, Moreschi, Panizza, and Farnese have demonstrated that it consists only in the terminations of the blood vessels, especially the roots of the veins, which are very large and extensible, supplied with many nervous filaments.—F. T.

(2) Although we find traces of a knowledge of the lymphatic system very early, and even in the works of Aristotle, (*Hist. anim.* lib. iii. c. vi.) the different portions of this system have been successively known; the Swede, Olaus Rudbeck, in 1650, discovered the connection of these vessels with the thoracic canal, and the motion of the fluid which they contain, (*Nova experimenta anat. exhib. ductus hepatis aquosos et vasa glandularum serosa*, Westeras, 1653). The structure and distribution of the lymphatics have been particularly studied in England by G. Hunter, (*Med. comment.* London, 1762, vol. i.) Hewson, (*Experimental inquiries*, vol. ii. London, 1784, vol. iii. 1777,) and Cruikshank, (*The anatomy of the lymphatic vessels of the human body*, London, 1774); in Germany by Meckel, (*Diss. epist. ad Haller. de vasis lymph. glandulisque conglob.*, Berlin, 1757, in 8vo.—*Nov. exper. de finibus venarum et vas. lymph. in ductus visceraque excretoria corp. hum.*, Berlin, 1772, in 4to.); in Italy, by Mascagni, (*Vasor. lymph. corp. hum. historia et ichnographia*, Sienna, 1787, in fol.) Ludwig has collected the principal works on this subject in *G. Cruikshank's und P. Mascagni's Geschichte und Beschreibung der Saeugadern des menschlichen Kærpers*, Leipsick, 1789, 3 vol. in 8vo.—Werner and Feller, *Vasorum lacteorum, atque lymphaticorum anatomica physislogica descriptio*, Leipsick, 1786.—Haase, *De vasis*

but which ought to be considered an appendage to this system, on account of the connections between them. We have more right to establish this connection, as the liquid carried by the lymphatics is almost always changed into blood in its course to the sanguineous system.

§ 113. The lymphatic system appears to be an appendage of the venous system, because of its connections, since it opens into it in several points. There are at least two of these points in man, viz., the junctions of the subclavian and jugular veins of each side, so that the system of the vena cava superior receives this appendage. The lymphatics unite in two trunks, one on the left called the thoracic duct, (*ductus thoracicus*,) the other on the right, which is smaller. The latter receives the lymphatics of the right half of the head and neck, lungs, liver, diaphragm, and of the right superior extremity; all others terminate in the former. It is not certain but that in man, as in different animals, the lymphatics of a small caliber open into the venous system(1) in other parts than the two already mentioned. Some anatomists nevertheless think, and comparative anatomy seems to authorize the belief, although it is not certain, that the number of large points of communication, of insertion of trunks, formed by the union of many lymphatics, is reduced to two in man, and that as we descend the scale of animals this number increases.

§ 114. The lymphatic system resembles the venous more than the arterial system, but it also differs much from it, although only in degree. The following are its analogies with the venous system, and its differences from the arterial system:

I. In relation to external form.

1st. These two systems form two layers, one superficial, and the other profound.

2d. The number of branches and twigs compared with that of the trunks, is much greater than in the arterial system.

3d. A branch remote from the heart is not always narrower than the branch with which it communicates.

4th. Their capacity is very variable.

5th. They are wider and more numerous than the arteries.

6th. Their direction is very straight.

7th. Their anastomoses are very numerous, and obey the same laws as in the veins.

But these relations do not establish the identity of the venous and lymphatic systems; for,

cutis et intest. absorb., Leipsick, 1786.—Schrœger, *Fragmenta anat. et phys. fasc.* i., Leipsick, 1791.—Altenther, *Lymphatologie, oder Abhandlung über das lymphatische System und dessen Leiden*, Vienna, 1808.

(1) Since this work was published, the communication of the lymphatics with the veins, other than by the thoracic canal, has been proved by Fohmann, (*Anatomische Untersuchungen über die Verbindung der Saeugadern mit den Venen.*, Heidelberg, 1821,) and by Lauth, jr., (*Essai sur les vaisseaux lymph.*, Strasburg, 1814). The latter admits that the lymphatics terminate in three modes: those which as capillaries empty into the veins, in the tissues of the organs; those which terminate in the veins within the lymphatic glands, ending in the same manner; finally, those which open into the thoracic canal and the large lymphatic vein of the right side. F. T.

1st. The distinction of the lymphatics into superficial and deep-seated, is more general than in the veins: not only the trunk, the head, and the extremities, but also all the viscera have superficial and deep-seated lymphatics. The difference is still greater between these two orders of lymphatics, than between the two corresponding orders of veins, both as respects number and volume, for the largest and fewest lymphatics are not the superficial, but the deep-seated.

2d. The proportion between the small divisions and the trunks is still more advantageous to the former than in the veins; the concentration is still less. In their course, which is often very long, as for example in the limbs, the lymphatics of no part of the body unite in several large trunks; but their diameter being exactly the same or nearly so, we see them, from the instant they become visible, advancing separately, or in great numbers, to the neighborhood of the principal trunk, where their number diminishes, although inconsiderably, and where their volume augments in the same proportion.

3d. The branches remote from the heart are often much more numerous and much larger than those near this central organ; this arrangement exists much more frequently in the lymphatics than in the venous system.

4th. Their capacity is much more variable than that of the veins. The preceding difference depends on this: hence, too, the reason that in living dissections, and sometimes even after death, we find the lymphatic system dilated from space to space, so as to form considerable vesicles, which in living animals often entirely disappear. Finally, it is for this reason that we cannot fix the exact relation between the trunks and their branches, and that the calculations made of the caliber of the large thoracic trunks are so very different.

5th. The lymphatic system is almost as broad as the venous; but as the branches do not unite in trunks, their number is much greater than that of the corresponding veins, and each large venous or arterial trunk is accompanied with at least ten lymphatics.

6th. The direction of the lymphatics is in general straight. Still they sometimes curve considerably, and even more than the arteries.

7th. The anastomoses are still more frequent in the lymphatic than in the venous system, which accords entirely with their less degree of concentration. Even their trunk is completely surrounded with very many large anastomosing vessels, which also communicate with it extensively, and which are sometimes so voluminous that we can with difficulty distinguish a single principal trunk, and are obliged to admit an immense network of lymphatics.

§ 115. The lymphatics are not a continuation of the arteries, like the veins. They arise independent of them.(1) It has usually been

(1) Although it is certain that the lymphatics are not connected with the arteries as with the veins, we however admit with Lauth, jr., (*Essai sur les vaisseaux lymph.*, sect. 2. p. 12.) the existence of lymphatics which arise from the internal surface of the arteries, as from all the other surfaces, which is well proved by inflammations.
F. T.

supposed, since the discovery of this system, that some arteries called lymphatic (*arteriæ lymphaticæ*) continue with the proper lymphatics, in the same manner as the final ramifications of the arteries, which also carry red blood, join the roots of the veins; but this arrangement cannot be demonstrated.

The principal reason alledged is drawn from what has been observed by several anatomists in different parts of the body, that fluids of all kinds, introduced into the arteries, penetrate into the lymphatics.

But then we always find ruptures and extravasations; when even the final twigs of the arteries should have been injected, they are filled only in their trunks or large branches: finally, the phenomenon itself is rare when there is no extravasation, even when the arteries are filled more successfully, and the injection reaches the veins through them.

When there is no rupture, and the arteries are perfectly injected, and the veins are at the same time filled, it sometimes happens, that the injection passes into the lymphatics; but its colorless portion penetrates into them, so that we cannot conclude from this there is an uninterrupted communication between the injected lymphatics and the arteries, since the colorless fluid is found also out of the vessels, and abounds in the part injected. This phenomenon then is better explained by saying, that the colorless portion of the injection transudes through the arteries, and is absorbed by the lymphatics.

The following are the principal arguments to prove that the origin of the lymphatics is independent of the arteries:(1)

1st. The circumstances attending the passage of fluids from the arteries or veins to the lymphatics.

2d. The phenomena presented by the lymphatic system in regard to the substances submitted to its action. The fluid contained in these vessels exactly resembles that found at their origin. The lymphatics coming from the liver contain a fluid analogous to bile; those from the breasts a milky fluid; those which arise from parts where blood is effused, a liquid resembling blood. The bronchial glands, and often even the lymphatics which go to them, are of a blackish blue, like the lungs. The color of the spleen is the same as that of the lymphatic glands placed near it. If a deleterious substance, as the pus of a venereal ulcer, or of a varioloid pustule, or generally of any ulcer whatever, be presented to the action of the lymphatics, those which arise from the diseased part inflame, and the glands in which they terminate swell. This effect takes place only in the side on which the deleterious substance acts.

As all these phenomena supervene uniformly when their causes exist within the organs, in the cavities of the viscera, or on the surface of the body, we have no doubt that the lymphatics arise from the substance of the organs, and from their surfaces, particularly from the

(1) Hunter, *Medical commentaries*, London, 1762, p. 5.—A. Monro, *De venis lymphaticis valvulosis*, Berlin, 1757.—Hewson, *Exp. inquiries*, p. 2., London, 1774, chap. ii.—Morgagni, *Loc. cit.*, sect. 3., *De vasorum lymph. origine.*

cutaneous system, both from the skin properly so called,(1) and from the mucous and serous membranes.

§ 116. Our remarks on the external form and on the track of the lymphatics, apply to their texture also. Their internal membrane is still finer, thinner, and more extensible than that of the veins, and is not subject to ossification. It also forms parabolic valves,(2) which are generally arranged in pairs, but are sometimes insulated, and are usually more numerous as the vessels diminish in caliber, so that the thoracic canal contains fewer than all the others. The distance between them is not every where the same: but a general law is, that it is much greater in the lymphatics than in the veins.

§ 117. The fibrous membrane(3) is deficient not only, as in the veins, in most of this system, but even in the thoracic canal; at least the most attentive observations have not recognized it in man. The internal membrane is directly under the cellular tunic, which is thinner in proportion to the size of the vessels, than in the other parts of the vascular system.

§ 118. Besides all these differences the lymphatic system presents others which are very considerable. We may mention here the *conglobate glands*, (*Glandulæ lymphaticæ, conglobatæ*,) peculiar formations which are found in no other part of the vascular system.

§ 119. These conglobate glands are small round bodies more or less oblong, usually a little flattened, of a grayish red color, hard, varying much in size, which exist in certain parts of the body, where they are about the same in number and volume; they interrupt the course of the lymphatics, are not symmetrical, and have no regularity in their arrangement.

These glands vary considerably and constantly in *number*, *form*, *size*, and *color*.

1st. Most of these glands are found in the neck and within the pectoral and abdominal cavities, along the sides of the vertebral column, and also between the folds of the serous membranes, which retain the organs situated in these cavities, and near these same organs, for instance, at the roots of the lungs, around the bifurcation of the trachea.

They are very numerous in the face, especially around the mouth. There are fewer in the skull.

(1) Lauth, jun., (*Essay on the lymphat.* sect. 2, p. 13.) has even demonstrated anatomically, that the lymphatics arise from the surface of the skin, having injected them to its outer face.—F. T.

(2) We often find (E. A. Lauth, *Essay on the lymphatics*, sect. 1, p. 4.) in the lymphatic trunks annular valves formed by the union of two valves, which being lower than usual, do not close the canal entirely. The same arrangement exists in the lymphatics of the different viscera, especially those of the liver.—F. T.

(3) Mascagni denies the existence of muscular fibres also in the lymphatics. Schreger admits, however, (*Fragm. anat. et phys.* fasc. 1, Leipsick, 1791, p. 9.) that there are transverse fibres in the thoracic canal of man and the calf. Sœmmerring also believes they exist in this canal. Rudolphi was unable to find them either in man or in the horse.—F. T.

In the extremities they commence usually at the elbow and knee, and are placed around the articulations; there are fewer, however, in those parts than in the axilla and groin.

Their existence has never been demonstrated within the organs, and the proofs of them, which are believed to have been found in those peculiar morbid masses, which are developed in these parts, as in the lungs, the liver, the spleen, the brain, &c., are insufficient, since these masses never present the characters of lymphatic glands; and examining them attentively, we recognize that they are not even glands. The conglobate glands exist only in the mucous tissue between the organs. We find none in the skull.

In comparing these glands, as regards their greater or less abundance in different regions, we arrive at the following results:

a. They increase in number as they approach the trunks, which throws some light upon their functions.

b. They are entirely distinct and separate from the proper substance of the organs.

c. They are especially numerous in those parts, where the mucous tissue abounds.

d. They are found in great numbers in those places where foreign substances come; consequently near the lungs and intestinal canal.

2d. The lymphatic glands vary much in size, in the same, and in different regions of the body. The largest exist in the groin, the pelvis, around the bronchia, in the mesentery, and in the axilla. But in these different places we see them alternately large and small. They are rarely more than an inch long, half an inch broad, and three or four lines thick. Age certainly affects their size. Is the same true of sex? We cannot think it, since excellent observers contradict each other on this point. Hewson says they are proportionally larger in the male,(1) while Bichat asserts that they are more evident in the female.(2) They are assuredly larger in youth than towards the close of life, for, in old age, they much diminish, and in some parts often entirely disappear. But do they enlarge much after puberty, as Hewson pretends? Our observations have not determined it.

3d. Their form depends in some measure on their size. The largest are flatter and more oblong, the smaller are rounder, the smallest are perfectly round. It is very remarkable that each system of organs is subject to the same laws as the whole series of organized bodies; since, in general, also living beings resemble them in every sense, that is to say, become rounder as their volume diminishes.

4th. Their color also varies much. Those found within the pectoral and abdominal cavities are the brightest; the subcutaneous glands have a deeper tinge; those placed at the base of the lungs and of the trachea are the darkest, and are almost black; those which are near the spleen are also deeply colored. These differences of shade seem

(1) *Exp. inquir.* p. 3 and 50.
(2) *Gen. Anat.* vol. ii. p. 113.

to depend partly on the influence of the light, and partly also on the nature of the fluids within them. Hence the dark color of the splenic and bronchial glands, the yellow color of those near the liver, and the white appearance of those of the mesentery, which are filled with chyle.

§ 120. The general conditions of the structure of the lymphatic glands are as follows. At first sight they resemble a homogeneous and almost smooth mass. But when the lymphatic vessels which enter them are filled, their surface becomes irregular. They receive a considerable quantity of blood which is generally conveyed to them by several branches which divide within them into very fine twigs. They receive branches of nerves, but these are very fine. They are not enveloped with a membrane proper and distinct from their substance ; their surface is well covered with a dense cellular tissue, but this tissue cannot be detached from their substance without destroying it. The cellular capsule does not continue insensibly with the surrounding mucous tissue, but is separated from it by well defined limits, so that these bodies are very movable in health, and do not become fixed and adherent in diseases, except when the cellular tissue which surrounds them is inflamed.

The general phenomena of the connection of the lymphatic vessels with their glands, are as follows. At some lines distant from the periphery of the gland, at the end farthest from the thoracic canal, one or several lymphatics, according to its volume, divides into branches which enter into it with the blood vessels, and these again separate into numerous small vessels ; but towards the other extremity of this gland, these ramusculi again unite in a small number of simpler trunks, which leave the gland and go forward. These last vessels may be considered as the excretory ducts of the lymphatic glands.

§ 121. Are there in the lymphatic glands any integral parts besides those already mentioned? Many anatomists, namely, Malpighi, Mylius, Cruiskshank, Werner, and Feller, admit also proper follicles, a species of hollow, rounded, white, and soft cellules, which constitute the glands in great part, and in whose parietes the blood vessels are distributed, and from whence new lymphatics arise. Some say that these cells are arranged uniformly, which is denied by others. Thus, Werner and Feller pretend that in the glands nearest the intestinal canal, there is but a single large central vesicle, from whence the vasa afferentia arise, while the glands situated farther from the intestine, and those of all the other regions of the body, contain several of these cellules. Facts in comparative anatomy also would lead us to admit the existence of cells in the lymphatic glands of man, for we find some very large, for instance, in the lymphatics of the horse and ass.

But according to other anatomists, particularly Ruysch, Albinus, Gmelin, Hugo, Haase, Meckel, Hewson, and Mascagni, the lymphatic glands are only agglomerations of blood-vessels, of lymphatics, and of mucous tissue. The cellular structure of these organs is very improbable, at least in man.

Hewson admits, besides the vascular plexuses, small cellules visible only with the aid of the microscope, from whence, he pretends, that new lymphatic vessels arise, and we see, even with the naked eye, numerous small points, from whence a fluid runs when they are compressed. But it remains to be ascertained if these be true cells, or only lymphatic vessels divided. The second supposition appears more probable, as the larger vesicles are themselves only single local dilatations of the lymphatics, which continue uninterruptedly both with the vasa efferentia and deferentia, as Mascagni has perfectly demonstrated; and secondly, a similar arrangement is observed in the venous system, for instance in the corpus cavernosum of the penis and clitoris.

The phenomena which are thought to favor the hypothesis of the cellular structure of the lymphatic glands, are rather opposed to it, or at least may be explained in another manner. It is pretended that these cellules become apparent, especially when the injection of a ganglion is suspended after it is half filled, that one series of cells only is discovered when there is only a single vas afferens and deferens, while, when the contrary is true, several of them are observed which do not communicate together, since they cannot be filled except by pushing the injection into their proper vasa afferentia; hence, consequently, the existence of cellules is indisputably demonstrated, especially in the glands of the groin, by pushing the mercury through a vessel until it comes from the opposite side, provided that the vascular network which entirely covers the glands does not hinder the process.

But these phenomena prove only, as is natural to expect, that the intimate structure of the glands becomes recognized more easily, when the external vessels are not filled with mercury. They do not demonstrate that the internal spaces are cellules rather than dilated vessels, which, of course, are filled with mercury more easily than vessels of a less caliber expanded on the surface of an organ. We should also naturally observe the curves better, in proportion as they are fewer. Besides, the want of communication between the different spaces or curves seems to indicate that they should be considered as partial dilatations of the vessels, and not as cellules.

The external appearance of the injected lymphatic glands, with which also Cruikshank supported his opinion, proves nothing in his favor, since the projections which give these bodies the appearance of a grape may be curves in the vessels as well as cellules.

Analogy drawn from the structure of animals attests only one thing, which is, that in some animals the ramifications of the lymphatics are larger than in others.

We have reason to deny, then, the existence of cellules. We should even reject the opinion of those who endeavor to reconcile the two hypotheses, by saying,

First, that the glands are simple vascular twigs in some parts of the lymphatic system, especially in the posterior medastinum and pelvis.

Secondly, that in other parts, particularly in the groin, they are composed both of vascular plexuses and of small cellules.

Finally, that in other regions they are formed entirely, or almost so, of small cellules, to which the lymphatic vessels proceed, without previously forming any plexus.

In fact it is not very probable that these organs, so similar in their other essential qualities, and which execute the same functions, should differ so considerably in a part of their structure in different places. Besides, it is probable that even where the third modification seems to exist, this appearance may depend on this, that the division of the convoluted lymphatic vessels, commences only within the glands.(1)

Some anatomists, as Malpighi(2) and Mylius, have admitted, above the cellular capsule, a muscular membrane enveloping the substance of the gland, and from the internal face of which numerous filaments proceed, which form a reticulated tissue, in the spaces of which the vesicles are placed; they add that the purpose of this arrangement is to favor the progress of the lymph. But this muscular membrane does not exist.

§ 122. The lymphatics are very extensible. This is demonstrated by the considerable variations presented in the same part in different subjects, as in the lactiferous ducts, and particularly the astonishing size to which the thoracic canal may be increased when the passage of the fluid it carries is obstructed. The total disappearance of very dilated lymphatics, when the fluid which distends them has been evacuated by an incision, and the wasting of the lymphatic glands when absorption is completed, prove that these vessels are no less contractile. This phenomenon takes place in the lymphatics, at least in a great degree, only as long as life remains. We cannot then attribute it to elasticity alone. Besides, these vessels when touched with strong acids, not only shrink up, which may be attributed, at least in some cases, to the chemical action of these bodies on animal substances, as Bichat has done, but evidently contract when touched with less powerful stimulants, as the chloride of antimony, alcohol, hot water, and even cold air. A mechanical irritation, the presence of a foreign body, the action of a cutting instrument, also cause contractions and alternate dilatation and closing.(3) The thoracic canal does not return to its original form af-

(1) Lauth, jun. (*Essai sur les vaiss. lymph.* sect. 3, p. 29.) also denies the existence of cellules within the glands. Among other proofs with which he supports his opinion, the following seem to us the most conclusive: the lymphatic glands do not exist in the fetus: instead of them we find only simple layers, where the continuity of the vessels cannot be doubted; but if this continuity be interrupted in the adult by the cellules of the glands, it would follow that these vessels, continuous in the fetus, should cease to exist when the glands are formed, which is not probable. In birds we find true lymphatic glands only at the upper part of the thorax, through which the lymphatics of the neck pass: in all the rest of the body, the glands are replaced by large layers where we observe the vessels are dilated at the points of their unions and divisions. These dilatations are evidently what have been considered as cellules in the glands, where this structure could not be as distinct as it is in birds, in which these layers are not united in a solid body. F. T.

(2) Malpighi, *De gl. conglob. str. annex. op. posth.* p. 1.—Mylius.

(3) Schreger, *De irritab. vas. lymph.* Leipsick, 1789, exp. 3, 4, 6, 7, 9.

ter death, as much as during life, when it has experienced a mechanical injury.(1)

We cannot deny then that the lymphatics are irritable, and we find no reason to attribute to them, in place of this property, a peculiar vitality which would render them susceptible of contracting.(2)

On the contrary, absorption which continues after general death, the direct relation between the rapidity and duration of this action, the selection made by the lymphatics, and their different degrees of activity, do not prove, as has been pretended,(3) that they are endowed with irritability, but only that the admission and motion of the substances which they contain, are phenomena dependent upon life, and not simply on the laws of mechanics. We need not demonstrate that Bichat is mistaken, or at least was unfortunate in his language, in saying they fulfill their functions by reason of an insensible contractility.

In the healthy state the lymphatics are not more sensible than other vessels, but become much more so when diseased, as in inflammation.

§ 123. The function of the lymphatic system is to absorb, to elaborate, to a certain degree, and to carry into the venous system, the substances presented to its radicles. The fluid it contains, then, goes from its branches towards its trunks and the heart. This is proved,

1st. By the phenomena already mentioned, (§ 115,) to demonstrate that the lymphatic system is independent of the arterial system, and that it arises directly from the substance of the organs and from their surfaces.

2d. By the swelling of the lymphatics between their periphery and the part where they are compressed or tied, and also by their contraction between this point and the heart. The fluid contained by them flows in accordance with the same law when they are wounded.

3d. By the direction and arrangement of their valves. (§ 116.)

As these conditions are the same in all parts of the lymphatic system, the function and motion of the fluid ought also to be the same in all its extent. We cannot, then, admit with some ancient(4) and even modern(5) writers, either that the lymphatic system does not conduct the lymph to the heart, but carries it in an opposite direction, or that this motion takes place in the lymphatics of the intestinal canal, in the *lacteals*, or *chyliferous vessels*, but does not occur in others, in the *lymphatics properly so called*, where the fluid moves, on the

(1) Ibid. exp. 2.
(2) Ontyd, *De causis absorptionis per vas. lymph.*, Leyden, 1795, p. 79.
(3) Schreger, *l. c.* p. 53.
(4) Bils, *Diss. quâ verus hepatis circa chylum et pariter ductus chyliferi hactenus dicti usus demonstratur.*—Cf. Haller, *De part. corp. hum. fab.* i. § v. vi.
(5) Humpage, *Phys. researches into the most important parts of the animal economy*, London, 1794.—Treviranus, (*Untersuchungen über wichtige Gegenstaende der Naturgeschichte und Medicin* 1803, p. 126, 128,) thinks that we ought to refuse to the lymphatic system the function of providing the nutritious substance designed to continue the vital action, and to attribute it to the veins alone: 1st, because it is too narrow; 2d, because nutrition takes place in aged persons when the mesenteric glands are obstructed; 3d, because this function is performed in animals destitute of lymphatics. We shall examine these arguments farther.

contrary, from the trunk to the branches, so that they immediately accomplish nutrition and absorption. It is easy to refute all the arguments adduced in support of these paradoxes.

But two problems are presented for solution. 1. Is the function attributed to the lymphatic system constant, or, does it not fulfill also the opposite function which consists in the retrogradation and excretion of the liquids within it? 2. Do they alone perform the function of absorption, or do the veins absorb?

I. Kratzenstein,(1) Humpage, and Darwin,(2) are the principal physiologists who think that the fluid contained in the lymphatics sometimes follows a retrograde motion. They found their opinion on the following facts:

1st. The valves are no obstacle, and as they enjoy life, they may either acquire the power of acting in a contrary direction by an increase of their vitality, or be paralyzed; in both cases the course of the fluids would be retrograde.

But the increase of life can only quicken the habitual motion. Besides the valves act not only by their vitality, but also by their mechanical arrangement, so that even after death they oppose the passage of a fluid from the trunk into the branches, however forcibly it may be propelled, while they permit it to flow in a contrary direction.

2d. The analogy of other vascular valves, which, in a morbid state, do not oppose the retrograde motion of the fluids and the valves of other organs also, as the pyloric and ileocœcal valves, overt he resistance of which the antiperistaltic action of the intestinal canal sometimes prevails. But these facts prove nothing: 1st, because the structure is not the same; 2dly, because the valves of which we are speaking are single.

3d. They pretend that after death the lymphatics absorb liquids in the opposite direction better than in the normal direction. But the experiments which have been made on this point prove, only, that the liquids transude sometime after death, and not that the lymphatics are channels which allow them to pass.

4th. The phenomena of the urinary secretions, after the introduction into the stomach of substances which communicate certain qualities to the urine; the changes arrive with too much rapidity for us to believe that the substances in question are carried to the kidneys by the circulation; but this proves nothing, since experiments which cannot be doubted, prove that they are in fact carried there by the circulation.

5th. The maladies which some have wished to explain by this hypothesis, as diabetes, scrofula, diarrhœa, &c., cannot be conceived according to the theory its partisans have stated, and are explicable in another manner much more satisfactorily.

II. We cannot exactly determine if the lymphatics alone absorb, or if this function be shared also by the veins. The former hypothesis, however, would seem more probable for the following reasons.

1st. The obliteration of the lymphatic system prevents the escape

(1) *Theoria fluxus diabetici more geometrico explicati*, Halle, 1746.
(2) *Zoonomia, rec. in Falleri coll. disp. pract.* vol. iv. p. 51. Hanover, 1795, vol. i. p. 2. xxix.

of the chyle or lymph, from the parts which inclose it. The ligature of the thoracic canal also causes death.

It is true that these phenomena have been used as arguments in favor of venous absorption,(1) but very wrongly, since where absorption by the veins was admitted because the lymphatics were thought to be obliterated, the latter were not *completely* destroyed; and again, when it was pretended that absorption ceased after the ligature of the veins,(2) the lymphatics were tied at the same time, and absorption took place when the latter were left unobstructed.(3)

2d. The lesion of the lymphatics produces the same phenomena, and wounds of their common trunk are fatal.

3d. The substances placed in contact with an absorbing surface serve only to modify the action of the lymphatic system and the nature of the fluid it contains.

This is proved by the fact, that at first only the lymphatic vessels and glands inflame and swell after infection.

2dly. That the characteristic properties of the substances placed in contact with an absorbing surface have been found only in the lymph, and not in the blood.

After having injected milk and colored or perfumed liquids into the intestinal canal of living animals, it is always observed that the liquid contained in the lacteals has the same color and smell; but this is not the case with the blood. If the intestinal canal be filled with a colored liquid, and another which is easily colored, as milk, be injected into the arteries, it reappears colorless, when it is returned by the veins. The same takes place when perfumed fluids are used. Although the intestine be distended with warm water, even till it bursts, the blood of the intestinal veins does not become more fluid.(4)

Mertrud pretends to have passed liquids several times from the lacteals into the azygos vein and the lumbar veins; but he mentions neither the fluids used nor the means employed.(5)

In other experiments, where water has been injected from the intestinal canal into the veins of the intestine,(6) compression has been made for a long time, and very probably it was torn, as is easily done, even when the compression is slight. We ought also much more to suspect either this cause or a transudation after death in those cases where a substance injected into the veins after death has passed into the intestinal canal, and in those where it has flowed back into the veins, either from the intestines or from other hollow organs, as the vesiculæ seminales.(7)

(1) As was done by Home, for instance. See his attempt to show that fluids proceed directly from the stomach into the circulation without passing through the thoracic duct.

(2) Lower, *De Corde*, vol. ii. p. 122.

(3) Hewson, *loc. cit.* p. 145.

(4) Hunter, *Med. comment.*, p. 42.

(5) Mertrud, *Mém. où l'on se propose de démontrer que tout le chyle n'entre pas dans le canal thoracique, &c.*, in *Mém. présent*, vol. iii. p. 155–58.

(6) Kaaw Boerhaave, *De perspirat.*, § 469–71.

(7) Meckel, *Exp. et obs. de finibus venarum.*

One is much more authorized in this, since in the experiments of Hunter, the phenomena first mentioned were found as long as animal existence continued; the second appeared only after death, and were not always constant. If water passes from the cavity of the intestinal canal into the veins, it transudes also in a much greater quantity on the surface of the intestine.(1)

We ought here to speak of the traces of the chyle which have been observed in the blood of the intestinal veins. But, admitting even that the whitish streaks which have been taken for it were really chyle, they are found also in the blood of other veins; so that they prove nothing.

4th. The lymphatic system is sufficient for absorption, as the number of its vessels is immense, and the motion of the fluid contained in them is very rapid. The narrowness of the thoracic canal proves nothing, both on account of this rapidity, and because the capacity of the duct varies very much, and more than one is always found.

5th. Even the mildest substances, as water, milk, oil, air, and mucilage, introduced into the venous system, endanger and destroy life.

6th. The other arguments by which the necessity of venous absorption is thought to be established are easily refuted. They are as follows:

a. The veins in fact absorb in some animals which have no lymphatic system. Until the time of Hewson,(2) the classes of reptiles, birds, and fishes, had been cited in support of this rule. Treviranus(3) denied the existence of lymphatics in them, even after they were demonstrated by Hewson. At present it can be asserted only of the invertebral animals;(4) but then we might say that absorption is not performed by the vessels, and that the nutritious fluid penetrates every where into the substance of the organs, since there are animals which have not a single vessel.

b. Absorption by the veins takes place also in certain parts of the bodies of animals provided with a lymphatic system. The examples cited are the placenta, the penis, and the clitoris, saying that the first has no lymphatics, and as for the other two, the blood which is effused from the vessels is in fact resumed by the veins, to be carried again into the circulation. But the absence of lymphatics in the placenta is not perfectly demonstrated; far from it: some observations made lately lead us to think their existence probable.(5) Farther,

(1) Mascagni, *loc. cit.*

(2) *Experim. inq.* London, 1774, vol. ii. ch. 4-6.

(3) *Unters. über wichtige Gegents. der Natur und Medicin*, Goettingen, 1803, p. 127. All animals below the mammalia have no entire lymphatic system.

(4) Magendie has resumed the observations of Hewson, and concludes from his own dissections that the lacteals and the thoracic canals do not exist in birds, and that the only traces of the lymphatic vessels are seen in the neck, where we find lymphatic vessels and glands, as in the mammalia, which during life are often filled with a diaphanous and colorless lymph. He is led to think that reptiles and fishes are entirely destitute of lymphatics, and that the organs described as such are sanguineous veins. See his *Mém. sur les vaisseaux lymphatiques des oiseaux*, in the *Journal de Physiol. experimentale*, 1821, vol. i. p. 47. F. T.

(5) G. Uttini, in the *Mem. dell' istituto nazionale Italiano*, vol. i. p. 11. Bologna, 1806, p. 209-16.—Michaelis, *Obs. circa placentæ ac funiculi umbilicalis vasa absorbentia*, Goettingen, 1790.

it might be possible that, as the placenta is a temporary organ, and consequently less perfect in its structure, its veins had the power of absorption, in the same manner as they every where possess it in the imperfect animals. As for the penis and clitoris, the blood in them is never extravasated, but the pretended cells of their corpus spongiosum are only dilated veins; besides, even if this were not the arrangement, the veins there would absorb only blood.

c. They pretend also that it is not possible to explain satisfactorily the great difference between the capacity of the arteries and that of the veins, unless we admit that the latter receive something besides blood. But on one part, the veins are not so much larger during life as is stated; and again, it depends, in a great part, on the obstacles to the course of the blood in these vessels, and the greater expansibility of the venous blood.

d. Finally, the alledged difference between the venous and arterial blood is that the former is less coagulable, while even that of the vena porta does not coagulate. This assertion, however, is erroneous. Besides, the chyle, to the presence of which this fluidity and want of coagulation has been attributed, coagulates itself.(1) This difference is founded on the change of venous into arterial blood.

(1) The opinion that the veins absorb may be referred even to Galen; but it was rejected by Bartholini, and also by Hunter, Hewson, and Cruikshank, and after 1795 was considered only as an historical curiosity, till 1809, when Magendie published his *Mémoire sur les organes de l'absorption chez les mammifères*, in which he related his experiments made conjointly with Dupuytren and Delisle. (*Journ. de physiol. expérim.*, vol. i. p. 18.—*Précis élément. de physiol.*, vol. ii. p. 176.) The principal results were, 1, that if all communications between the thoracic canal and the subclavian veins were tied, the animal would perish in five or six days; 2, that the ligature of the thoracic canal would not prevent or even retard the death of an animal when exposed to the influence of poison; 3, that poison applied to a part would produce its effects, although this part communicated with the rest of the body only by its artery and vein; 4, and finally, that perfumed or colored substances, when submitted to absorption, were found in a very short time in the venous blood, but not in the lymph of the thoracic canal.

Magendie concluded from these results, 1, that the veins absorb; 2, that it is doubtful if the lacteals absorb any thing but chyle; 3, that it is not certain that the other lymphatics possess the power of absorption. Ribes (*Mém. de la soc. méd. d'émulation*, 1817, vol. viii. p. 604 et seq.) also thought the veins absorb, having satisfied himself by injections that their orifices open into the cellular tissue and cavity of the intestines, and having also found in the veins different substances, as fat and pus, while these are never seen in the arteries and lymphatics. Emmert, Mayer, Nasse, Jaeckel, Tiedemann, Gmelin, Seiler, Ficinus, and several others, drew the same conclusions, either from their own experiments or from repeating those of Magendie. All these experiments, however, served only to prove absorption by the veins, and did not exclude that of the lymphatics. To determine this point, Ségalas instituted a series of experiments in an inverse order, (*Note sur l'absorption intestinale*, in the *Journal de phys. expér.*, vol. ii. p. 11,) that is, poison was submitted to the action of the lacteals only; the deleterious substance being introduced into a portion of intestine, having first tied the blood-vessels, taking care not to include the lacteals, which were seen gorged with chyle. The results were, that none of the symptoms of poisoning appeared when the fold of intestine communicated with the rest of the body only by the lacteals; but they were seen as quickly as usual, when the blood passed through the vein to the rest of the body. He concluded that the veins exclusively absorb substances other than chyle which are found in the intestinal canal. These experiments having been repeated several times, and always with the same results, many physiologists have adopted this opinion, and every day it gains new advocates. Fohmann (*Anatomische Untersuchungen über die Verbindung der Saeugadern mit den Venen*, Heidelberg, 1821) was the first to raise doubts in regard to these conclusions, by explaining the results of Magendie by communications

§ 124. In regard to the duration of its action, the lymphatic system is one of those organs which preserve their vitality the longest. Colored liquids, which are injected into the chest or abdomen, or in which an organ is immersed, penetrate into the lymphatics forty hours after death.(1)

The activity of these vessels remains longer than the irritability of the muscles,(2) and continues even after the animal heat has vanished.(3)

These experiments do not always succeed,(4) but we must be careful not to conclude from this that the phenomenon never takes place.(5)

On the contrary, the difference observed proves that it is really owing to the influence of life, and that the absorption which continues after the death of the other organs, is not a capillary phenomenon, al-

between the lymphatics and the veins, which he demonstrated to exist in the tissue of the organs and within the lymphatic glands.

Lauth, jun., (*Essai sur les vaisseaux lymphatiques*, Strasburg, 1824) pursuing the same method, confirms the existence of the channels asserted by Fohmann; and then, availing himself of his own experiments, or those made by authors before him, which prove the absorbing power of the lymphatic vessels, drawing an argument too from the impenetrability of the tissues by inorganic pores, in the physiological state, and finally considering that the sanguineous veins are necessarily continuous with the arteries, and that every venous branch which arises by an open orifice is no longer, for this reason, a sanguineous vein, concludes, 1, that the lymphatics absorb; 2, that these vessels terminate partly in the sanguineous veins, partly in the tissue of the organs, and in the lymphatic glands; 3, that there seem to be substances which are always poured into the veins by the lymphatics, in order to be eliminated from the animal economy more quickly; 4, that we have no proof that the veins absorb, and that this is even contradicted by the idea we ought to have of these vessels. See also on the subject Tiedemann and Gmelin, *Recherches sur la route que prennent diverses substances pour passer de l'estomac et du canal intestinal dans le sang*, translated from the German, Paris, 1821.—Fodera, *Recherches expérimentales sur l'absorption et l'exhalation*, Paris, 1824.—Wertrumb's Memoir on the question, *Y a-t-il ou non passage immédiat des substances appliquées au corps humain, de la surface d'application dans le système sanguin*, in the *Journ. compl. du Dict. des sciences méd.*, vol. xvi. p. 225.—*Expériences sur le pouvoir absorbant des veines*, by Seiler and Ficinus, in the same Journal, vol. xviii. p. 318, and vol. xix. p. 125.

We observe in the *Florence Anthology* that Lippi has discovered several large lymphatic trunks which empty directly into the vena cava, in the centre of the abdomen, and explains by this several of the phenomena adduced to support the opinion that the veins absorb. His memoir was read before the Medical Society at Florence, on the 6th of May; but it has not yet been published, or at least we have not seen it.* F. T.

* These experiments have since been confirmed by M. Amussat. He injected the abdominal lymphatics, when the mercury passed directly from the lymphatics into the vena cava and the common iliac veins. This communication between the lymphatic glands and the large trunks is established through the medium of certain canals.

Dr. Dubled has also injected the two inferior thirds of the thoracic duct and some of the neighboring lymphatics, by pushing an injection by the inferior vena cava. But in order to this, the vein must be forcibly distended, as was verified by the following experiment: the inferior vena cava having been tied below the diaphragm in a living animal, he found, many hours afterward, blood in the thoracic duct and in some other vessels of the same system.—*Amer. med. journal*, May, 1830, from *Archives générales*, Nov., 1829.

(1) Mascagni, *Ichnograph. vas. lact.*, pp. 21, 22.
(2) Schrœger, *De irrit. vas. lymph.*, p. 21, 22.
(3) Ontyd, i. p. 30.
(4) As has been frequently remarked by Mascagni.
(5) Walther.

though the inclined position of the parts favors it.(1) Experiments are more successful as life is less extinct; hence they never, or seldom, succeed in men, or animals, who have sunk under disease;(2) and are seen in young men better than in aged persons;(3) when the liquid too is warm, sooner than when it is cold.(4)

§ 125. These facts throw some light upon the cause of absorption; it follows, then, that it is a vital phenomenon, a consequence which is deduced still more,

1st. From the choice made by the lymphatics, if not always, at least in their normal state, between the substances presented to their action.

2d. From the fact that their activity is not always the same. Connected intimately with the degree of vital energy, their activity remains sometimes suspended during whole years in certain parts, as is seen in dropsy for instance, and reappears suddenly, often without any evident cause, or in circumstances proper to exalt the energies of life.

ARTICLE SECOND.

OF THE VASCULAR SYSTEM IN THE ABNORMAL STATE.

§ 126. In quitting the normal state of the vascular system to study the abnormal state, we must first seek the accidental origin of the anomalies.

They arise from *inflammation* supervening in the substances produced by the coagulation of the effused fluids. As all the regular or irregular formations are produced by Inflammation, or an act analogous, and as this is situated in the vascular system, it appears proper to mention here its historical character very briefly, and attending particularly to the form.

Inflammation is situated in the finest ramuscules of the sanguineous system, in the capillaries. Blood accumulates there in greater quantity than usual, and circulates sometimes with more, and sometimes with less rapidity than in the normal state.(5) The result of this accumulation, is to dilate the capillary vessels.(6) The part then becomes

(1) Schrœger, *loc. cit.* p. 47.
(2) Ontyd, *loc. cit.* p. 28, 30.
(3) Mascagni, *loc. cit.*
(4) Mascagni, p. 22. Ontyd, p. 31.
(5) For the state of the blood vessels in inflammation, see Thompson's *Lectures on Inflammation*, Edinburgh, 1813.
(6) This dilatation can remain even when the inflammation is discussed, whence the vessels are visible even on the surface of parts where before they were very minute, as, for instance, in the pterygium. F. T.

redder than usual. When this state has existed some time,(1) others supervene, called the terminations of inflammation. But we should not forget that the first termination excepted, inflammation continues, although more feebly, during the consecutive states. Sometimes inflammation disappears without leaving any traces, and then it is said to be *resolved;* sometimes a new formation supervenes. The most simple is *exsudation*, which occurs by the effusion of the colorless portion of the blood, in a greater or less degree of purity, into the substance, or on the surface of the inflamed part.(2) As the fluid effused is more or less coagulable, there results from it either a kind of dropsy only, or an *induration* of the substance of the organ, or, finally, the adhesion of parts originally separated, but adjacent, because the effused fluid solidifies, and represents more or less the mucous or serous tissue. We rarely find these last two states united. Blood vessels generally develop themselves in the effused and coagulated substance. These vessels are not necessarily prolongations of those which already exist, but, even as at the period of the first formation, the vessels appear in the homogeneous substance, and gradually unite with each other, as with those which previously existed.(3) Their structure is not so regular as that of the latter, and they are simple *channels*(4) rather than real vessels, and are not separated by peculiar membranes from the substance in which they are developed. The mucous and serous tissues, which are very similar, are especially disposed to adhesions of this nature, which prevent the motions of the parts to a greater or less extent. When this process occurs in organs which have experienced a solution of continuity, it is called union by *adhesion*, or by *the first intention.*

A second kind of new formation is that of *suppuration*. Here the texture is changed more essentially, since the inflamed part becomes in a great measure a new secretory organ, analogous to the mucous membranes, and produces a peculiar fluid called *pus*.(5) The previous

(1) Physicians have been led by scholastic views, dictated by empiricism, to divide inflammation into *acute* and *chronic*, terms connected with the vague idea of an inflammation which has continued a shorter or longer period of time. From the pretended success of stimulants in the latter state, it has been considered as opposite to that of inflammation; so that acute inflammation is allied to strength, or is a *sthenic* state, and chronic inflammation with weakness, and is an *asthenic* state. The latter has been called *atonic inflammation* by those whose language is the most contradictory. While these scholastic speculations have been infinitely varied under the influence of all sects, the part which inflammation takes in new or abnormal formations, has been most generally neglected, though sometimes recognized. At this moment it attracts general attention. No one now, at least among us, admits asthenic inflammation; but some physiologists still deny that all new formations depend on inflammation. We shall return to this subject in a note to Section XII. F. T.

(2) Hunter on the Blood, &c.

(3) See, on this subject, an important note of Th. Dowler, *Sur les produits de l'inflammation aigüe:* in the *Journ. complém. du Dict. des sciences méd.* vol. xviii. p. 188.

(4) Bordeu, *Recherches sur le tissu muqueux*, Paris, 1767, p. 28. See on this subject, the important note of Home, on the changes which take place in the blood in coagulating, in the *Phil. Trans.* 1818, p. 172–185.

(5) Brugmans, *De puogenis*, Groningen, 1785.—Home, *On the properties of pus*, London, 1788.—Pearson, *Observations and experiments on pus*, in the *Phil. Trans.* 1810, p. 294–317.

formation of this organ is, however, not indispensable to produce pus ; thus it is not observed in the mucous membranes. In general, in order that suppuration should take place, the inflammation must have attained a certain degree of intensity, and have lasted a certain length of time. But these conditions are not rigorous.

The fourth termination of inflammation is by *sphacelus* of the part which is preceded by gangrene. The first of these states is called *moist*, the second *dry gangrene*. The bright red color changes to a deep red, and soon becomes black ; the mortified part then undergoes changes, which every organized body experiences after its death.(1)

When this state occasions only the death of the inflamed part, the gangrene is arrested. There forms then on the limit of the dead and living part a reddish fissure, a furrow along which the living part appears of a bright red.

This furrow is produced by absorption, which becoming more active, endeavors to separate the dead from the living parts.

The means of restoration are more complex where suppuration and mortification occur than where resolution and adhesion only take place. There are developed on the surfaces which secrete pus, small reddish elevations, formed of mucous tissue, and of minute vessels ; these are called *granulations*. These gradually unite, contract, and finally form a cicatrix, which is smaller in all its dimensions than the diseased part, and which has more or less perfectly the structure of the organ it replaces.(2)

§ 127. Although in parts newly formed new vessels also are developed, of which some arise independently of those already existing, while others are simple prolongations of the latter, (§ 126), the old vessels do not possess the power of being entirely regenerated. When a vessel is destroyed by a ligature, or in any other manner, a new vessel is never formed in its place. Even when a wound made in a vessel heals by cicatrization, and the canal is not obliterated, this vessel always differs in hardness and indefinite texture from those which have never been injured, although Maunoir advances the contrary. What this anatomist considered as the commencement of regeneration, was merely an imperfect closure of the artery.(3)

§ 128. The four portions of which the vascular system is composed, viz. the heart, arteries, veins, and lymphatics, present a great many anomalies in their external and in their internal form. Of these many are common to all, while others belong more particularly, or even strictly, to one of them ; but those which are formed indefinitely in the four portions of the system, are more or less modified, by differences in the normal structure of each one.

(1) For the state of the blood vessels in gangrene, see Thompson's *Lectures on Inflammation*, p. 352.

(2) Moore, *On the process of nature in the healing of wounds*, London, 1789.—Home, *On the change of pus into granulations*, in the *Phil. Trans.* 1819, p. 1-11.

(3) Maunoir, *Mém. sur l'anévrysme*, Geneva, 1802, p. 108.

We may establish the following classification. The aberrations of the vascular system are divided into anomalies: 1st, of their *external form;* 2d, of their *internal form*, or *texture*, and of their *chemical composition.*

The former relate, 1st, to their situation; 2d, to their *mass* and volume; 3d, to their *figure;* and 4th, to the continuity of the system.

All these anomalies may be congenital, or produced accidentally by influences which act contrary to rule. Not being able to enter into a minute description of all the peculiarities which, to be well understood, should be referred to special anatomy, we shall confine ourselves to the following remarks.

§ 129. I. The anomalies of situation are marked in the vessels principally by an unusual character in their origin and course; in the heart, by changes in its direction.(1)

§ 130. II. Anomalies in mass and volume, consist in an excess or diminution in the vessels from the normal state. The mass and volume are not necessarily increased or diminished both at once; the anomalies in these respects are often at the same time opposite. Increase in mass and volume is more common than diminution and contraction.

Enlargement is not usually attended with change of texture in the heart, veins, and lymphatics. It is often attended in the heart with an increase of substance, while, generally, there is only a dilatation in the veins and absorbents. As to the arteries, when they are dilated, we observe not only an alteration of texture, but a partial rupture.

The history of the special alterations presented by the heart in this respect, also belong to special anatomy; but the history of those of the other portions of the vascular system may be given here.

Abnormal dilatation in the arteries is called *aneurism* (*aneurisma.*)(2) Nevertheless, by this term we mean several states of the arteries which are essentially different, viz.

1st. The total or partial dilatation of their circumference.

2d. The total or partial destruction of their continuity.

These two states are still distinguished from each other by the term *true aneurism* applied to the first, and of *false* or *mixed* aneurism to the second.

By *true* aneurism, (*aneurisma verum*), we usually understand simply a dilatation of the circumference of the arteries. Such a state is possible, and sometimes even occurs; but it is extremely rare, and seldom exists in the cases usually supposed. Although this does not take place in all circumstances, there is more frequently a slight dilatation, accompanied by a morbid alteration of the inner membrane of the artery, such as inflammation, formation of cartilage, fragility of this tunic, and afterwards, when the dilatation has progressed, the internal and fibrous membranes are ruptured, blood is effused into its cellular membrane through the fissure, which is always more or less perceptible.

(1) See our *Memoir on the primitive deformities of the heart and large vessels*, in Reil's *Archiv für die Physiologie*, vol. vi. p. 3.

(2) The principal writer on this subject is Lauth, *Collectio scriptorum latinorum de aneurismatibus*, Strasburg, 1785.—Scarpa, *On aneurism.*

The cellular membrane already, before this, intimately adhered to the inner tunic, either from its diseased state or from compression; so that, whether the rupture be sudden or gradual, no effusion of blood could occur which, by its unlimited duration, should cause death. Hence, why the artery is not uniformly distended in large aneurisms; we observe on the artery only the sac produced by the cellular tunic, which is usually united to it by a narrow neck. This sack adheres to the parts adjacent, but the pressure of the blood gradually or suddenly destroys it. When the part destroyed corresponds to a hard part, especially to a bone, and the opening every where adheres to this part, no fluid escapes from it; but when its adhesion to another organ, which is not itself protected, is torn, the blood rushes from the opening, runs slowly or rapidly into a cavity of the body, or into another organ, even to the surface of the body, and death sooner or later occurs. Such at least is the usual result of true aneurism. When the tumor is left to itself, an inflammation, accidentally developed, rarely obliterates the vessel in its diseased portion, and the circulation is very seldom re-established by the dilatation of the collateral arteries.

These remarks demonstrate that most of the aneurisms regarded as true, are in fact *mixt;* since there is, at the same time, a rupture of the internal, and a distention of the external, tunic. Simple dilatation of the arteries rarely occurs, except in organs which enlarge much: since, then, the artery participates in the increase of nutrition; still this does not always happen even in this case.

The arterial system is sometimes more or less disposed to this morbid alteration, in a greater or less portion of its extent. This is termed an *aneurismatic diathesis* (*diathesis aneurismatica*); in it we find several aneurisms in the different parts of the same body, and in the different arteries of the same part. Such a predisposition is not however necessary; and whether there be or be not fragililty of the arterial tunics, external mechanichal influences can produce this effect, although these causes are generally confined to alterations of the tissue in the arteries of those parts upon which they act.

The false aneurism (*aneurisma spurium*) does not deserve the name of aneurism, since it does not consist of a dilatation, but merely a solution of continuity in the artery. It is produced generally by an external injury, frequently by bleeding when the artery is opened instead of the vein. Hence it is found more particularly at the lower end of the brachial artery; accordingly then, from different causes, as the blood is diffused through the whole limb between the muscles and beneath the skin, or pervades only a small space, the aneurism is termed *diffused*, (*aneurisma diffusum*,) or *circumscribed*, (*aneurisma circumscriptum*.)

The *mixt aneurism* (*aneurisma mixtum*) of authors is where some of the membranes of the artery are ruptured, and others are simply distended. They admit that the external membranes may be ruptured, and the inner membranes distended, or the latter may be ruptured and the former dilated.

The latter, as we have stated, generally occurs in a true aneurism. The first is necessarily very rare, since the removal not only of the external coat, but also that of the middle membrane, occasions no dilatation in the vessel, even when the adjacent parts of the artery do not protect it.(1)

Besides these abnormal states which relate to the arteries only, the lesion of an artery may be attended with that of the veins. If then the wounds are so placed that the two vessels open into each other, there results a varicose aneurism (*aneurisma varicosum*, *varix aneurismaticus*), called also, but improperly, a *mixt aneurism*.(2)

This accident is rare and purely fortuitous in the aneurisms determined by an internal cause, which are usually considered as true aneurisms. It may be that the sac then opens into an adjacent vein, or into a vessel carrying black blood,(3) to which it adhered before, and the parietes of which it finally destroyed at the point of contact. But the accident is more common and necessarily supervenes where an external lesion produces an ordinary false aneurism, when the vein has been pierced through and through with the corresponding wall of the artery which accompanies it. The blood runs, then, from the artery into the vein and surrounding cellular tissue; but the nearness of the two vessels, the ease with which the blood passes from the artery into the vein, and the effect of compression, cause the two corresponding openings to close, as also the external wound of the vein, and an abnormal communication between the two vessels only remains.

The dilatation of the veins(4) (*varix*), and that of the lymphatics,(5) (*cirsus*) are seldom attended with a degeneration of the membranes. They depend upon a simple dilatation more frequently than the aneurism, because the veins and lymphatics are much more extensible than the arteries. They mostly arise from mechanical obstacles which oppose the free course of the fluids. Nevertheless, ruptures some times occur when the distension progresses too far.

The partial dilatations of the lymphatics, which occur between two pairs of valves, and which are attended with the obliteration of the vessels, can give place also to the formation of a kind of hydatids, which are much more rarely developed in the veins from this cause.

(1) Hunter in the *Transact. of a soc. for the improvement of med. and surg. knowledge*, vol. i. p. 144.

(2) Hunter, *History of an aneurism*, in *Med. obs. and inq.* vol. i. No. 26. p. 340.—*Farther observat. upon a partic. species of aneurism*, *ibid.* vol. ii. No. 36.—Cleghorn, *Case of an aneurismal varix*, *ibid.* vol. iii. No. 13.—White, *On the varicose aneurism*, *ibid.* vol. iv. No. 34.—Armiger, *On varicose aneurism*, *ibid.* No. 35.—Brambilla, *Von der blutader igten Schlagadergeschwulst*, in *Abh. d. Joseph Akad.* vol. i. p. 92.—Larrey, in the *Bullet. de la fac. de méd.* 1812. No. 1-3.

(3) Wells, *A case of aneurism of the aorta communicating with the pulmonary artery*, in the *Transact. of a soc. for the improvement of med. and surg. knowledge*, vol. iii. No. 7.

(4) F. A. B. Puchelt, *Das Venensystem in seinen krankhaften Verhâltnissen dargestellt*, Leipsick, 1818.

(5) Sœmmerring, *De morbis vasorum absorbentium corporis humani*, Frankfort, 1795.

Abnormal dilatation of the vessels affects, usually, but one system. Still it is not rare that it extends to all the three together. The capillaries are then always diseased. The disease appears as a red pulsating tumor which bleeds often, and is composed of a complicated tissue of vessels; it is frequently found in the subcutaneous cellular tissue, and called *aneurism by anastomosis*, *angiectasia*, or *accidental cavernous*, or *erectile tissue.*

§ 131. The opposite state, the abnormal smallness and narrowness of the vascular system, is much less common than the preceding. It is rarely general. For the most part it affects only one series of vessels; and the abnormal contraction of one, determines an unnatural enlargement of the other.

This state may be only a simple defect of formation, or depend on a morbid alteration of texture. To this is referred the contraction of the canal by an effusion of fibrous matter supervening to inflammation of the vessels. But in most cases this effusion not merely contracts the vessels, but it entirely obliterates them.

The vessels always diminish gradually, contract, and are obliterated without previous inflammation, when the blood no longer flows within them, whether this state be connected with the regular development of the organism, as for instance in the obliteration of the umbilical arteries and veins, or depends on some accidental cause.

§ 132. III. The peculiar conditions of the abnormal form of the vascular system, cannot be examined here, any more than those of its abnormal situation, and for the same reasons. Besides, the anomalies of configuration and of situation usually accompany each other, at least in the primitive deviations of formation. We shall only observe here, that most of the anomalies of configuration are congenital, and may all be referred to two classes: the first comprises those, the results of which are attended only with an irregularity in the motion of the blood, while the second embraces those which, consisting in an unusual communication between the systems of red and black blood, derange the formation of blood, and cause the disease called the ***blue disease***, (***morbus cæruleus***,) or cyanopathia, from its most prominent symptom, the abnormal discoloration of the skin.

§ 133. IV. The investigation of the changes which supervene after the wounds of the vessels, especially of the arteries, are healed, is very important. We must examine here, 1st, the total and partial solutions of continuity; 2dly, wounds from stabs and incisions; 3dly, the longitudinal and transverse wounds; finally, the phenomena produced by ligatures of the vessels.(1)

(1) Petit, *Mém. sur la manière d'arrêter les hémorrhagies*, in *Mém. de l'ac. des sc. de Paris*, 1731-1732.—Morand, *Sur les changemens qui arrivent aux artères coupées*, in *Mém. de Paris*, 1736, p. 440-450.—Ponteau, *Ven den mitteln vel che die natur anivendet Blutungen zu stillen*, &c., Dresden, 1764.—Jones, *On the process employed by nature in suppressing the hemorrhage from divided and punctured arteries*, London, 1815.—Travers, *Observations on the ligature of arteries*, in the *Medico-Chirurg. transact.*, London, 1813, vol. iv., p. 434-465.

The ordinary mode of healing in wounds of the arteries is the obliteration of the vessel by inflammation. This occurs even when there is no solution of continuity, when a ligature is merely passed around the artery, and is removed after being drawn tightly. The effect of this constriction is always to cut the two internal tunics without injuring the external; consequently it produces a wound in the first two, and changes them into a secretory surface, which immediately adheres. In some experiments made expressly, adhesion took place immediately, one hour after the application of the ligature, for the pulses were not perceptible in the side operated upon, even after the ligature was removed.(1) When we merely tie the ligature and immediately remove it, the circulation is, at first, uninterrupted; sometimes, but not always, obliteration takes place immediately,(2) which proves that it does not result from the coagulation of the blood, but from inflammation and from exudation. The artery is obliterated, not only at the part on which the ligature or compression acts directly, but its cavity is almost always effaced from this point to the first branch it gives off. In this part it becomes a fine cord, and finally entirely disappears, while the collateral branches dilate in a greater or less degree (§ 94).

This occurs necessarily when the whole extent of the vessel has been divided crosswise. But the pricks, the cuts, which implicate but a small portion of the arteries, can heal without the obliteration of the vessel, and even without the diminution of its cavity, or at least without any considerable contraction.(3) It is then possible to heal certain wounds of the arteries by cicatrization without obliteration, although(4) the latter frequently results from the method employed to form a cicatrix.(5)

The following occurs in all wounds of the vessels. Blood escapes from the wounded vessel and coagulates. If the lesion be inconsiderable, and the circulation uninterrupted, the effusion takes place only on the external surface of the artery; but the coagulated portion projects a little internally, and soon adheres on one side with the edges of the wound, and on the other with the portions of the external surface of the vessel which immediately surround it. If the vessel be entirely divided, it contracts very much, both lengthwise and across, after the effusion of blood. The blood which remains around it, and that which rests in its cavity, coagulates, whence results a transitory obliteration; but afterwards the internal membrane of the artery inflames, all the internal surface of the vessel adheres, and its cavity is completely effaced.

§ 134. The alterations of tissue in the vascular system are,

1st. *Inflammation* and its consequences, which act on all the portions of this system, and which very often, by the exudation with which

(1) Travers, *loc. cit.* p. 463.
(2) Travers, *loc. cit.* p. 442.
(3) Jones, *loc. cit.* p. 151.
(4) Lambert, *A new method of treating aneurism*, in the *London med. obs. and inquiries*, vol. ii. p. 360.
(5) Asman, *De aneurismate*, Groningen, 1773.

they are followed, determine the obliteration, even of the larger trunks, especially in the venous(1) and the lymphatic system, for they attack principally their internal membranes. Inflammation sometimes causes, particularly in the veins, a chain of abscesses, which progress along their course,(2) gradually open externally, and by cicatrizing, obliterate the vessel.

2d. *Ossification* of the vascular system is not rare. It depends undoubtedly, like other new formations, particularly that of the osseous tissue, on an increase of blood. But the state which precedes it hardly deserves the name of inflammation.

The principal phenomena in the ossification of the vascular system are:

a. Ossification always takes place in the internal membrane.

b. The newly formed osseous substance appears as scales of different breadths, which cover more or less of the vessel.

c. Very commonly the internal membrane, in this part, is either totally or partially destroyed.

d. These ossifications develop themselves almost exclusively in the system of red blood. They are very common in the arteries, especially the descending aorta below the diaphragm, in the arteries of the lower extremities, and in the left ventricle of the heart. The venous portion of the system of red blood, and all the system of black blood, on the contrary, rarely afford instances. They are not rare in the lymphatic glands, even in young subjects. In fact, these small bodies often seem to be entirely ossified; but when attentively examined, we find a greater or less portion, which has undergone no alteration.

e. They are more common in the male than in the female.

f. Ordinarily they supervene only at an advanced age (§ 86). Still we ought to consider them as a morbid state; for, although they are often met with in Europeans, there are aged persons who offer no traces of them, and they are rare in the West Indies.(3) Besides they are sometimes developed in young men, both in the pulmonary artery, and in the system of red blood.

Fragility in the arteries(4) is somewhat allied to ossification; this sometimes exists alone, but almost always accompanies the anomalous development of the osseous tissue.

Of all portions of the vascular system, the lymphatic glands are almost the only parts liable to be converted into formations entirely

(1) Bouillaud, *De l'oblitération des veines, et de son influence sur la formation des hydropisies partielles*; in the *Archives générales de médecine*, June, 1823, p. 188., May, 1824, p. 94.—Id., *Observations sur l'état des veines dans les infiltrations des membres*; in the *Journal de physiol. expériment*, vol. iii. p. 89.

(2) J. Hunter, *Observations on the inflammation of the inner coats of veins*; in the *Trans. of a soc. for impr. of med. and surg. knowl.*, London, 1793, vol. i. no. 2. —Schmuck, *Diss. de vasorum sanguiferorum inflammatione*, Heidelberg, 1793.—Sasse, *Diss. de vasorum sanguiferorum inflammatione*, Halle, 1797.—Spangenberg, *Sur l'inflammation des artères et ses terminaisons*; in Horn. *Archiv fur med. Erfahrung*, vol. v. p. 2. no. 1.

(3) Stevens, in *Medico-chirurg. transactions*, vol. v. p. 434.

(4) Malacarne, *Osserv. in chirurg.* vol. ii., Turin, 1784, art. xii. p. 160.

anomalous. These formations are sometimes *primitive*, as in scrofulous patients, where the lymphatic glands swell, and finally are partially or totally changed into a whitish albuminous substance; this is rather hard at first, but afterwards alters to a thick, grumous pus. They may grow by *infection* when a contagious principle, absorbed in a part before diseased, arrives at the lymphatic glands, which react rapidly upon it, as it is their function to assimilate foreign substances. Hence inflammation, tumefaction, and suppuration of these organs, and their changes into morbid tissues analogous to those already previously developed in other parts, with which they communicate by means of lymphatic vessels, as is observed in different kinds of ulcers, in cancers, &c.

SECTION III.

OF THE NERVOUS SYSTEM.

ARTICLE FIRST.

OF THE NERVOUS SYSTEM IN THE NORMAL STATE.

§ 135. *The nervous system* (*systema nervosum*)(1) of man, and of most animals, namely, of all those which have a vertebral column, comprises two portions: the one, more or less globular, terminates in a prolongation similar to a tail; it is inclosed in the cavity of the skull and spine. The other is composed of elongated fine rays, which ramify, and which, being attached to the former by their *central* extremities, are expanded through the whole body among the other organs, which are partly formed by their other extremity, or periphery. The first portion, called the *central* or *internal*, is composed of the *brain*, (*encephalum*),(2)

(1) Willis, *Cerebri anatome nervorumque descriptio et usus*, Geneva, 1676.—Vieussens, *Neurographia universalis*, Lyons, 1684.—J. C. Mayer, *Abhandlung vom Gehirn, Rückenmarck und dem Ursprunge der Nerven*, Berlin, 1779.—G. Prochaska, *De structura nervorum tractactus anatomicus*, Vienna, 1779.—Monro, *Observations on the structure and the functions of the nervous system*, Edinburgh, 1783.—Vicq d'Azyr, *Recherches sur la stucture du cerveau;* in the *Mémoires de l'académie des sciences de Paris*, 1781, 1783.—Pfeffinger, *Diss. de structurâ nervorum*, Strasburg, 1782, 1783.—Metzger, *Animadversiones anat. physiol. in doctrinam nervorum*, Koningsberg, 1783.—Gall et Spurzheim, *Recherches sur le système nerveux*, Paris, 1819.—Carus, *Anatomie und Physiologie des Nervensystens*, Leipsic, 1814.—Wedemeyer, *Physiologische Untersuchungen über das Nevrensystem und die Respiration*, Hanover, 1817.—Nasse, *Ueber das verhaltniss des Gehirns und Rückenmarks zur Belebung des übrigen Körpers.* Halle, 1818.—Georget, *De la physiologie du système nerveux, spécialement du cerveau; recherches sur les maladies nerveuses, etc.*, Paris, 1821.

(2) Malpighi, *De cerebro;* in the *Epist. anat. de cerebri cortice;* ibid.—Vicq d'Azyr, *Traité d'anat. et de phys.*, Paris, 1786.—J. and C. Wenzel, *De penitiori structurâ cerebri hominis et brutorum*, Tubingen, 1812.—Reil, *Fragmente über die Bildung des Gehirns*; in the *Archiv für die Physiologie*, vol. viii. ix. xi.—Rolando, *Saggio sulla vera struttura del cervello dell' uomo*, Sassari, 1809.—Rosenthal, *Ein Beytrag zur Encephalotomie*, Weimar, 1815.—Gordon, *Observations on the structure of the brain*, Edinburgh, 1817.—Burdach, *Vom Bau und Leben des Gehirns*, Leipsic, 1819-1822.—Tiedemann, *Anatomie du cerveau*, transl. by Jourdan, Paris, 1823.—Serres, *Anatomie compareé du cerveau*, Paris, 1824.

and of the *spinal marrow* (*medulla spinalis*,)(1); the other, the *external* or *peripheric*, is the *nerves*.(2)

Those nerves which arise from the brain are called the cerebral nerves, (*nervi cerebrales*,) and those coming from the spinal marrow are called the *spinal nerves* (*nervi spinales*). The whole number is forty-two pairs, twelve of which are *cerebral*, and the other thirty *spinal*; strictly speaking, however, there are only eleven pairs of cerebral and thirty-one of spinal nerves.

§ 136. It is in the nervous system especially that we discern that the body is composed of two lateral corresponding portions. In fact, all its parts are double, or when simple are placed near the median line, along which the two halves which constitute them unite, and blend in one mass. This arrangement is observed equally in the central portion, and in the periphery. At the same time the two lateral parts correspond exactly in all the nervous system, so that they vary less in situation, form, and volume, than other organs, and it is often impossible to perceive the least difference between them. This system is then symmetrical in the strictest sense of the word. The symmetry appears especially in the brain and spinal marrow, and the nerves which are immediately attached to these two organs. It is less marked in the great *sympathetic nerve*, a part of the system almost isolated from the rest. This difference deserves to be more attended to, because the symmetry of the organs corresponds exactly to that of the portion of the nervous system with which they are connected. All parts of the brain, the spinal marrow, and their nerves are not however equally symmetrical. The external is less so than the internal portion. Hence why the surface of the brain and the arrangement of the extreme ramifications of the nerves on the right and left sides differ more than the deep portions of the encephalon, and the origins of the nerves on both sides.

§ 137. The structure of the nervous system is also very constant. It is indisputably the system of organs in which we find the fewest anomalies. In this respect however the same difference exists between its parts as in the preceding; for the great sympathetic nerve presents numerous and considerable variations in every respect, while the internal parts, especially the origins of the nerves, are very constant. We have no instance of a nerve arising from any other than its usual point; unlike the vascular system, in which anomalies, even of the largest trunks, are very common.

(1) Blasius, *Medullæ spinalis anat.*, Amsterdam, 1666.—J. J. Huber, *De medullâ spinali*, Gottingen, 1739.—G. C. Frotscher, *Descriptio medullæ spinalis*, Erlangen, 1788.—G. T. Kenffel, *De medullâ spinali diss.*, Halle, 1810.—Racchetti, *Della struttura, delle funzione e delle malattie della midolla spinale.* Milan, 1816.—Ollivier, *Essai sur l'anatomie et les vices de conformation de la moelle épinière*, Paris, 1823.—Idem, *De la moelle épinière et de ses maladies*, Paris, 1823.—Rolando, *Ricerche anatomiche sulla struttura del midollo spinale*, Turin, 1824.

(2) Arnemann, *Versuch über die Regeneration an lebenden Thieren*, Gottingen, 1787, vol. i. p. ii. p. 127-308.—Reil, *Exercitationes anatomicæ de structurâ nervorum*, Halle, 1797.

§ 138. Considered either in regard to symmetry or structure, the nervous system of man is less regular than that of other animals, even those which are nearest to him. This remark has already been made by Vicq d'Azyr;(1) and the observations of Wenzel(2) prove its justice. In fact the halves of the nervous system correspond more perfectly in the mammalia, and the deviations from the normal state in these animals are rarer than in man.

§ 139. The nervous system is composed principally of semi-coagulated albumen. We find, besides, two kinds of fatty matter, a peculiar reddish-brown gelatinous substance, osmazome, phosphorus, sulphur, hydrochlorate of soda, and several phosphates.(3) The analysis of the brain of man gives the following results:

Water	80.00
Whitish fatty substance	4.53
Reddish fatty substance, called cerebrine	0.70
Albumen	7.00
Osmazome	1.12
Phosphorus	1.50
Salts and sulphur	5.15
Total,	100.00

The spinal marrow and its upper part, the medulla oblongata, have the same chemical composition; but they differ from the brain in containing more fatty matter, and more albumen, osmazome, and water.

In the nerves on the contrary, we find less fatty substance and more albumen than in the brain.(4)

§ 140. This system is mostly formed of a white and soft substance called the *medullary substance*, (*substantia medullaris.*) This substance alone probably constitutes the nerves. In the central part of the system we find an abundance of another substance called the gray or *cineritious substance*, (*substantia cinerea,*) from its color, and the *cortical* substance (*substantia corticalis,*) because it forms the external layer of the brain, where it envelopes the medullary substance. Finally, the brain contains more or less of a third substance, the *yellow substance*, (*substantia flava,*) and, besides these two, in some parts, even a fourth, the *black substance*, (*substantia nigra;*) but properly speaking, these are simple modifications of one and the same substance.

§ 141. Besides their difference in color, these substances vary from one another in many respects:

(1) *Mém. de l'Acad. des sc.*, 1783, p. 470.

(2) Wenzel, *Prodr.* et *De penit. cer. struct.*, chap. iii.

(3) Fourcroy, in the *Ann. de chimie*, vol. xvi. p. 282-322.—Vauquelin, *Analyse de la matière cérébrale de l'homme et des animaux*, in the *Ann. du Mus. d'hist. naturelle*, vol. xviii. p. 212-239.

(4) Home, *Observations on the brain and nerves*, proving that their component materials exist in the blood, in the *Philosoph. Transact.* 1821, p. 25.—Chevreul has detected cerebrine in the blood.—F. T.

1st. *In their proportional quantity.* The medullary substance exceeds the cortical substance, although in certain parts of the brain the latter is more abundant.

2d. *In structure.* Their final elements of form are in fact the same; but we remark in the medullary substance that they more evidently combine to produce secondary formations, as we shall show hereafter.

3d. *In their physical qualities.* The gray substance is softer and more fluid than the medullary substance; it also diminishes more in drying.

4th. The gray substance receives more blood vessels than the medullary substance; hence it has been considered as entirely vascular; but this is not probable, since even the most successful injections do not change it into a tissue of vessels.

5th. The gray substance differs perhaps a little from the medullary substance in chemical composition. It is said not to contain phosphorus.(?)(1)

This substance is not similar in all parts. Thus it is paler in the tubercula quadrigemina than in the thalami optici; paler too in the latter and on the surface of the brain than in the corpora striata. The yellow substance is less abundant than the gray, and the band it forms between the latter and the medullary substance, is narrower than the gray stratum. Still the gray substance forms considerable masses in different parts; for instance, in the centre of the cerebellum, in the corpus fimbriatum, and the eminentia olivaria. It is there also firmer than the medullary substance.

The black substance is found only in a few parts. There is also in some parts a bluish substance.(2)

§ 142. The structure of the nervous system is every where the same, at least in its essential characters. Its remote elements of form are globules, united by a semi-fluid substance.(3) These globules are found both in the medullary and cortical portions, in the brain, spinal marrow, and in the nerves. Opinions vary in regard to their form and size, and to the degree of consistence of the substance which unites them.

§ 143. According to Della Torre, these globules differ in volume and transparency in all parts of the nervous system; the largest being found in the cerebrum so called, the next in size are those of the cerebellum, while those of the medulla oblongata are still smaller, although larger than those of the medulla spinalis; the smallest and most opaque are found in the nerves; even in these they vary in size, diminishing continually from the origin of the nerves to their terminations. The globules of the cortical, are always larger than those of the medullary, substance.

(1) John, *Chemische Tabellen des Thierreichs*, Berlin, 1814, p. 74.

(2) Wenzel, *loc. cit.* chap. 16.

(3) Della Torre, *Nuove osservazioni microscopiche*, Naples, 1776, p. 16–21.—Prochaska, *De structurâ nervorum*, Vienna, 1779, sect. ii. c. 10.—Wenzel, *loc. cit.* chap. iv.—A. Barba, *Osservazioni microscopiche sul cervello e sulle parti adjacenti* Naples, 1807.—Home and Bauer, in the *Phil. trans.*, 1821.

Prochaska and Barba on the contrary think that the globules are of the same size in every part of the nervous system; and that the difference remarked by some depends on the difficulty of separating from each other.

Prochaska estimates their size at one eighth of those of the blood;(1) but he thinks they are not all similar in this respect, even in one and the same part.

It has not yet been ascertained whether they differ regularly at different periods of life, as has been observed in certain animals.(2)

§ 144. They are not perfectly round. Whether they are hollow or solid has not yet been determined; because, from their smallness, and from optical deception, this part of their history is ascertained with difficulty.

§ 145. According to Prochaska, these globules are united by a delicate cellular tissue. Della Torre thinks, however, that it is by a transparent viscous fluid, more tenacious in the medullary than in the cortical substance. In the different parts of the nervous system the viscidity of that which belongs to the medullary substance increases in the same ratio as the size of the globules decreases.

Barba says, however, that this difference is only imaginary, and depends on the length of time which elapses between death and the moment of observation.

§ 146. These two elements of form unite in all parts of the nervous system, giving rise to fibres, most of which are longitudinal.

§ 147. In no system is this fibrous structure more apparent than in the nerves. Almost all the nerves are formed of a greater or less number of *fasciculi*, visible to the naked eye, these are composed of smaller *cords*,(*funes*) and these again of minute *filaments* (*fila.*) The fasciculi, cords, and filaments ramify and anastomose extensively; and we cannot find a single fasciculus which extends any distance in a straight line. At the ends of the nerves these ramifications and communications are fewer than in their course. The size of the filaments and cords formed by them differs not only in different nerves, but even in the same nerve. Their diameters vary from one tenth of a line to several lines. They are thicker in the body of a nerve than at its extremities, where they separate and become smaller. All the nervous fasciculi, whether formed of large or small collections of fibres, follow the longitudinal direction of the nerve.

§ 148. The medulla of the nerve is not loose. Each filament, even the smallest, has a special sheath which closely envelopes it, and which is formed like the filament. Hence when the medullary substance is removed by an alkaline solution, the tunnels represent the form of the entire nerve, and the medullary substance exhibits the

(1) *Loc. cit.* p. 72.

(2) Carus thinks that the globules are arranged in masses in the central portions, and in regular lines in the nerves. Milne Edwards determined that the nervous substance of the encephalon, of the spinal marrow, and of the nerves, in the four classes of vertebral animals, is formed of globules of $\frac{1}{300}$ of a millimetre united in a series so as to form primitive fibres which are considerably long.—F. T.

same appearance when its tunic is removed by immersion in an acid.(1) The alkalies dissolve the pulp, which may be pressed out easily, so that having tied the nerve and filled it with mercury or air, and dried it, the canaliculated structure becomes apparent. On the contrary, the acids destroy the sheath and harden the fibres, the finest of which then become visible to the naked eye.

§ 149. The nerve then is composed of two substances, a medullary portion and the canals which inclose it. These canals are formed of mucous tissue, and are called *neurilemma*, a term derived from their relation to the medullary substance. The neurilemma envelopes the whole nerve, and generally we can suppose it furnished internally with folds which continually diminish. It receives numerous vessels which divide, at right angles, into two trunks, one straight, the other retrograde; these frequently anastomose together.

The neurilemma is very firm and difficult to tear. It appears to be the secretory organ of the medullary, with which its relations diminish at the two extremities of the nerves. Near the central termination it disappears within the nerve sooner than on the surface, so that the collection of the neurilemmatous canals forms a considerable depression towards the brain and spinal marrow.

§ 150. Besides the fibrous structure of the nerves and their formation by two substances, the pulp and neurilemma, and the irregularity of form which results from this circumstance, their external surface is banded and undulated, and hence appears uneven.(2) By the naked eye we observe on the surface of the nerve, and with a microscope, in the cords which compose it, spiral bands which are directed obliquely in zigzag. This appearance vanishes when the nerve is extended, but is again perceptible when the extension ceases. It disappears entirely in the morbid state, or at least in nerves softened or decayed, either from maceration or from the effect of alcohol. It doubtless depends on a folding which takes place when the nerve shortens, on account of its slight contractility. It is principally seated in the neurilemma, for it is not well marked in those nerves which are soft, and those furnished with a feeble sheath, as the olfactory nerve.(3)

(1) Reil, *De structura nervorum*, p. 3-17.—Osiander, *Epigr. in compl. musei anat. res.*, Gottingen, 1807, p. 51.

(2) Molinelli, *Comment.* Bonon., vol. iii. p. 280.—Fontana, *Sur la structure des nerfs*; in his *Obs. sur les poisons*, vol. ii.—Monro, *loc. cit.* chap. 12, 13.—Arnemann, *loc. cit.* p. 147-174.

(3) Prevost and Dumas have published some observations on the structure of the nerves, which we shall here mention. They state that the nerves have a satinlike appearance, which was first completely and exactly described by Fontana. It is very smooth, especially in the nerves of the cat, rabbit, guinea pig, frog, &c. When examined with a magnifier of ten or fifteen diameters only, we then see on their surfaces alternate white and dark bands, which frequently resemble the turns of a spiral spring which might be placed under the neurilemma. This appearance, like that of the tendinous tissues, depends on a slight folding of the fibres of the neurilemma, which loses its transparency in some parts, and retains it in others. Those which are opaque reflect all the light which strikes on their surface, and the others on the contrary allow it to pass in sufficient quantity to render visible the colored bodies placed under the nerves. When we attempt to draw it out, all this appearance

§ 151. All nerves are not formed exactly after the same type, and probably the modifications observed in this respect depend on differences in their mode of action. These differences relate to their inner structure and their configuration or external form.

Modifications of the inner structure may depend either on the medullary substance, or the neurilemma ; but it is probable that in most cases both are concerned. They are—

1st. Differences in solidity and hardness. Generally, the nerves which go to the heart, the large vessels, and to the abdominal viscera, the auditory, and particularly the olfactory nerves, are much softer than the others. We find scarcely a trace of the neurilemma in the olfactory nerve. On the contrary, the fasciculi of the optic nerve are, proportionally speaking, much larger than those of the other nerves. Very probably, then, this difference depends not only on the greater or less consistence of the medullary matter, but also on the arrangement of the neurilemma.

2d. Differences in color. The nerves of the heart and abdomen, and the olfactory nerves, are mostly reddish, and not white like the others. There is even a gray substance in the centre of the olfactory nerve.

3d. Differences in the arrangement of the nervous cords and filaments. Their size varies, but not in proportion to the volume of the nerves. The cords of the principal nerves of the inferior extremity, for

vanishes, and if we divide the neurilemma we find nothing resembling it. It would not then deserve notice if it did not offer a very certain mark to recognize the small nervous filaments, and render it easy to distinguish them from the blood-vessels or the lymphatics. But when we take a nerve, and, dividing its neurilemma longitudinally, draw out the pulpous matter under water, we find it composed of numerous small parallel filaments of equal size, and which seem to be contained in the whole nerve. At least we never see them unite or divide, whatever part we examine. These filaments are flat and composed of four elementary fibres, arranged in nearly the same level, whence they appear like a ribbon. They are also formed of globules, as usual, and are curious, as the two external are most apparent. The middle range is observed occasionally, doubtless, because the pressure it experiences causes the line traced by the globules of which it is composed to disappear. The number of these secondary nervous fibres is very great, as is seen by the following calculation, even when the results of experiments are not strictly regarded. Let us suppose that each nervous fibre occupies one thirtieth of a square millimetre of a section of a nerve, we have 90,000 for each square millimeter. But we know that the secondary nervous fibres include four elementary fibres. We should then find 22,500 in the same space, or about 16,000 in a cylindrical nerve of the diameter of a millimeter. See their *Mémoire sur les phenom. qui accomp. la contract. de la fib. musc.*, in the Journ. de Physiologie Experimentale, vol. iii. 1823, p. 301.—F. T.*

* In regard to the composition of the nerves, M. Raspail, from recent microscopical observations, asserts, "that if a filament from a nervous trunk be examined by the microscope, the trunk is seen to consist only of an agglutination of cylinders, the 50th part of a millimeter in diameter." Fontana has proved that these cylinders are composed of a smooth and transparent membrane, containing within "a glutinous, transparent, and elastic matter that does not dissolve in the water in which the cylinders float." Having pressed out this matter between two glasses, he caused it to return again by diminishing the pressure. M. Raspail considers each of these cylinders as a cellule which has grown only in length. It incloses a true cellular tissue, imbued with a homogeneous and fatty substance. It has no longitudinal cavity, and its growth extends itself from the encephalon to its extreme ramifications. *Am. Med. Jour.*, Nov. 1828, from the *Répertoire d'Anatomie*, &c.

instance, are always finer than those of the superior, although the nerves of the latter are larger than those of the former. The laryngœal nerve appears as one fasciculus, on which are numerous furrows, which indicate the smaller cords, and it is surrounded externally only by a tissue composed of fine filaments. In some nerves, as the median nerve and the sciatic nerve, the size of all the cords is nearly the same. In others we see the large cords alternating with those which are very small. The anastomotic structure, so apparent in most of the nerves, is not observed in the optic nerve which is composed of straight separate cords, which proceed one at the side of another ; these cords do not divide in turn into others which are smaller, so that we may consider them filaments as well as fasciculi.

In regard to figure, the nerves are generally similar in their round form ; nevertheless, the olfactory differs from all others, as its shape is triangular.

Most nerves resemble long trunks, which give off branches along their course, and gradually divide into smaller trunks. The cords and fasciculi consequently are united here. Another arrangement is seen in the nerves of the abdomen, where the fasciculi and cords are separated from each other ; so that the trunks which are formed, when compared with their branches, are not very thick. This difference must be ascribed partly to the difference in the form of the regions to which the nerves proceed, since the trunks of the extremities are the longest of all, and those of the head and trunk are much shorter ; and it must doubtless be ascribed also partly to the general law, which is, that the organisms and organs of an inferior character are, as a whole, less centralized than the organs and organisms of a superior character.

§ 152. The large or small collections of fibres of which the nerves are composed, do not remain united ; but the nerves ramify in their course, as their fibrous fasciculi separate. The trunks divide into branches, and these into twigs, &c. The branches are generally given off at acute angles. But the cords and filaments which unite to form a secondary division, are always separated within the trunks much higher than they seem to be when we examine their surfaces only. In this arrangement the nervous and vascular systems differ greatly. It is not strictly correct to say, that the structure of the nerves differs from the arrangement of the vessels, because the cords and filaments which constitute a trunk or a branch of a nerve partially retrograde, as there is something analogous in the arrangement of the branches and ramuscules of the vessels. But the nerves differ from the vessels because their trunks sometimes run a long space without dividing, while the vessels ramify every where and at short intervals, except in a few instances, as the spermatic vessels, which in fact prove nothing, since this arrangement exists because, at a certain period of life, the vessel is inclosed in a small space.

§ 153. The fibrous and anastomotic structure is seen not only within the nerves, but is apparent also at their origin and in their course. Many nerves anastomose differently together.

There are three kinds of anastomosis: 1st, anastomosis, properly so called, or union in a web, (*ansa*); 2d, the plexus; and 3dly, the ganglion.

Anastomosis is formed by isolated branches of different nerves, which have nearly the same size. In this manner, for instance, the ulnar and the median nerves unite in the hand; the spinal nerves, shortly after, leaving the vertebral canal, the different branches of the fifth pair, the branches of this nerve, with the facial and cervical nerves. In this manner also the *ansæ* are formed around the vessel. Anastomosis occurs:

1st. Between the different branches of the same nerve, as is seen in the fifth pair, those of the facial, laryngœal, and intercostal nerves.

2d. Between two branches of different nerves, situated, however on the same side, as between two spinal nerves, or between the branches of the spinal and the intercostal nerves.

3d. Between two branches of synonymous nerves on each side, as the superficial nerves of the fifth and seventh pairs, and the nerves of the neck.

§ 154. The plexus(1) is, properly speaking, only an anastomosis between the different cords of the same or of different nerves. The cords divide into very minute branches, and the filaments which come from this division give rise to very numerous anastomoses between different nerves; so that the new nerves, which come from the plexus, are formed of filaments derived from many different trunks. The pneumogastric nerve, before it enters the lungs, is an instance of a plexus formed by different cords, coming from the same nerve. The plexuses formed from different nerves occur in the nerves of the upper and lower extremities particularly.

One cannot admit the difference between the plexus and anastomosis, mentioned by Bichat, when comparing the communication between the filaments of the facial nerve, and of the fifth pair with that between the spinal nerves, by saying, that in the former there is an intimate mixture, a perfect fusion or identity, while there is only a simple propinquity, a simple juxtaposition in the second; for there is as much fusion and mixture in both; but in the latter, the branches which unite are smaller and more numerous.

§ 155. The structure of the ganglions is more complicated than that of the plexus, and their destination is probably different. Their existence seems to be more independent than the plexuses; they appear to be distinct bodies, much larger than the nerves with which they are united, while the plexuses are simple communications which intimately connect adjacent nerves, but do not increase their substance.

The ganglions(2) have no general and regular form; in different persons they vary exceedingly in size, form, attachment, and even in

(1) Scarpa, *De nervorum gangliis et plexubus*, 1779.

(2) Haase, *De gangliis nervorum*, Leipsic, 1772.—Kwiatowsky, *Theses anat. phys. de nervorum decussatione et gangliis*, Konigsberg, 1784.—Weber, *De systemate nerveo organico*, Leipsic, 1817.—Wutzer, *De corporis humani gangliorum fabricâ atque usu*, Berlin, 1817.

existence, since large ganglions are sometimes entirely deficient. Most of them, however, are rounded, a little flattened, smooth on the surface, situated very deeply, and surrounded with an abundance of cellular tissue. They are somewhat hard, and of ordinary color. When we open them, we see they are homogeneous masses, having no determinate structure. In all their qualities they singularly resemble the lymphatic glands. The substance of which they are composed is always closely surrounded with a peculiar thin membrane formed of mucous tissue, and very abundant in vessels, over which there is either a loose cellular tissue, or a fibrous capsule, a continuation of the dura mater spinalis. Nerves arise from the ganglions.

When the nervous ganglions are macerated, they can be resolved into two substances, viz. into convoluted filaments, which are continuous with the nerves attached to the ganglions, and a grayish red, gelatinous, saltis mass, which fills the spaces between the filaments, and also envelopes them. According to Scarpa(1) the latter substance is oily, and even pure fat in gross people. Bichat(2) was mistaken in saying that fat is never formed in the ganglions.

The substance of the nervous ganglions is very vascular.

§ 156. The ganglions may be divided into *simple* and *compound*. The former are developments of the filaments of one nerve only, and communicate with no other. The compound, on the contrary, are the central and connecting points of several nerves. They differ too from each other in more than one respect.

§ 157. The form and situations of the *simple ganglions* are constant. They are never deficient, and are found near the origins of the spinal nerves, and belong to their posterior roots. Their envelope and substance is firmer than those of the compound ganglions. Their external capsule continues with the dura mater spinalis, and the internal with the spinal portion of the pia mater. Although the filaments of these ganglions ramify, and anastomose very extensively, yet they have all the same longitudinal direction. Nerves arise from them only in the two opposite points, viz. from the inside arises that portion of the posterior root of the nerve which is between the ganglion and the spinal marrow, and from the outside, the external nerve, which soon connects itself with the anterior root. (§ 170.)

§158. The *compound ganglions* exist in every part of the body, but are found principally in the thoracic and abdominal cavities, more particularly in the latter. They are softer than the simple ganglions; their external envelope is formed by the surrounding cellular tissue. They vary in form, situation, and number. Their constituent fibres do not extend from one extremity to the other, but proceed in all directions. Finally, nerves emerge not only from their two extremities, but from various points of their surface. The filaments never come from the points where other nerves enter; hence these same filaments are never intercepted at very acute angles.

(1) *Loc. cit.* p. 16.
(2) *General Anatomy*, vol. i. p. 259.

§ 159. The fibrous structure and the intercrossing of the nerves are also found in the brain and spinal marrow; but here they are less evident than in the nerves. At first, the brain and spinal marrow seem formed only of a soft, pulpy, and homogeneous mass; but the fibrous structure should not be denied on account of this appearance, as has been done by several anatomists.(1)

We have no need of mechanical or chemical agents to observe in many places distinct fibres, especially in those brains which are firmer than usual. Thus they are seen in the corpora pyramidalia of the medulla oblongata, the crura cerebri, the corpora striata, the corpus callosum, the tuber annulare, the commissures generally, and in the fornix. We have even distinguished them on cutting into the mass of the hemispheres. But those who admit their existence in several parts of the encephalon, say it is not certain that the structure of the whole organ is fibrous, or at least they allow it only in certain cases.(2)

Others, who admit the existence of these fibres after death, regard them as produced by the coagulation of the cerebral substance, which they consider pulpous during life;(3) consequently these two opinions are similar. Malpighi was the first to demonstrate the fibrous structure of the brain, and to describe in what manner its fibres come from the spinal marrow. But the principal writers on this part of anatomy are Gall and Reil; the latter, especially, has rendered a very important service to science in making known the structure of the spinal marrow,(4) which, before his time, had been regarded as a shapeless, pulpy mass, even by those who admitted the fibrous structure of the brain.

Those who admit the fibrous structure of the brain, differ in opinion whether this structure be peculiar to the medullary substance, or whether the cortical substance also be fibrous.

Those who admit fibres in the medullary substance, deny that they exist in the cortical; as Malpighi, Haller, and Sœmmerring. The cortical substance, however, is truly fibrous. In dissecting some very firm brains, we have often observed, not only the phenomenon remarked by Stenson(5) and Vicq d'Azyr,(6) viz. that the delicate fibres of the medullary substance may be followed into the cortical portion, but also that the latter is evidently fibrous in its structure.

The fibrous structure of the brain is demonstrated by another circumstance; that the fibres are always arranged in the same manner, however various are the means used to demonstrate them.

§ 160. The spinal marrow makes the transition from the nerves to the brain, since it is, like the latter, inclosed in a bony case, enveloped by the same membranes, communicates directly with it, and

(1) See Bichat, *Anat. descrip.* vol. iii. p. 96., where he goes so far as to ascribe the transverse fibres of the corpus callosum to a slight laceration by the knife.
(2) Haller, *De part.* vol. iii. p. 48.—Sœmmerring, *Nervenlehre*, p. 29.
(3) Ackermann, *Ueber die Gall'sche Schädellehre*, § 6.
(4) *De cerebro*, Amsterdam, 1669, p. 8–10.
(5) *Disc. sur l'anat. du cerveau*, Paris, 1669.
(6) *Mém. de l'ac. des sc.* 1781. p. 511.

at first view has a soft and pulpy appearance ; but in texture it resembles the nerves. It is closely surrounded with a membrane formed of mucous tissue and of vessels, which resembles the neurilemma, but is called the *pia mater*, on account of its intimate union with it, or the *vascular* membrane, from its numerous vessels. A simple prolongation is detached from the centre of the internal face of the anterior part of this membrane, which goes inward and backward, and penetrates to the centre of the spinal marrow. Numerous small channels arise from each side of this prolongation, which pass through the whole spinal marrow, anastomose frequently together, and are visible, especially when the medullary substance has been destroyed by an alkaline solution. This structure is also seen when the spinal marrow is hardened by immersion in an acid, for it is then divided into numerous longitudinal layers, formed in their turn of very fine cords. Sometimes it is observed in the spinal marrow in its natural state, when its two portions are gently separated; and it may be distinguished also on the surface of this organ if it be naturally firm, and its pia mater be removed. The channels are smaller in the gray than in the medullary substance, and are limited suddenly by it.

The internal structure of the spinal marrow is then more analogous to the nerves, although it is softer and its fibres are less apparent.(1)

§ 161. The spinal marrow is composed of two lateral parts, which are separted from each other before, by the prolongation of the pia mater above mentioned. Towards the upper part of this organ, near where it enters the skull, its cords divide into several fasciculi, which cross obliquely, so that those from the right side pass to the left, and vice versâ. At the same time, these are enlarged by the addition of several masses of gray substance. On the sides are detached the crura cerebelli, or corpora restiformia, which develope and give rise to the cerebellum. Before and above are perceived the *pyramidal bodies*, (*corpora pyramidalia*,) two oblong eminences placed near each other, on the under face of the upper extremity of the spinal marrow. These pass over a large projection formed of transverse fibres of cortical and medullary substance called the pons varolii, or *annular protuberance*, (*nodus cerebri*,) and penetrate the inferior face of the brain, where their fibrous structure becomes apparent by the separation of their medullary substance, in the interstices of which the gray substance extends. Being now much enlarged and divergent, they pass before the pons varolii, and produce the peduncles of the brain, (*crura cerebri*.) These pass below and across the two masses of gray substance, situated one at the side of the other, called the *thalami optici*, and before which are formed the *corpora striata;* after this, their fibres, becoming very apparent, unfold in all directions in the cerebral hemispheres, of which they form the principal part, and extend circularly ; this radiation of fibres from the gray substance is called, by Reil, the corona radiata (*stabkranzes*).(2)

(1) Sœmmerring, *Nervenlehre*, p. 62-63.
(2) Reil, *Archiv.*, &c. vol. ix. P. 1. p. 159.

§ 162. The two lateral portions of the spinal marrow and of the encephalon are not only placed close to each other, but are attached by medullary fibres, and gray substance. The places where they are connected may be termed by the general name of *commissures.* These commissures are every where narrower than the parts which they unite. If examined attentively, they can be traced in each part much farther than one would suppose at first view. As the fibres described in the preceding paragraph are longitudinal, while those of the commissures are, on the contrary, oblique, Gall(1) considers them as forming a peculiar fibrous apparatus, and admits both in the cerebrum and in the cerebellum, an order of *diverging*, and *one* of *converging fibres.* These two orders have been more physiologically termed the first, the *apparatus of formation*, the second, *the apparatus of union.* They are also named from the parts they concur to form; the first, *the system of the cerebral peduncles*; the other, *the system of the corpus callosum.* The fibres of these apparatuses differ, not only in their direction, but in their origin, position, and consistence. In fact, while the diverging fibres terminate at the external surface of the encephalon in the gray substance, the recurrent fibres arise from the gray substance and proceed on the median line, where they unite by commissures of greater or less extent. We cannot consider these unions themselves as origins of the recurrent fibres; for it is a general law, that the medullary substance arises from the gray substance, and the commissures extend some distance beyond the two cerebral hemispheres. The fibres of this system are placed between those of the diverging system, and consequently much more internally. They are much softer and finer than the latter. They form distinct layers, which envelope the cerebral ventricles. In admitting this second system which arises from the gray substance deposited on the surface of the encephalon, we explain how the two parts of the organ inclose more of the nervous mass than the corpora striata, so that they appear only as an appendage or appurtenance of these parts.

We cannot determine with precision how the two systems unite. Even Gall admits that we cannot ascertain whether the fibres of the diverging mass are reflected in the gray substance, and change their direction, and thus produce a new recurrent nervous system, or if the latter be really a separate body, which does not arise from the former. Reil, who does not appear to admit a single system of commissures connected in all parts, since he describes the structure of the corpus callosum separately from that of the anterior commissure of the brain, and no where informs us that their expansions are connected, Reil, we say, thinks the two systems are not in every part united in the same manner. He only states generally in regard to the union of the radiating fibres of the anterior commissure with those of the cerebral peduncles, that they form a whole, but he believes the modes of union be-

(1) Gall, *On the anatomy of the nervous system*, Paris, 1809.—Ibid. *On the anatomy and physiology of the nervous system*, Paris, 1810.

tween the radiations of the corpus callosum and that of the cerebral peduncles are numerous. In fact, we find between them and forward, a medullary substance less evidently fibrous, which unites them. Farther back, the two systems anastomose; and still farther, their fibres reciprocally penetrate each other, and intercross several times, forming a delicate suture; finally, the most posterior part of the corpus callosum passes above the system of the cerebral peduncles without uniting to it, and gives origin to two separate masses, which may be entirely detached from each other.(1)

§ 163. The structure of the brain differs from that of the nerves principally in two respects: 1st, its constituent fibres mostly form layers; 2d, we find no neurilemma within it. Its fibres are loose and the surface of the brain is covered only with a capsule analogous to the neurilemma, which, as in the spinal marrow, is called the *pia mater*. The neurilemmatic tubes do not exist, even in those parts which, from their form, are usually considered as nerves; as that part of the optic nerve situated behind the place of crossing, and the olfactory nerves. Thus they consider the olfactory nerves as making a part of the brain itself, and very properly regard their branches alone as constituting so many distinct olfactory nerves. Besides the absence of neurilemma, the form of the nerve, its gray mass and the swelling of its round extremity, which resembles a ganglion, are so many circumstances in favor of this opinion. The same remarks apply to the inner part of the optic nerve, which would then arise only at the place of crossing.

The arrangement of the pia mater, however, and its relations to the cerebral substance also establish an analogy between it and the neurilemma. On one hand, the external surface of the brain is folded, at least partially, in certain animals; and every where in man, and in most mammalia, has circumvolutions (*gyri*) and furrows (*sulci*) situated between them, by which the pia mater penetrates to the internal surface of the brain, into the ventricles, where the *choroid processes*, (*processus choroidei*) form, and numerous vessels enter, especially in certain uniform places, into the internal part, and may there be recognized on examination, not only by red points in consequence of the blood which flows out when they are cut, but may even for a short distance be drawn out freely from the soft parts. On the other hand, several parts of the brain resemble the nerves, both externally and internally: such as, for instance, the anterior commissure which is surrounded by a cellular sheath furnished by the pia mater of the ventricles; this sheath accompanies it in its course across the thalami optici and is changed, like the neurilemma, into a delicate cellular tissue, and disappears only at that part where the extremities of the commissure expand into a radiated tissue.(2) Perhaps, then, the struc-

(1) The recurrent fibres of the brain are not admitted by Tiedemann, who considers the cerebral commissures and the corpus callosum merely as prolongations of the cerebral peduncles. (See his *Anatomy of the Brain*, p. 266.)
(2) Reil, *Archiv.* vol. xi. P. i. p. 91.

ture of the brain is every where the same as that of the nerves, but the softness and fineness of the mucous tissue prevents its demonstration.

§ 164. From the above remarks it follows, that the brain and spinal marrow are formed of fibrous fasciculi differently intermixed; that these fasciculi are perceived more easily in the medullary than in the gray substance, and that their connections are more or less evident. It follows, then, *that the nervous mass contained in the skull and vertebral canal is formed, essentially, after the same type as that formed in the rest of the body, and that the principal difference between the two masses is, that the first is accumulated in one part, while the second is more diffused.*

§ 165. *The gray substance does not form, like the medullary substance, a continuous system.* According to several anatomists(1) the neurilemma supplies the nerves with a gray substance, because these are not so white as the cerebral substance, and become more voluminous as they leave their centre. But these two circumstances are not sufficient to establish the opinion in favor of which they are adduced, although this opinion is probable to a certain extent, as it increases the analogy between the brain and nerves. That it should be more than probable, it is requisite that the pia mater should no where possess the direct power of producing the medullary substance, but it really does possess it in several points of the encephalon, and in all the spinal marrow. So little does the gray substance represent in the brain a connected whole. The gray substance, it is true, forms an uninterrupted layer over the whole surface of the cerebral organ, but it does not communicate with the nerves of the same substance within this viscus, nor can we demonstrate an uninterrupted communication between these latter.(2) Some anatomists admit, also, a sort of communication dependent, 1st, on the vessels, as the cortical substance is entirely vascular; 2d, on the communication between the internal portions of the thalami optici with the corpora striata, the tubercula quadrigemina with the other parts of the encephalon, and the medulla oblongata with the pons varolii :(3) but the truth is, that a layer of medullary substance exists every where between the gray substance of the thalami optici and that of the corpus striatum,(4) and that the gray substance of the pons varolii and of the olivary bodies does not communicate with the distant masses of this same substance.(5)

The gray substance diffused in the body by the ganglions, is likewise insulated. The mass of this substance within the brain, and generally in all the central parts evidently corresponds to that which ex-

(1) Battie, *Exerc. de princ. anim.*, p. 156.
(2) Munro, *On the nervous system*, chap. 10, § 25.
(3) Ludwig, *De cinereâ cerebri substantiâ*, Leipsic, 1778, p. 11, § 2.
(4) Wenzel, *loc. cit.* chap. 6.
(5) Vicq-d'Azyr, *loc. cit.*, an. 1781, p. 507.

ists in the ganglions.(1) When man is fully developed, the quantity of the medullary substance is much greater than that of the cortical.

§ 166. The inner ends of the nerves communicate with the central parts of the nervous system. The fasciculi which form them, there separate more or less distinctly, proceed without communicating together, and enter the cerebral substance; but we cannot distinctly perceive where the fibres of the two unite.

Two questions arise as respects the origins of the nerves. With what substance of the central part are they connected? Do the origins of the synonymous nerves communicate, or do they arise from sides opposite to where they are distributed, so as to intercross?

§ 167. In regard to the first point, the most general opinion is, that the nerves arise from the medullary substance; that they radiate from it and are prolongations of it.(2) It has even been conjectured that in the spinal marrow this substance is placed externally, so that the nerves which come from it pass over less space, and are not obliged to penetrate through the gray substance.(3) Nevertheless, when closely examined, all the nerves are seen to communicate more or less evidently with the gray substance. Vicq d'Azyr had ascertained this fact, as he says that the gray substance is generally accumulated near the origins of the nerves.(4) Gall has added his testimony in favor of it, and we are satisfied from our observations that he is perfectly correct.

This fact is incontrovertible in regard to insects, worms, and fishes, where the nerves arise by several roots from the mass of gray substance. It is evident, also, in some nerves of the superior animals, and of man, for instance, in the olfactory and optic nerves. It is more difficult to prove it in regard to the other nerves, which, at first view, seem connected only with the medullary substance; but we must carefully distinguish the place where the nerve detaches itself from the central mass, from that where it arises.(5) Although in the first of those two points, which is external to the central part, most of the nerves communicate with the medullary substance only, and several, as almost all of the cerebral nerves are so feebly attached to it, that they may be easily separated from it, whence we might infer they arise from it; we can, however, follow them farther, and at a certain depth, sometimes their bundles unite in a cord which communicates with the gray substances, as takes place for instance, in the fifth pair; sometimes their filaments come from this same substance separately, as is the case with all the spinal nerves.

(1) This is intended for Haller, who says expressly: *In homine et quadrupedibus, quæ mihi innotuerunt, in nervis ipsis ejusmodi noduli unice reperiuntur, neque in cerebro unquam aut in spinali medullâ.* (*De part. corp. hum. fab.* vol. viii. p. 322.)

(2) Haller, *De part.*, vol. viii. p. 319. *Principium nervorum communi sensu in medullâ est encephali et spinalis medullæ.*

(3) Martin, *De nervis corp. num.*, Halle, 1781, p. 27.

(4) *Loc. cit.*, p. 508.

(5) By origins of the nerves, we commonly understand that portion between the place where they arise from the central mass and that where they emerge from the skull. But this term is too inconvenient to be long retained.

Although in man and the superior animals, all the parts of the spinal marrow, from whence nerves arise, are not enlarged by the accumulation of the gray substance, as Gall pretends, yet we cannot deny but that this substance exists in greater quantity at the origins of the large nerves. Hence its greater volume at the origin of the nerves which go to the extremities.

§ 168. But although we should seek the origin of the nerves beyond the surface of the central mass, we have no right to believe it deeper than we can trace it, and to consider all the nerves as arising from a single point of small extent; an opinion maintained by those who are disposed to consider the *medulla oblongata* as this common origin.

§ 169. Do the nerves arise from the same side of the body as that to which they are distributed? Do the synonymous nerves unite or cross each other? or do we find both union and crossing? All these problems have been resolved, sometimes negatively and sometimes affirmatively. Throwing out of view the fact that all observations have not been made with the same exactness, the difference of opinion in this respect depends on this, that the arrangement of the parts is not the same in all animals. The interlacing of the nervous fibres has been supposed, from the paralysis of one side of the body, when the opposite side has been injured.(1) But we learn from dissections, both in the normal and abnormal states, that these observations and experiments demonstrate only the crossing of the spinal marrow at the point mentioned above, (§ 161,) and do not prove that all the nerves arise from the half of the brain or spinal marrow opposite to that side of the body in which they are distributed. Although we have often followed the spinal nerves into the gray substance, we have never observed a single filament passing to the side opposite. Injuries of the central portion are not followed by a paralysis of the opposite side of the body, when they affect a part above that where the intercrossing, of which we have spoken, takes place. This paralysis of the opposite side occurs when the medulla oblongata is injured,(2) but not when the parts below are affected; for then it supervenes on the same side as that where the section of one half of the spinal marrow has been made. Galen was acquainted with this difference in the consequences of the injuries of the brain and spinal marrow.(3) Even when one half of the spinal marrow is cut near its upper part, paralysis takes place only on the corresponding side, as is proved by recent experiments.(4)

(1) Hippocrates, *Epid.*, Book vii. § 1.—Valsalva, in Morgagni, *Ep.* vol. xii. p. 14.—Prochaska, *Obs. path.* in *Opp.*, Vienna, 1800, vol. ii. p. 298–320.

(2) Yelloly, *A case of tumor in the brain, with remarks on the propagation of nervous influence;* in the *Med. chirurg. trans.* vol. i. xvi. p. 181–222. A tumor as large as a nut on the left side of the pons varolii and of the left pyramid, produced a paralysis of the right side.

(3) *De anat. administr.* vol. viii. p. 5, 6.

(4) Yelloly, *loc. cit.*, p. 197.

No interlacing, either in the brain or spinal marrow, can be demonstrated, except that which exists in the place indicated above. Observations and experiments, from which it has been concluded that fibres cross each other principally in the corpora striata(1) prove nothing. Besides the proposition contradicts itself, since the corpora striata are not connected with each other; nor does the anterior commissure, which passes through them, communicate either with their proper substance, or with the fibres which enter them. From these observations we can only observe, that the fibres cross below the corpora striata, as we have proved above.

Still a partial communication takes place between some of the nerves, as their external filaments arise from one side, and their internal from the side opposite. This arrangement however has been observed only in *the optic nerve.*

Nor can we demonstrate that the origins of all the nerves unite on the median line, although this union is sometimes observed between the corresponding nerves of the fourth pair, and the auditory nerves. Probably this is not rare, especially in the spinal nerves.

§ 170. The origins of all the nerves are similar in one respect, that the fasciculi which form them separate from each other in those places (§ 147). But the spinal and cerebral nerves differ constantly from each other in their mode of origin from the central mass.

In fact the cerebral nerves arise by a single root, while the spinal nerves have two, a posterior and an anterior, corresponding to the anterior and posterior faces of the spinal marrow. Nevertheless, we see that the nerves of the brain (commencing at the fifth cerebral nerve) resemble those of the spinal marrow by the division of their fasciculi into two parts. The posterior roots are always larger than the anterior, and usually arise nearer the centre of the spinal marrow; but their fasciculi are fewer and less evidently fibrous, single, and do not ramify, while the anterior come from the medulla by numerous ramifications. The two series of the anterior and posterior roots are separated by a prolongation of the tunica arachnoidea, called *the ligamentum denticulatum*, which goes from the lateral face of the medulla to the corresponding part of the internal face of the dura mater.

The fasciculi of each nervous root are also remote from each other until they leave the dura mater spinalis, and are connected only by a looser mucous tissue. But arrived at the dura mater, they reunite, and each root emerges by a single foramen, formed by this membrane. The foramina of the anterior and posterior roots are near each other, but always separate, and the roots unite in a single nerve only after traversing the dura mater.

On the contrary, the fasciculi which form the cerebral nerves come from the dura mater by a single opening, although at the moment they

(1) L. Caldani, *Esperienze ed. osservaz. dirette a determinare qual sia il luogo principale del cervello, in cui, più di altrove le fibre medollari dello stesso viscera si incrocicchiano;* in *Mem. di Padova*, vol. i. p. 1-16.

arrive at it they are not intimately united, as is seen particularly in the posterior nerves.

The direction of the origins of all the nerves is not the same. The cerebral and spinal nerves are totally different in this respect. The nerves of the encephalon are all directed forward, those of the spinal marrow downward, except the first two, the superior fasciculi of which descend, while the inferior ascend.

The cerebral nerves generally proceed much more directly forward, and the spinal form acute angles at the base, which are more acute as the first arise farther forward, and the second farther behind. The middle pairs, the posterior nerves of the encephalon, and the upper spinal nerves, have a more oblique direction.

We also find, that the filaments of several pairs of nerves communicate within the dura mater, as is seen especially in the upper spinal nerves, and also between the fourth and fifth pairs of the cerebral nerves.

The posterior root of each spinal nerve, shortly after passing through the dura mater, becomes a simple, oblong, rounded ganglion, (§ 157,) with which the anterior root does not communicate,(1) although, as Gall very justly remarks, we sometimes see, especially in the neck, the anterior roots forming thick reddish plexuses, which may be considered as ganglionary bodies.

In many cerebral nerves, either in their passage across the dura mater, or at some distance from this point, we see analogous bodies, which are formed however by all the nervous fasciculi.

§ 171. The nerves gradually enlarge in their course. In fact they always ramify; and the trunks which arise from the encephalon and spinal marrow divide into branches, twigs, and filaments. These are given off almost always at acute angles, and rarely at right or obtuse angles. But if we imagine all the branches reunited, we shall have a cone, the summit of which corresponds to the origin of the nerve, and the base to its periphery. This is a general law. The nerves which do not give off branches in their course, as the optic nerves, the auditory, and also the olfactory nerve, (if the portion of the nervous system generally so called, be a real nerve,) are not every where equal in size, but sometimes even become thicker, as is seen in the last two especially.

(1) Scarpa is generally regarded as having discovered that the ganglions of the spinal nerves are formed only by their posterior root. The honor of this discovery is however ascribed to Monroe by Nicolai (*De medullâ spin. av.* Hal. 1811, p. 28); but wrongly, since Prochaska states, in his treatise on the nerves, (1778, p. 139,) "*Funiculi posterioris principii (nervorum spinalium) soli in ganglium spinale intumescunt; anterioris vero principii funiculi ganglio illi ope cellulosæ adhærentes solummodo et prætereundo cum posterioribus ex ganglio egressis primo conjunguntur,*" &c. Scarpa's work appeared in 1779, the original of Monroe's in 1783; but Haase (*De gangliis nervor.* Leips. 1772, p. 87) says: "*Sed hæc, (radix nervorum spinalium anteriori,) non tota in ganglion inserebatur, sed paucis tantum succulis in ganglion immisis, major hujus radicis pars ganglion quasi præteribat, ut nonnisi contextu celluloso ganglio leviter agglutinata per foramen vertebrale.*" Thus the honor of this discovery belongs to a German.

The three branches of the fifth pair are evidently larger than its trunk, &c. Some branches also are arranged in the same manner, as the nerves of the lips and the cord of the tympanum. This law, however, does not depend on the large size of the nerves of some organs, as among others of those of the muscles of the eye, for this size depends upon the circumstance, that the nerves of which it treats are very large, proportionally, at their origin.

The central mass also enlarges from the inferior extremity of the spinal marrow to its termination in the skull, where it produces the encephalon.

§ 172. The relations of situation between the nerves and vessels are not every where the same. Some nerves accompany the arteries and veins, and this is most usually the case; we see it in the crural nerve, in the median nerve, those of the forearm and leg, the intercostal nerve, and those of the abdominal viscera. Others accompany the veins only, as the large cutaneous nerves of the extremities. Many proceed alone, at least for some distance, as the ischiatic, the radial, the ulnar, and the laryngeal nerves. These differences depend on those in the modes and places of origin of the nerves and vessels; for 1st, the nerves arise more detached from each other, and more directly from the spinal marrow and the encephalon than do the vessels from the aorta and the vena cava; 2d, the central parts of both systems are distant from each other, so that the principal rays must pass through a certain space before meeting. Hence why the secondary branches of the nerves usually accompany the vessels, and why the branches of the nerves and vessels enter the organs at the same point, while their principal trunks are separated.

§ 173. The terminations of the nerves are not every where the same. The optic nerve differs from all others, as it does not ramify; when it reaches the eye it forms a homogeneous expansion, called the retina. Some assert that the structure of the retina is fibrous,(1) but the observations on which this opinion is founded are not conclusive.

On the contrary we cannot deny that the fibres of the auditory nerve interlace like a plexus, and terminate in a thin expansion. Generally, we cannot discern the terminations of those nerves which penetrate to the interior of the organs, and do not form like the preceding, a particular layer, but seem rather blended with their substance. Nevertheless, the final branches certainly become very soft, and consequently, seem wholly or partially deprived of their envelope, so that the medullary substance appears to predominate at their periphery, as also at their central extremities. This arrangement is very important, not only in an anatomical, but in a physiological point of view, as it establishes between the two extremities an analogy of structure, expressed, even in the external form, by the uniform separation of the filaments, while the denudation of the medullary substance, in these two points, attests its importance for the reception of internal or external impressions.

(1) Darwin's *Zoonomiæ*, vol. i.

The nerves do not probably ramify so much that they are identified to a certain extent with the substance of the organs, for microscopical observations demonstrate the contrary, even in those organs which are very sensible, as the muscles. The finest nervous filaments are, however, certainly twelve times as large as the smallest muscular fibres, but the latter are compressed against each other so closely that we see them only, and cannot perceive the nervous filaments, or even the branches of the vessels, although both are considerably larger than the muscular fibres.(1) Probably then the extremities of the nerves have an atmosphere by which their influence extends beyond their substance. In this manner we can explain how parts, destitute of nerves and therefore insensible, when diseased, experience very acute sensations.

§ 174. The nervous system is not connected with all the organs, nor does it exist to the same extent in those in which it is found. The parts destitute of nerves are the mucous tissue and its semi-fluid fat, the serous membranes, the bones with their medulla, the cartilages, the fibrous parts, the epidermis and its appendages the nails and the hairs, some organs of a peculiar tissue, as the transparent cornea, the crystaline humor, and finally certain parts of systems which receive nerves in others, as all parts of the ovum, notwithstanding the large size of the umbilical arteries and veins.

Among the organs possessing nerves, the viscera of the chest and abdomen are those which receive the smallest and fewest. As they are formed principally of mucous membranes and of vessels, we may say that the mucous membranes are those parts which possess the fewest nerves.

The vascular system stands a little higher in this respect; the arterial system possesses more nerves than the venous and lymphatic systems.

The nerves of the muscles are still larger. But the muscles differ greatly in this respect. The nerves of the heart are smaller than those of the voluntary muscles, and thus it makes the transition from the arteries to these organs. Among the voluntary muscles, the nerves of those of the eye are the largest, the others are nearly similar in this respect.

The nerves of the flexor muscles are generally larger and more numerous than those of the extensor muscles.

The organs of sense which must be considered as simple appendages of the nervous system, are those in which the most nervous substance is found. Of these the skin receives the smallest nerves: but all its parts are not similar in this respect. Thus the skin of the fingers, of the lips, of the clitoris, and of the penis, possesses more nerves than in other places. The olfactory membrane of the nose, and the envelope of the tongue possess still more. The auditory nerve is still larger, and the optic nerve the largest of all.

(1) Fontana, *Ueber das Nipserngift*, Berlin, 1787, § 392.

Further, all the organs of the senses, except the skin, receive nerves from different sources. One is the nerve of sense, properly so called, which developes itself to give rise to the sensitive apparatus, the other is another pair, generally the fifth.(1) The tongue by its structure and the arrangement of its nerves, forms the transition from the other organs of sense to the skin; for it receives branches from several pairs, of which one alone is developed in the organ of taste, and that is not a distinct trunk, but comes from the fifth pair.

§ 175. The nervous system is supplied with a considerable quantity of blood. The strictest and most exact calculations estimate the blood which goes to the brain of man(2) one-fifth of that in the whole system. The nerves also in their course receive numerous vessels which are proportionally large. These vessels usually penetrate them almost at right angles. Arrived at their surfaces, they divide into two branches, an ascending and a descending branch, which curve, frequently subdivide, penetrate the tissue of the nerve, and anastomose not only with each other, but with the adjacent branches. From the frequency of these anastomoses and the numerous vessels of the nervous system, the circulation can never be interrupted. This arrangement exists in all parts of the system: for each side of the brain receives two arteries which anastomose with each other and with those of the opposite side, and form a circle of vessels. The arrangement of the vessels is also peculiar in this respect, that the circulation in them is much retarded. This is strikingly seen in the brain where all the arteries make numerous and very considerable curves. The vessels of the nerves offer something analogous in their division into two branches, forming together a right angle. All these vessels divide also into very minute branches before penetrating into the substance of the nervous system. However, they do not extend very deeply into this substance, at least the nerves of the medullary part of the brain are not tinged, and hardly change their color, even when other parts become entirely red.(3)

The vessels of the gray substance, both in the brain and ganglions, are more numerous and larger than those of the medullary substance (§. 141.) Even where the latter is external, vessels pass through it to expand in the gray substance. Those which come to the latter proceed inward, dividing continually until they have attained the white substance, when they change their direction, follow that of the fibres, and do not give off any more branches.

The arteries and veins in the nervous system have not the same relations of situation as in most other parts. In fact, they do not accompany each other mutually; so that their trunks come from entirely different parts of the skull and nerves. The arrangement of

(1) On this subject see Treviranus, *Observations pour servir de complément à l'Anatomie comparée et à la Physiologie de l'organe de la vue;* in the *Journ. compl. du Dict. des sc. méd.* vol. xvi. p. 331.—F. T.

(2) Haller, *De part. corp. hum. fub.* vol. viii. p. 230.

(3) Prochaska, *Disq. organ. corp. hum. an. phys.* Vienna, 1812, p. 100-103.

the veins is peculiar in this respect, that the branches unite to the trunks in a direction opposite to that of the course of the blood. They have no valves. This arrangement, with that of the arteries, proves that the blood in the brain circulates slowly and uniformly.

The vessels of the cortical substance are also peculiar in this respect, that the veins are not more numerous than the arteries, as in other organs.(1) Ruysch asserts even that this substance has no veins, and that the passage from the arteries to the veins takes place on its outer surface, in the pia mater.(2)

The existence of absorbent vessels and lymphatic glands within the brain has not as yet been demonstrated. Pathological phenomena, particularly the formation of round tumors in the brains of scrophulous subjects, which have been considered as proving the existence of lymphatic glands,(3) prove nothing; for these tumors may be wholly new formations, as they are in other parts of the body where similar formations are developed.

§ 176. The nervous system is surrounded with different envelopes, which are not alike every where. The most immediate and essential, and that which seems most intimately connected with the nervous substance, is a membranous layer of mucous tissue, in which the vessels expand before they pass into the nervous substance. This membrane is the *pia mater*, the *neurilemma*, the principal modifications of which have already been stated, since its transition from the brain and spinal marrow to the nerves is very evident. A thick layer of mucous tissue is found immediately above it. The structure of this tissue is not fibrous in the nerves; but it is very strong, and has a silvery lustre. It not only entirely envelopes the nerves in all parts, but also sends prolongations internally, which surround their several cords. Serum and generally fat also are deposited within this cellular layer; it becomes thinner externally, is continuous with the mucous tissue of the whole body, and unites the nerves with the parts adjacent. The nerves within the skull and vertebral canal are destitute of this external and solid envelope; but the brain and spinal marrow are there surrounded with two membranes beside the neurilemma. The middle lining is the *arachnoid membrane*, (*tunica arachnoidea*,) a thin white membrane, which is destitute of vessels. This membrane, after lining the brain and spinal marrow, sends a hollow prolongation, which extends to the opening of the skull or of the vertebral canal, where it disappears.

The third envelope is the *dura mater*, which takes the place of the periosteum, at least in the skull; for it is intimately connected to the internal face of its bones, while it does not adhere to the parietes of the vertebral canal. This membrane belongs to the class of fibrous organs. It generally stops at the opening through which the nerve emerges from the skull or vertebral column, and blends

(1) Vicq-d'Azyr, *Mém. de Paris*, 1783, p. 510.
(2) *Thes. anat.*, vi. no. 73.
(3) Reil, *Memor. clin.*, vol. ii. pp. 1. 39.

with the periosteum and the external cellular membrane which covers it. The optic nerve alone is an exception to this rule; since, after leaving the skull, until it is inserted into the globe of the eye, this nerve is surrounded by a thick and firm membrane, resembling the dura mater, and entirely different from the external envelope, which continues uninterruptedly with the fibrous membrane of the eye. The external or cellular tunic of the nerves has some analogy with the dura mater, and the two are united. Still the ancient anatomists were wrong in blending them, and in thence admitting that the nerves are enveloped by the dura mater, an opinion which Haller (1) and Zinn (2) have refuted.

The *ganglions* have the same envelopes as the nerves with which they are connected. All have an internal cellular capsule, analogous to the neurilemma or to the pia mater, in which their vessels are expanded, and an external envelop which arises in the compound ganglions from the cellular coat of the nerves, with which it is blended; in the ganglions of the spinal marrow, however, this is the same as the dura mater.

§ 177. The nervous substance possesses to a certain degree the power of extending and contracting. But this power does not exist in all parts of the system in the same degree. The changes of form and volume are every where slow and gradual.

The dropsy of the ventricles of the brain proves the *extensibility* of the nervous tissue. In this disease the thickness of the brain, which is usually several inches, diminishes to a few lines only, and the whole organ becomes an immense vesicle. Here we may mention the nerves over large tumors, which resemble broad flat bands.

The nervous substance is *contractile;* for the nerves which are cut across retract, whether they be, or be not organically connected with the parts to which they go.

Elasticity is also a property of the nervous substance. If the brain be compressed, it rises when this compression ceases; a nerve when drawn out, lengthens, and when released, returns to its original dimensions.

But the phenomena of extensibility, contractility, and elasticity, do not prove the *irritability* of the nerves, as Home asserts;(3) for the contractions observed in experiments on nerves removed from the body or still attached to the organs, prove only the existence of the first three properties, and not that they possess the fourth.

All the parts of the nervous system are not alike in regard to *sensibility*. Its periphery, comprising the nerves properly so called, is highly sensible, and it is even in this that their function consists. This power undoubtedly resides in the nervous substance, since the neurilemma disappears at the extremities of the nerves, and pain is not

(1) *Prim. lin.* n. 370. *De fab.*, vol. viii. pp. 305, 306.
(2) *De l'enveloppe des nerfs*, in the *Mémoires de Berlin*, 1753, p. 130-144.
(3) *On the irritability of the nerves*, in the *Phil. Transact.*, 1801.

caused by merely exposing these organs, but they must be compressed or divided.

Opinions differ in regard to the sensibility of the cerebral substances. Some writers, particularly Lorry(1) and Lecat,(2) wholly deny it; others, on the contrary, as Haller,(3) admit it in regard to the deep portions of the encephalon, but refuse it to the cortical substance and even to the superficial layers of the medullary substance; finally, many assert its non-existence in the deep parts, but admit it in the superficial portions. The last hypothesis seems most probable to us. It belongs to Boerhaave (4) and Caldani.(5)

§ 178. Although we have seen above that the masses of gray substance do not communicate, still the whole nervous system is every where connected, and all its parts communicate with each other in different modes. We must now point out the relations between these different parts, that is, we must determine, 1st, what are the relations between the two substances, and the functions performed by each; 2d, what is the mutual relation of the different parts or the principal sections of the nervous system.

§ 179. The medullary and gray substances have undoubtedly important relations with each other, since they exist in all those animals which have a nervous system; but it is difficult to determine what these relations are. It is generally thought that the medullary substance is connected with the intellectual faculties more intimately than the cortical substance, the function of which is to nourish the medullary substance, or to secrete a principle which acts in it;(6) and this because it receives so many vessels. The gray substance is supposed to be the matrix of the medullary substance,

1st. Because it is generally diffused. It not only covers all the extremities of the nerves, and forms, for instance, most of the pituitary membrane, the retina, and the fluid in which the extremities of the auditory nerve and the rete mucosum of Malpighi are placed, but also accompanies the nerves in their whole course.

2d. Because we find it in masses wherever the medullary substance exists in greater quantity, and its functions are more important.

But these two circumstances are not sufficient to prove that these are the functions of the cortical substance. It is not proved that the gray substance accompanies the nerves in every part, nor that it surrounds their extremities; and if it abounds in the parts where the medullary substance is found in excess, it may be designed for an end very different from that assigned to it. The accomplishment of certain vital actions may possibly depend on the simultaneous presence, the union, and reaction, of these two substances. If the hypothesis above mentioned were correct, the cortical substance probably would not become more and more

(1) *Mémoire sur les mouv. du cerveau*, in *Mém. prés.*, vol. ii. p. 354.
(2) *Traité du mouv. musc.*, Berlin, 1765, p. 289.
(3) *Mém. sur les part. sens. et irrit.*, sect. vi. no. 1, exp. 139-147.
(4) *Impetum fac. dic. Hipp.* p. 257.
(5) *Mém. sur les part. sens. et irrit.*, vol. iii. p. 82.
(6) Ludwig, *De substantiâ cinereâ*, Leipsic, 1779.

predominant as we descend the animal scale; its relations with the medullary substance would be every where the same.

We need not explain the progressive increase of the nerves from their centers to their peripheries(1) by supposed additions to this substance, since the gray substance within them is demonstrated by no fact, and it is evident that the medullary substance can enlarge of itself.

The most probable hypothesis is that which considers the gray and white substance as two masses in antithesis with each other, while the difference in their structure and chemical composition is necessary to accomplish the functions of the nervous system.(2)

§ 180. Notwithstanding the undoubted importance of the gray substance, we have no right to think that is more noble than the medullary substance, or that the changes in the mind, corresponding to corporeal changes, take place in it, as Wenzel seems to think(3) when he says, "*Cinerea singularum cerebri partium substantia videtur præcipue id esse, quo propriæ cuivis istarum partium sensationes efficiuntur;*" and tha tthe medullary substance is merely a simple conductor. Reil comes nearer the truth in stating that the principal organs of the soul are placed around the masses of gray substance within the the brain.(4) Haller had already advanced this theory before him.(5) He says, "*Non ergo in cerebri cortice sensus sedes erit aut plena causæ muscularis motus origo; eritque utraque in medulla cerebri et cerebelli.*"

This opinion is favored by the excess of gray substance in the fetus and the inferior animals.

§ 181. *What is the mutual relation of the different parts of the nervous system? Do they form so many separate systems merely connected with each other?* Or do they all emanate from a *central part?* The last opinion has prevailed even in modern times. But the first begins to be general, although with several modifications.

It supposes either two opposite nervous systems, or many which co-exist and are independent.

§ 182. The first hypothesis which is defended by the most ingenious anatomists(6) and physiologists, opposes to the system formed by the brain, spinal marrow, and their nerves, that of the great sym-

(1) Sprengel, *Inst. phys.*, vol. ii. p. 191.

(2) A hydrogen and oxygen antithesis, a gray and a white substance, appear to be essential parts of every nervous tissue. (Reil, *Archiv für die Physiologie*, vol. ix. p. 485.)

(3) *De penitiori cerebri struct.*, p. 69, chap. vi.

(4) *Archiv für die phys.*, vol. ix. p. 207.

(5) *Elém. Phys.* vol. iv. p. 392.

(6) Winslow, *Expos. anat.*, vol. iii. p. 220.—Johnstone, *An essay on the use of the ganglions of the nerves*, 1771.—Pfeffinger, *De structurâ nervorum*, Strasburg, 1783.—Sœmmerring, *Ueber das Organ der Seele*, Konigsberg, 1796, p. 9.—We consider the last (the sympathetic nerve,) as a separate pair of nerves independent of the brain and spinal marrow, which is, however, connected with them mediately, but not immediately.—Bichat, *Traité de la vie et de la mort.*, ch. vi. § iv. p. 76.—Reil, *Archiv. für die Physiologie*, vol. vii. part ii.—Gall, *Anatomie et Physiologie du système nerveux*, 7810.

pathetic or intercostal nerve which expands in the neck and in the cavities of the chest and abdomen, and admits only simple connections between these two systems, which are otherwise independent.

As the first is distributed principally to the organs which preserve the relation of the mind with external objects, and are subject to the influence of the will, and the second is expanded in the organs which are only materially connected with external objects, the first is called *the nervous system of animal life*, and the other *the nervous system of organic, vegetative, or automatic life*.

According to this theory, the ganglions, formed of medullary filaments and of a gray substance, are so many small brains from whence the sympathetic nerve arises. Some of the ganglions which form the centres of this system are situated internally upon or beyond the median line of the body, and others on its edges. The nerves of the organs of circulation, of digestion, of the urinary secretion, and partly, also, those of generation, come from the first, as well as those filaments which unite these inner ganglions with those which are placed on its edge. The latter extend in a row on each side along the vertebral column. They connect the internal ganglions and the filaments which come from them with the system of animal life, since they unite with the cerebral and spinal nerves by one or many filaments.

The great sympathetic nerve, on the contrary, is generally considered either as a cerebral nerve, the trunk of which proceeds along both sides of the vertebral column, and unites with the spinal nerves by ganglions, while its branches swell out from space to space to form other ganglions, or as a nerve formed by all the spinal nerves. Against this opinion and in favor of the preceding,(1) we may adduce the following arguments :

1st. What is termed the trunk of this nerve is often interrupted without any derangement in the organs to which it proceeds. We sometimes find a very distinct interval between two or more ganglions.

2d. Other ganglions, not belonging to the sphere of the sympathetic nerves, are always distinct, and communicate by their branches with the cerebral nerves only.(2)

3d. Its trunk is often divided lengthwise, which never happens in the other nerves.

4th. This nervous trunk becomes evidently thicker in its passage downwards, so that it cannot come from the fifth and sixth pairs of cerebral nerves. Nor have we reason to think that it arises from any of the spinal nerves, since the branches which spring from the ganglions are larger than those which come from the spinal nerves.

(1) Bichat's *General Anatomy*, vol. i. p. 250.

(2) Bichat also grounds his opinion on the fact, that in birds the upper cervical ganglion is constantly distinct, and never communicates with the lower. But Cuvier has demonstrated that this assertion is erroneous. Tiedemann (*Zoologie*, vol. ii. p. 45–46.) and Emmert (Reil, *Archiv*, p. 337.) have demonstrated this communication still more circumstantially. We need not observe that by an impartial comparison of the different passages cited, we may easily judge correctly in respect to the claims of discovery after Cuvier.

5th. Its texture is different. It is softer and grayer than the other nerves.

6th. Its external form does not resemble that of the nerves of the system of animal life, being neither constant nor symmetrical.

These arguments prove only that the great sympathetic nerve does not arise from the brain or spinal marrow by a single point, and that it is distinguished from the nerves by several peculiarities; but it does not follow that it forms a system independent of the brain and spinal marrow. Far from it: recent experiments would lead us to think that if it forms a separate system, of which the ganglions are the centres, while its extremities communicate with the nervous system of animal life, this communication is absolutely essential to the integrity of its functions, since the motions of the heart, which derives its nerves principally from it, are always arrested when the spinal marrow is destroyed, while only a small portion of this organ is necessary for their continuance.(1)

The manner in which the ganglions placed on the borders of this nerve unite with the spinal nerves, also appears to favor this opinion. The filaments of communication arise principally from the anterior cords of the spinal nerves, which are immediately connected with the spinal marrow, instead of coming from the posterior cords, along which ganglionic enlargements are found.(2)

The opinion with regard to the great sympathetic nerve, when thus modified, is admissible, and thus the ingenious Johnstone has stated it.(3)

§ 183. Gall,(4) instead of admitting this general opposition between the nervous systems of organic and animal life, considers the system of organic life, the nerves of voluntary motion, of the senses, of the proper organs of the intellectual functions at least in perfect animals, as so many distinct and independent systems, which are closely united and connected in their action, but which do not come from each other. The nervous system of the senses and of voluntary motion is, however, composed of the spinal marrow, the medulla oblongata, and the nerves which come from them: they may, and even should, be considered then as one system; since, with a few exceptions, each nerve is at the same time a nerve of sensation and a nerve of motion. Besides, even when we examine the nervous system of organic life, we do not consider the ganglions and filaments separately, nor can we separate the study of the nerves of perception and of motion from that of the brain. The preceding hypothesis is then more probable than that of Gall.

§ 184. But although it is true that the animal and organic nervous systems differ, the second being subordinate to the first, although the different parts of the nervous system considered as a whole, are united

(1) Legallois, *Exp. sur le principe de la vie*, Paris, 1812.
(2) Scarpa, *Annot. acad*, l. i. § xi. xii.
(3) *Loc. cit.* p. 80.
(4) Gall, p. 467.

in many different ways, so that they are always in a state of reaction and mutual dependence, we cannot deny but that each part is to a certain extent independent of the rest. Each part of the nervous system preserves itself in virtue of a peculiar activity, and reproduces itself constantly from the blood which flows to it. Hence when a nerve is divided it remains as large below as above the cut.

We sometimes find nerves when there is no trace of a brain or spinal marrow, and the spinal marrow is often perfect, although there is not the least appearance of a brain.(1) Even when the development is perfect, we have instances where considerable injuries of the brain and spinal marrow do not diminish sensation or the power of motion, especially when they are not sudden, but slow and gradual. The limbs, when detached from the body, are agitated if their nerves be irritated.

§ 185. Hence some late writers have opposed the opinion of the ancients, that the nerves and even the spinal marrow come from the brain, and it is admitted that these parts do not arise from the encephalon, but are merely connected with it. It is even pretended that the nervous system of organic life is formed before that of the nervous system of animal life.(2)

They appear however to have gone too far on this side; for, 1st. The history of the development of the nervous system in the animal series, and in the fetuses of the superior mammalia, proves that the central part of the nervous system of animal life in fact exists before its radiations, and before the nervous system of organic life. In several worms we find in the place of a spinal marrow, only a simple cord destitute of filaments.(3) The spinal marrow is the first part which appears in the chicken, so that this organ in some measure appears to be the origin of the whole nervous system. In fact we find the spinal marrow without the brain,(4) but never find the brain without the spinal marrow, neither in animals nor in human monsters. When the nerves are seen without the brain and spinal marrow, these two organs existed previously, or the defect is but partial. Hence why the whole brain may be extirpated. A small portion of the spinal marrow is sufficient to sustain life in that part of the trunk with which it communicates; but if the whole spinal marrow be destroyed, the phenomena of life cease.(5)

2d. The ordinary results, even of those experiments which are alledged to prove that the different parts of the nervous system are independent of each other, demonstrate that the nervous activity emanates, at least partially and perhaps entirely, from central parts. A limb, if its nerve be divided, becomes feeble and often wastes. The functions of all these parts cease when the continuity of their nerves

(1) Monroe, *On the nervous system*, p. 20, 21.
(2) Ackermann, *De system. nerveis primordiis*, Heidelburg, 1813.
(3) Cuvier, *Anatomie comp.* vol. ii. p. 330.
(4) Cuvier, *Anatomie comparèe*, vol. ii. § 339.
(5) Malpighi, *loc. cit.*
(6) Legallois, *loc. cit.* p. 32-3-4-131.

is interrupted, even when these nerves are connected with them in all their extent. Hence, in order that the nerve should perform its functions, it must communicate with the brain and spinal marrow—a fact from which we deduce at the same time a powerful argument against the opinion that the nerves possess gray substance in every part.

The nerve has then the power of vegetating or of nourishing itself independent of the central part; but it proceeds from this center, and must communicate with it, to animate the organs to which it goes.

§ 186. What is the function(1) of the nervous system? What is the relation between its whole structure, and that of its parts, and this function?

The function of the nervous system is to produce the actions corresponding to the activity of mind, the *phenomena* of *sensibility* or of *intelligence*. Consequently, it is the system of *sensibility*. Hence

(1) See on this subject, Lobstein, *Discours sur la prééminence du système nerveux dans l'économie animale et l'importance d'une étude approfondie de ce système*, Strasburg, 1821.—Charles Bell, *On the nerves—Memoir on the respiratory nerves.*—Shaw, *Experiments on the nervous system*, in the *London med. and phys. journal*, December, 1822, June, 1823.—See also, *Journal de phys. exp.*, vol. ii. p. 77; *Archiv. gén. de méd.*, August, 1823, p. 511.—Desmoulins, *Recherches anatomiques et physiologiques sur le système nerveux des poissons*; in the *Journ. de phys. exp.* vol. ii. p. 348; Id. *Exposition succincte du développement et des fonctions du système cérébro-spinal*, in the *Archiv. gén. de méd.*, June, 1823, p. 223; Id. *Exposition succincte du développement et des fonctions des systèmes nerveux latéraux des organes des sens et de ceux des mouvemens dans les animaux vertébrés*, same journal, December, 1823, p. 571.—Magendie, *Expériences sur les fonctions des racines des nerfs qui naissent de la moelle épinière*; in the *Journ. de phys. exp.*, vol. ii. p. 276-366.—Rolando, *Exp. sur les fonct. du syst. nerv.*, same journal, vol. iii. p. 95.—Coster, *Expériences sur le syst. nerv., publiées en Italie en* 1819, *et répétées en France en* 1823; in the *Archiv. gén. de méd.*, March, 1823, p. 359.—Fodera, *Recherches expérim. sur le syst. nerv.*; in the *Journ. de phys. exp.*, vol. iii. p. 191, and in the *Journ. compl. du Dict. des sc. méd.*, vol. xvi. p. 290, vol. xvii. p. 97.—Tréviranus, *Essai d'une détermination du rapport des diff. org. cérébraux aux. div. manifestations de la vie intellectuelle*, same journal, vol. xvii. p. 13.—Id. *Sur les organes cérébraux, les nerfs de la vie végétative et sensitive, et leurs connexions naturelles*, same journal, vol. xvi. p. 113.—*Id. Sur les différences qui existent, relativement à la forme et à la situation du cerveau dans les différentes classes du règne animal*, same journal, vol. xvii. p. 216, vol. xviii. p. 235.—Desmoulins, *Mémoire sur le défaut d'unité de composition du système nerveux, et sur la concordance de ce défaut avec l'irrégularité des facultés des animaux*, same journal, vol. xviii. p. 79.—Wilson Philip, *On the influence of galvanism on digestion and respiration, &c.*, London—Humboldt, *Résultats à expér. faites sur les actions galvaniques, et sur les effets de la section longitudinale et de la ligature des nerfs*, in the *Archiv. gén. de méd.*, October, 1823, p. 292.—Breschet, M. Edwards, and Vavasseur, *De l'influence du syst. nerv. sur la digestion stomacale*, same journal, August, 1823, p. 179. The last three memoirs establish the identity between the effects of galvanism and certain phenomena dependent on the action of the nervous system. Wilson Philip was the first who attempted to re-establish the action of the stomach suspended by the division of the parvagum nerve, by passing a continual current of galvanism across this organ, which was transmitted by the lower extremity of the divided nerve. Charles Bell's observations on the simple and compound nerves, and those of Magendie on the different functions of the two roots of the spinal nerves, are, with those of W. Philip, the most important additions to the science of Physiology, since the commencement of this century. We must, however, admit that C. Bell's theory was indicated, and even developed, to a certain extent, in the different works of Lamarck; among others, in his *Philosophie zoologique.*—See also Vavasseur, *De l'influence du système nerveux sur la digestion stomacale*, Paris, 1823.—Foville and Pinel Grandchamp, *Recherches sur le siége spécial des différentes fonctions du système nerveux*, Paris, 1823.—Flourens, *Recherches expérimentales sur les fonctions et les propriétés du système nerveux dans les animaux vertébrés*, Paris, 1824. F. T.

why a perfectly normal state of this system is indispensable to produce these phenomena normally.

But its different parts have different functions. The function of the nerves is to convey the impressions to their opposite extremities, and thus produce changes in those organs which receive these impressions. These changes depend on the nature of the organs. They are *sensations* in the central part, and *changes of volume* or *motions*, and modifications of the form in the organs different from the nervous system.

§ **187.** The nerves are conductors. This is proved by the following facts:

1st. The propagation of the external or internal impressions ceases, when their continuity or connections with the central part and the organs in general are interrupted. Hence the loss of motion, secretion, and sensation, when the nerve of an organ is cut, or compressed by a liga- or tumor in its course, at its origin, or at its entrance into an organ. Hence the loss of smell when a schirrhous tumor compresses the olfactory nerve;(1) and deafness in another case, where the auditory nerve was compressed in the same manner;(2) and squinting in a subject, where the origin of the nerve of the sixth cerebral pair(3) was also compressed by a tumor, blindness in a case of compression of the optic nerve by an aneurism of the carotid artery within the skull;(4) complete paralysis of the arm by the swelling of the lymphatic ganglions in the axilla, thus forcibly pressing upon the brachial plexus.(5) Hence the derangement and even the complete suspension of digestion, and the loss of voice from tying or dividing the par vagum nerve, which goes to the organs of these functions.(6)

Hence, too, excruciating pain is often cured by dividing the nerves of the diseased part; and sometimes it ceases for a time, even when those nerves are compressed. Hence, finally, the happy use made of this resource against tic douleureux and similar fixed pains in other parts of the body.

The number of parts, then, which lose their sensibility and motivity, is always much greater in proportion as the nerve is tied or divided near its origin. When the loss of these two powers depends on a ligature or on compression, they reappear when these cease to act.

2d. The propagation of the external or internal impressions continues to take place on one side between the point compressed and the central part, on the other between this same part and the organ to which the nerve goes. When we touch the parts of a limb above the place where its nerve has been cut or tied, a sensation is excited, the intensity of which depends on the manner in which the contact is made, and the degree of force given to it. Motion takes place even in

(1) Loder, *De tumore scirrhoso et organo olfactus*, Jéna, 1779.
(2) Sandifort, *Obs. anat. pathol.* lib. i. c. ix. p. 117.
(3) Yelloly, in the *Med. chirurg. trans.*, vol. i. xvi.
(4) Blane, in the *Trans. of a soc. for impr. of med. and chir. knowl.*, vol. ii. p. 193.
(5) Van-Swieten, *Comm. in Boerhaav. Aphor.* vol. i. p. 222.
(6) Legallois has collected all the ancient and modern references to experiments on this subject, (*loc. cit.* p. 164.)

a limb detached from the body, when the nerve is irritated; although the irritation of the parts of the nerve above this division, of the brain, or the changes which supervene in the encephalon, have no effect on the motion of a limb, the nerve of which is only tied.

3d. Other things being equal, the degree of sensibility and of motivity of an organ depends on the size of its nerves. Hence the large size of the nerves of the organs of the senses, which probably contributes to render them more susceptible of being affected by certain qualities of bodies, although the structure of the organs to which they go, their mode of distribution, and the differences in the internal structure of the nerves themselves, are the principal sources of this faculty. Hence why those muscles of the eye which move continually receive the most and largest nerves. The nerves of the heart are neither so large nor so numerous as those of the other muscles, but they come from ganglions which communicate directly with the spinal marrow, and they have more medullary substance in proportion to the neurilemma, than the other nerves.

4th. The central part of the nervous system experiences no change from internal impressions made on the organs which do not receive nerves. These organs are insensible (p. 79).

§ 188. The external and internal impressions are generally conducted always in the same direction. It rarely or never happens that when we touch a nerve, we produce motions in those muscles, which are supplied with nervous filaments from the trunk, between the point of contact and the central part. Thus the nervous influence which is to act on the external organs goes directly to the periphery.

§ 189. As the phenomena which result from the conducting power of the nerves are finally reduced to sensation and motion, the nerves have been divided into *nerves of motion*, *nerves of sensation*, and *mixt nerves*. But this classification is valueless; for although there are some nerves intended exclusively for sensation, (as the olfactory, optic, and auditory nerves,) there are none which are designed simply for motion. Those which go to the muscles have in fact only the power of propagating impressions from their periphery inward.

§ 190. The same nerves convey external and internal impressions, since the section of one of these cords destroys both sensation and motion. The divisions of these organs into nerves of sensation and nerves of motion, is then incorrect in this second respect.

On the contrary, the phenomena above mentioned (§ 188) lead us to conjecture, with some probability, that there are in the same nerve, different fibres, some designed to convey impressions inward, and others to carry them externally: at least these phenomena are explained very satisfactory by this hypothesis. In fact, the fibres do not apparently differ in arrangement, but the variation may, however, be so slight as to escape us; hence we draw no conclusions.

This hypothesis is, besides, more probable than that which supposes that the transmission of impressions internally differs from that of conveying them externally, and that it requires less energy to conduct external than internal impressions. The partisans of the last theory found it on the circumstance, that the loss of motivity is observed oftener than that of sensibility. Still the contrary case is not rare; some physiologists believe, even, that it requires more energy to propagate external impressions. And again, the sensibility almost entirely disappears in raphania, although motivity is but slightly diminished.

Finally, the loss of one of the two faculties, with the continuance of the other, demonstrates neither the existence of nervous fibres differing in their conducting power, nor the necessity of greater energy to propagate either internal or external impressions, since the cause of the loss of sensation and motion unquestionably depends on the abnormal state, not of the conducting nerve, but of the centre to which it extends, or of the organ in which its periphery is expanded.

Still less can we admit, that the conducting power of external and internal impressions resides in different substances, viz. that of internal impressions in the medullary substance, and of the former in the neurilemma. All the arguments adduced in support of this improbable hypothesis are easily refuted.(1)

Considering all things, it is probable, 1st, that the conducting power resides in the medullary substance alone, and not in the neurilemma.

2d. That all the fasciculi and all the fibres of the nerves equally fulfill the function of transmitting the external and internal impressions, even as the same muscular fibres contract sometimes in one direction, and sometimes in the opposite.

§ 191. The following facts demonstrate that the nerves possess only the conducting power; that is, they are only the necessary means of producing intellectual phenomena, in accordance with the impressions transmitted by them to the centre of the nervous system, and that, in man at least, the brain is the only organ in which changes corresponding with the phenomena of intelligence occur.

1st. The only portion of the nerves which is not sensitive, and which loses the power of exciting voluntary motion, is that which is separated from the rest of the nervous system by compression or division.

2d. The intellectual acts remain entire when the communication between the brain and the rest of the nervous system is interrupted, and there is paralysis of all those parts of the body which are situated below the parts injured, as, for instance, in dislocations, or fractures of the cervical vertebræ accompanied by compression of the spinal marrow.(2)

(1) Treviranus, *On the nervous influence and its effects*, in *Phys. Fragmenta*, vol. i. Hanover, 1797, vol. ii. 1799.

(2) Vicq d'Azyr has seen the paralysis of the extremities and of the sphincters of the anus and bladder, with an insensibility of the whole body, except the head, from an injury of the cervical portion of the spinal marrow. (*Encyc. méthod. Méd. Anat. pathol.*, p. 264.) Ludwig has known loss of motion and sensation in the whole body after a fracture of the fourth and fifth cervical vertebræ; the patient continued perfectly sensible for sixteen days. (*Advers. med. prop.* vol. iii, p. 507.)

3d. The intellectual functions are more or less injured by the compression, irritation, destruction, violent concussion of the brain, and by changes in its physical qualities; by the too great or too little flow of blood to this organ; in a word, by all anomalies which can exist in it, although the structure of the other parts of the nervous system is perfectly normal.

4th. These lesions disappear when the cause which acts on the brain is removed or when the action of this organ returns to its normal rythm.

5th. The development of the intellectual faculties is parallel with that of the brain, in regard to its mass, form, chemical composition, and distinction of its two substances, both in the fetus and in animals. But we should not forget that the increase of the encephalon in size is not exactly ascertained by comparing the brain and nerves together. The large animals have, 1st, a brain positively larger than the small animals, and sometimes larger than that of man: 2dly, in many, also, it is larger, in proportion to the body, than in others, without a corresponding development of intellect. On the contrary, there is constantly a direct relation between the development of intelligence and the increase of the brain, when compared to that of the nerves. This relation is no where more favorable than in man.

6th. Even from the sense of effort and fatigue in thinking, which very evidently has its seat in the head, at least in preference to other parts.

7th. The brain, although united to the rest of the nervous system, forms a separate and perfectly distinct organ, which fulfills special functions.

8th. After a painful limb has been amputated, the patient thinks he still feels pains at the stump.

§ 192. Most of these facts, especially the 2d, 3d, 4th, 5th, 6th, and 7th, prove at the same time that, at least in man and the superior animals, the brain is the only central part of the nervous system which cooperates with the phenomena of intelligence, and that the spinal marrow takes no direct part in them.

§ 193. Does the whole brain take part in all acts of intelligence, or do certain intellectual phenomena occur in some particular parts? In one or the other case, is there, or not, some more or less extensive part of the encephalon where the primitive source of all spiritual or corporeal life resides, in this respect, that the local or general changes which take place in the brain are reflected in it, and that it is the point of departure of all cerebral influence to the nerves?

Observation and experiment can alone assist in resolving these questions.

The arguments in favor of the first opinion, are, 1st, that most of the brain may be destroyed without a sensible diminution of the intellectual faculties; 2d, that the destruction of the same part of the brain does not always necessarily involve that of the same intellectual faculty; 3d, that the complication of the brain remains the same, while its mass and volume increase in proportion to the development of intelligence.

We may conclude from this, that the whole cerebral mass acts in all intellectual operations, and that a part of this organ, by increasing its activity, can well replace those which may be destroyed.

The following are the facts in favor of the second hypothesis:

1st. The difference of the intellectual operations, and of the moral qualities which appear to correspond to the complicated and constant structure of the brain.

2d. The development of certain parts of the brain corresponding with that of certain intellectual faculties, and reciprocally.

The arguments favorable to the first hypothesis may be adduced against the second. But we must remark,

1st. That it is very difficult for two injuries of one and the same part to be perfectly similar.

2d. That from the symmetry and doubleness of the cerebral parts of the brain, the lesion of one of its two portions may be unattended with inconvenience.

3d. That those parts even which do not exactly correspond may supply them, since we see organs formed very differently, as the skin, the kidneys, the lungs, the intestinal canal, the mammæ, the peritoneum, &c., replace each other.

It is, then, not improbable that the different faculties of the soul have different organs in the brain, even as the different corporeal functions, and the different acts of one and the same function, are performed in the body by different organs, but it is difficult to assign the seat of these faculties; we can only say that those of a secondary order reside in the lower and posterior parts of the brain, while the most noble faculties exist in the upper and anterior. In fact,

1st. The inferior parts are found in all vertebrated animals commencing with the lowest in the scale.

2d. They do not differ much in different animals.

3d. As the intellectual faculties perfect themselves in the animal series, and in different individuals of the same species, the cerebral mass increases upward, forward, and on the sides; the hemispheres enlarge in respect to the inferior parts of the brain, which have a definite outward form, and appear as distinct organs; and the cerebrum is larger in proportion to the cerebellum.

§ 194. The nervous system is not only the organ of the mind; it animates also all the other organs, because it probably exists before them, and because the vital energy of these organs is proportional to the size and number of the nerves they receive, and the destruction of their nerves deranges more or less the fulfillment of all their functions. Is there a common source of this vivifying and preservative power of the nervous system, or is it diffused through the whole of it?

That the periphery of the nervous system takes no part in the preservative influence exerted upon the whole organism, is proved by the fact that all the limbs may be amputated without destroying life. The source of this faculty undoubtedly resides in the central part. But is it diffused through all the central mass, or confined to a particular part? The former is not true; of this we may be convinced by comparing the degree of tenacity of life in those animals in which the brain is considerable, and those in which it is small. The difference in this respect must undoubtedly be ascribed to this, that the two conditions are directly opposed to each other. Experiments seem to demonstrate that the source of the preservative power, which exerts an influence on the whole organism, resides in the medulla oblongata; since if this part be injured, life is destroyed sooner than from wounds of any other part of the brain or spinal marrow; and farther, the latter have been found changed, and the vital functions have not been affected. This part is principally important because the par vagum nerve arises here and goes to the organs of respiration; for when that is injured, the second condition, which is essential to maintain life, the change of venous into arterial blood in the lungs, no longer takes place, and the vital energies cannot be produced. Thus, after destroying the medulla oblongata, and even separating the head from the body, if artificial respiration is carried on, the trunk continues to live during a certain period, if the spinal marrow be uninjured, and the vessels are carefully tied to prevent the loss of arterial blood; but if the spinal marrow be destroyed, all the vital phenomena cease, although respiration is continued. If a portion of it only be destroyed, life ceases only in those organs which receive their nerves from this part. The medulla oblongata is then not so important to all the organism, except as a medium. The true source of the preservative power of the nervous system resides in the posterior and inferior part of the encephalon and in the spinal marrow, and the integrity of all these parts is absolutely necessary to maintain life. This is farther proved by the fact, that although when part of the spinal marrow is destroyed, the vital phenomena cease instantaneously only in those organs to which it sends nerves, yet the other organs also soon perish, and at the same time as when the heart is removed and the spinal marrow uninjured. The destruction of the nervous system appears then to cause death by checking the circulation of the blood. Hence why the motions of the heart become much weaker when a part of the spinal marrow is destroyed; and the reason too that when a considerable part of this cord is destroyed, life remains so much longer if the circulation be carefully restricted to a few organs, and the relation between the extent of the circulation and the force which remains in the heart after the lesion of the spinal marrow, be more favorable.

§ 195. The nervous system is also the medium between all the organs. It unites them all, and changes in one are felt not only in the central mass, but also produce changes in the other parts of the body. It is then the organ of *sympathies*.

§ 196. The texture of the nervous system and the numberless communications of its different parts, greatly favor the development of sympathies. The plexuses of the nerves seem to be the medium of these sympathies, since they unite the filaments of the different nerves; so that the branches given off by them, are always composed of filaments from two or more of these different nerves.

The nervous filaments separate and unite in the ganglions also. Hence they have been regarded in the same light as the plexuses, and their uses have been considered—

1st. To increase the ramifications of the nerves, and to render them more minute, since on entering them, the nerves abandon their neurilemma, and are reduced to their constituent filaments, which receive a thinner and softer envelop when they emerge.

2d. To facilitate the passage of the branches of the same nerve to different organs, and to guard them against the dangers which might attend them in a long course.

3d. To unite in a single trunk several filaments of one, or of different nerves, or the different roots of the same nerve.(1)

But, then, we cannot conceive why the ganglions differ so much from the plexuses, or even why they exist; it seems, then, more natural to think, that *these organs increase in some manner the action of the nerves*, an opinion which many ancient and modern physiologists have sustained with different modifications.

§ 197. The ancient anatomists were more strenuous to prove the existence of these ganglions than to determine their uses ; still, Galen's opinion seems to have been, that they increased the action of the nerves. He says, " *Ubi enim aut longo itinere nervum est* (*natura*) *ductum, exiguum aut motui musculi vehementi ministraturum, ibi substantiam ejus corpore crassiori quidem, cœtera autem simili, intercipit.*"(2) Willis,(3) and Vieussens,(4) that they prepared, perfected, or modified in some manner the active principle of the nerves. We may consider as modifications of this theory the opinion of Lancisi,(5) that they possessed muscular fibres to quicken the course of the active principle of the nerves, to render this principle more prompt in obeying the impulse of the will, and that of Gorter,(6) who believed them designed to concentrate the blood vessels, which, by their action, favor the passage of the nervous fluid. Lancisi, Winslow, Lecat, Winterl, Johnstone, Pfeffinger, Monro, Bichat, Gall, and Reil, have considered them as small brains, secondary brains, sources to increase the nervous power, because they are, like the brain, composed of a white and a gray substance, and because the latter is as vascular as in the encephalon; and farther, in the fetuses destitute of a brain by primitive formation, or where the brain has been accidentally compressed, the substance which replaces it very much resembles, in color and consistence, the nervous ganglions ; and finally, because the nerves given off by the ganglions are larger and more numerous than those they receive. Even the analogy between the structure of the nervous ganglions, and that of the lymphatic glands has

(1) Meckel, *Obs. anat. sur un nœud ou ganglion du second rameau de la cinquième paire des nerfs du cerveau, nouvellement découvert, avec l'examen physiologique du véritable usage des ganglions des nerfs*, in *Mém. de l'Ac. de Berlin*, 1749, p. 85-102. Zinn, *ibid.* p. 753 ; *De l'enveloppe des nerfs*, p. 144.—Scarpa, *Ann. Acad. Mutinæ*, 1799, B. i.—Haase, *De gangl. struct.* p. 32-35.

(2) *De usu part. corp. hum.* B. xvi. c. v. The nervous ganglions were discovered by Galen. F. T.

(3) *Descript. nerv.*, in *Opp. omn.*, Geneva, 1695, p. 120.

(4) *Neurogr.* p. 193.

(5) *Diss. de structurâ usuque gangliorum annex. Morgagni advers. an. V.*

(6) *Chirurgia repurgata*, Leyden, 1742, p. 184.

been adduced in support of this hypothesis, because it has been concluded that their functions ought also to be analogous.

This opinion is far from being contradicted by asserting, that the existence of the *animal spirits* is not demonstrated, which, according to the ancient physiologists, were produced, elaborated, kept in reserve, and rapidly propelled by the ganglions,(1) or that the structure of the organs which secrete them ought to be much more delicate, and that the mass of nervous substance does not increase in the ganglions, but that in them the filaments of the nerves are only divided into smaller filaments ;(2) and finally, that the structure of these ganglions is not similar to that of the brain.(3) The imponderable principle which acts in the nerves is not what the ancients termed *vital* or *animal spirits*, and although we are now better acquainted with its laws, although we suspect it extends throughout all nature, this knowledge does not affect the state of the question in the least. We know of no other organ which can secrete it, except the gray and white substance, and both of these exist in the ganglions. But the ganglions are similar even in this respect to the brains, and although the anatomy of the superior animals does not prove this identity, we cannot doubt it, when we compare the ganglions and the brain of the inferior animals ; in fact, it often happens in these animals, that the different ganglions have the same inner and outer structure, and the same volume, as the brain.

We may, then, consider this opinion as demonstrated generally, although its different modifications are somewhat erroneous. Thus, for instance, Lancisi's assertion is untrue, that the function of the ganglions is to determine the flow of the vital spirits into the voluntary muscles ; for the organs which receive their nerves from these enlargements are in fact the involuntary, such as the heart, viscera, &c., although he maintains the contrary. It is, then, much more correct to say with Johnstone, that the ganglions interrupt the influence of the cerebral action on the organs, and to admit, with Haller and Metzger, that they blunt the sensations, in short, that the organs to which they send their nerves are more insulated than the others from the rest of the nervous system. In fact, the nerves of several of the voluntary muscles also have ganglions ; but they are formed from their posterior roots alone, and these do not unite to the anterior, till after the ganglions are produced. Finally, from what has been stated above(§ 182), it is wrong to say that the ganglions are situated in the course of the nerves to interrupt the cerebral influence ; the nerves emerge from the ganglions and are connected with the rest of the nervous system only by intermediate filaments ; the ganglions are centres, and hence the organs which they animate are insulated.

It follows, then, that several functions which have been considered as so many principal functions of the ganglions, are merely subordinate

(1) Sœmmerring, *Nervenlehre*, p. 130.
(2) Haase, *loc. cit.* p. 19, 20.
(3) Haase, *loc. cit.* p. 25.

and inferior, or rest only on false suppositions. Thus, according to Zinn, the ganglions are designed to give a cellular envelop to the nerves which come from them. But the relation of the cellular tunic of the nerves with the ganglions, does not differ from that of the neurilemma with the pia mater of the brain or spinal marrow. It appears wherever a nerve is formed. Nor is the use of the ganglions to unite the different filaments of the nerves in a single trunk, as Meckel has pretended. This anatomist rested his opinion principally on the fact of the ganglions of the spinal marrow; but Haase has demonstrated the incorrectness of the pretended fact. It is true that the nervous filaments ramify and interlace in a thousand ways in the compound ganglions; but the same is the case in the brain and spinal marrow. We then have more reason to say, that the ganglions establish a contrast between the nerves which they give off and those which they receive; since the former are reddish and soft, and they are easily distinguished by their color and degree of solidity from those with which they anastomose.

§ 198. The nervous system differs considerably during life, both in itself and in its relations with other organs.(1)

The following are the most remarkable peculiarities in this respect:

We have already observed (p. 45) that the nervous system is one of the first, if not the very first, which appears. Are all its parts seen at once, or successively? If they arise in succession, in what order do they appear? This is, perhaps, no place to decide whether the nerves appear in those regions of the body which are formed after the others, later than in those parts which show themselves the first; if, consequently, they develop themselves first or last in the extremities. The problem reduces itself to determine if the central and peripheral parts do or do not arise at the same time, and if the latter be true, which appears first. As the nervous and vascular systems, and the intestinal canal, are formed entirely or almost entirely together, the smallness of the objects renders it almost impossible to determine if the parts which are first seen, be the central parts of the nervous system, or if they belong to the vessels, or to the intestines. Analogy favors the first hypothesis; for in many worms we find only a single cord extending the whole length of the body, which does not give off any nerves;(2) and also different organs, particularly the heart, the intestinal canal in the animal series, and even the whole body of the fetus, form in this manner, that is, we see the trunk first, and then the branches which proceed from it.

(1) J. and C. Wenzel, *loc. cit.* chap. 27, 28, 29, 31, 34.—Dællingerrs, *Beitræge zur Entwicklungsgeschichte des menschlichen Gehirns*, Fvant, 1814.—Ackerman, *De systematis nervei primordiis*, Heidelberg, 1813.—Carus, *loc. cit.* p. 262–265 and 277–297. Meckel, in the *Deutches Archiv für die Physiologie*, 1815, vol. i. chap. 1 and 3.

(2) Cuvier, *Anatomie compareè*, vol. ii.

But which of the central parts appears first? There are two central masses, formed one by the encephalon and the spinal marrow, the other by the ganglions of the grand sympathetic nerve (p. 177). Does the former appear before the latter; and are certain parts of these two masses formed before the others?

The most probable opinion is that which attributes priority of origin to the encephalon and spinal marrow. This is supported,

1. By observations on the fetus;(1) and,

2. By the analogy of the development of the nervous system in the animal series; for that part of the system found in imperfect animals corresponds to this portion.

The same reasons should apparently lead us to think that the spinal marrow is formed before the brain. We may add to these the following:

a. The size of the brain in proportion to that of the spinal marrow always diminishes as we descend the animal scale. *b.* The spinal marrow is perfected long before the brain. *c.* We sometimes see deformed fetuses in which the upper part of the body, and consequently the brain, is deficient, but never those in which the brain and upper part of the body are alone formed.

Other arguments have also been adduced to favor the priority of the spinal marrow. Some have thought to demonstrate that it was indispensable, by saying that "the central organ of sensitive life ought necessary to develop itself at the same time with the heart, the central organ of vegetative life."(2) But, as the spinal marrow appears before the heart, as in the fetus; and, as in some animals, (insects,) we find nerves and even a spinal marrow, but no real heart; and, as in the invertebral animals, the position of the heart is not constant, although that of the central part of the nervous system never varies, this explanation, imagined to establish that the spinal marrow necessarily precedes the brain, is as little plausible as most explanations of the same kind.

Ackermann has advanced another opinion, to which it may be objected that it does not rest on observation. He thinks that the sympathetic nerve is formed first, and that its priority is equally necessary, because the heart, the organ possessing the highest degree of vital energy, is the centre of vegetative life. According to Ackermann, in fact, the globules of the blood pass through the substance of the heart, and arrange themselves in a series, to produce the fibres of the nerves, the softness and transparency of which he considers as another proof of this priority. He admits that the nervous system reaches the skull along the large vessels which arise from the heart, and that its mass gradually increases, to form the encephalon and spinal marrow; that the latter is formed by the brain, and is a prolongation of the cerebrum and cerebellum. Against this

(1) Malpighi, *De ovo incubato*, *Op. anat.*, London, 1686, p. 4. *Post diem integrum—tres ampliores vesiculæ, cum productâ spinali medullâ;* and in the Appendix: *Elabente die—spinali medullæ—cui vesiculæ cerebri appendebantur.*

(2) Carus, *loc. cit.*, p. 78.

hypothesis may be adduced most of the objections to that of the nervous system necessarily appearing at the same time as the heart, to contrast with it, and also the arguments which demonstrate the priority of the spinal marrow.(1) In truth, Ackermann admits this priority of the spinal marrow, which he construes favorably to his hypothesis, saying that the nervous system of the invertebral animals corresponds to the great sympathetic nerve of the superior animals, but not to their encephalon nor to their spinal marrow; but this comparison is not correct.(2) In fact, the arrangement of these systems in the invertebral animals proves that it may be compared to the cerebro-spinal system, since, 1st, the nerves come from its centre, and they are seen to arise from the same place in the superior animals; 2d, some parts of this nervous system are developed in the upper classes of the invertebral animals, as the cephalopodous mollusca, so as to resemble the brain; finally, in these same animals we see a second nervous system, which corresponds to the sympathetic nerve, and which communicates with the other, in the same manner as in the superior animals. Let us also add, that if Ackermann's hypothesis be correct, there should be a period of life when the sympathetic nerve is much greater than the brain and spinal marrow, or at least should be largely developed in proportion to them; but this is not the case. Besides, the experiments of Le Gallois have proved that the life of the sympathetic nerve and of the organs animated by it depends on the spinal marrow,(3) which could not be true if this nerve were formed before all the other parts of the brain, and if the spinal marrow were only an expansion from it.

According to Ackermann's hypothesis, the spinal marrow is not formed before the brain. This physiologist thought to reverse the argument drawn from acephalous monsters, by saying that in this monstrosity the brain is never primitively deficient, but that it has been destroyed by disease; but this etiology of acephalia is admissible only when it is applied to monsters which have the body perfectly developed, but not the skull. There, in fact, every circumstance induces us to think that the brain, developed more or less irregularly according to the primitive type of the fetus, has been destroyed by an accumulation of serum. But we must distinguish these cases from the true acephalia, where most of the upper half of the body is deficient, and there is no trace of its having been destroyed. Besides, even when this argument in favor of the priority of the spinal marrow is refuted, all the others retain their weight.

§ 199. It is then almost demonstrated, that *the spinal marrow is that part of the nervous system which is first seen.* But the brain soon appears at its upper extremity. This conjecture seems very probable

(1) Carus (*loc. cit.*, p. 79) has made good use of these reasons; but, unless we are much mistaken, he has collected them against himself.

(2) At least Ackermann's reason is incorrect, that the sympathetic nerve, as an inferior nervous system, must develop itself in the class of animals lower than where the more exalted brain and spinal marrow are found.

(3) Le Gallois, *Exp. sur le principe de la vie*, Paris, 1812, p. 151.

from the progressive development of this organ in the fetus and in the animal series, since those parts which are situated the farthest forward, and are consequently the most distant from the primitive source of the spinal marrow, are developed the slowest, that is, they appear and enlarge the last. So too the great sympathetic nerve develops itself in front of the spinal marrow, in the form of a series of ganglions, which communicate with it and with each other by medullary cords. The brain and sympathetic nerve retain the distinctive characters of secondary formations longer than the spinal marrow. They preserve them even through life, since the different masses of ganglions which form them do not unite in one, but represent a series of organs more or less similar, as in the nervous system of the invertebral animals. On the contrary, the spinal marrow forms a single mass, in which we distinguish only two lateral parts, and which, examined from one extremity to the other, no where resembles a series of ganglions. The great sympathetic nerve, which is only an imperfect repetition of this organ, appears later even than the brain, if we may judge from its imperfect appearance; for its component masses are still more distinct and separate than those of the encephalon.

§ 200. The nervous system, proportionally speaking, is much larger, softer, and moister in the early than in the subsequent periods of life. The reason that the proportion of the liquids exceeds that of the solids is that the parietes of the permanent cavities are much thinner when the organism is younger, and because some of its cavities, as that of the spinal marrow, are soon obliterated.

The texture of the nervous system differs remarkably at different periods of life in this respect, that at first there is no distinction between the gray and the white substance, and that all the nervous mass has at first a grayer tint.

It whitens in the nerves and in the spinal marrow sooner than in the encephalon, within which the medullary substance is darker than the gray substance, even sometimes after birth: this arises from its great number of vessels.

The lower parts of the brain assume their medullary appearance before the upper portions.

The nervous system differs also in other respects at different periods of life. At first, its surface is perfectly smooth, and its proportional size and the forms of its different parts do not remain the same. Thus, at first the spinal marrow fills the whole length of the vertebral canal, the cerebellum is smaller than the tubercula quadrigemina, and these are as large as the cerebrum.

§ 201. As the *sexual differences*, we shall mention that the volume of the brain is larger in proportion to the nerves and the rest of the body in females, than in males; and for the differences of races, that the nerves are proportionally larger in the negro.

ARTICLE SECOND.

OF THE NERVOUS SYSTEM IN THE ABNORMAL STATE.

§ 202. We shall commence the history of the anomalies of the nervous system by that of the accidental injuries with which its form may be affected, as this will naturally lead us to speak of its power of regeneration.

The changes in the structure of the nerves, caused by the wounds of these organs, differ much from those seen in other parts of the body in similar circumstances.

When a nerve is divided, its extremities always swell into a larger or smaller tubercle.(1) The color of this tubercle is grayish, and it is often so hard and solid that the scalpel glides off when cutting it, and the sound resembles that from cutting cartilage. The size of this tubercle is in direct ratio with the abundance of cellular tissue, and to the time which has elapsed since the wound. It not only enlarges in time, but also becomes harder.

The tubercle of the upper extremity is smaller, but as hard as that of the lower. That portion of the nerve below the section, withers and loses its distinctive color.

In amputations, this tubercle seems not to develop itself exactly at the extremity of the divided nerve; at least, Van Horn(2) has found that an inch above the wound, the nerves were blended with the granulations of the muscles, and could not be distinguished from the mass. One month after the operation, they were reddish internally and externally, and the tubercle distinguished from the end of the nerve by its whiteness, was then situated still higher. The lower end of the nerve is wasted more or less, like that of all other organs. Finally, the tubercles are seen both in the small and the large branches of the nerves, and they remain apparently during life.

§ 203. If the lower part of the nerve has not been removed, it unites with the upper portion. But observers are not agreed on the nature of the uniting substance. Some think it real nervous substance, while others consider it simply as a cellular tissue, or coagulated lymph, which can never acquire the peculiar structure of the nerves. Hence the dispute in regard to the regeneration of these organs.

There are two ways of ascertaining if an organ be renewed; these are, to study its functions, and to investigate the nature of the substance formed in place of the portion removed. The first method is very uncertain, since the mechanical arrangement of the nervous system is such, that the nerve which is divided may be replaced by the anastomosing filaments, and a substance imperfectly analogous to that which

(1) Arnemann, *Ueber die Reproduction der Nerven*, Gottingen, 1786, p. 48.—Id. *Versuche über die Regeneration der Nerven*, Gottingen, 1787.

(2) *De iis quæ in partibus membri, præsertim osseis, amputatione vulneratis notanda sunt*, Leyden, 1803, p. 33–35.

normally exists, is sufficient to unite the two extremities so perfectly, that the functions may be performed with perfect regularity. The second method is more certain, but is also liable to deceive.

Cruikshank,(1) Haighton,(2) Fontana,(3) Monro, Michaelis,(4) and Mayer,(5) reasoning from different researches, have admitted that the nerves have the power of perfect regeneration. Arnemann, on the contrary, thinks himself authorized, by numerous observations, to deny it. He states(6) that the extremities of the nerves are always united by cellular tissue, condensed by inflammation, which sometimes acquires the hardness of cartilage, and fills up the space more or less perfectly, accordingly as the nerve was more or less surrounded with cellular tissue, and that it gradually and slowly becomes consolidated with the two extremities of the nerve. Munro(7) has also found that the newly formed substance has always a deeper color.

Fontana believed that true nervous substance was reproduced in some cases where he had removed from the intercostal nerve, a portion six lines in length, because that the nervous filaments passed uninterruptedly through this substance, in going from one end of the nerve to the other.

Michaelis removed portions of nerves, nine or ten lines long, and found, after eight weeks, that the extremities of these nerves were united, by a substance perfectly similar or nearly so, to the nervous substance. The transition from the old to the new nerve was but slightly perceptible by the microscope.

Mayer, having removed portions one or two lines long, found the extremities of the nerves reunited by filaments more or less fine, which, like the true nervous substance, did not dissolve in nitric acid; but, on the contrary, became harder, and consequently possessed one of the most essential qualities of this substance.

Haighton divided in a dog the pneumogastric nerve on one side, and six weeks after, that of the opposite side; in six months the animal had entirely recovered. But all dogs in which the two par vagum nerves were cut simultaneously or shortly after each other, died. Hence he concluded, that death did not occur in the first case, because the wound of the nerve was cicatrized perfectly in six weeks. Still the function might have been performed by the other nerves, which, perhaps, had enlarged. If this was the case, the animal would continue to live when the two pneumogastric nerves were divided simultaneously. Haighton repeated this experiment, but the animal died: proving that the functions were re-established, because the substance of the nerves was reproduced.

(1) *Experiments on the nerves, &c.* in Reil, *Archiv.* vol. ii. p. 57-81.
(2) *Experiments on the reproduction of the nerves,* ibid. p. 79.
(3) *Versuche über das Viperngift,* part ii.
(4) *Ueber die Regeneration der Nerven,* Cassel, 1785.
(5) Reil, *Archiv für die Physiol.* vol. ii. p. 449.
(6) *Loc. cit.* p. 47.
(7) *Ueber das Nervensystem,* p. 94.

Arnemann has rejected all those experiments in favor of the reproduction of the nerves, in which they were merely divided and no portion of them was removed, saying, that in these cases there was no reproduction. But the difference in the cicatrization of wounds, with or without loss of substance, is only in degree ; since the simple wounds do not unite immediately, and the lymph which transudes gives rise to a new substance which joins their two extremities. The above mentioned experiments seem to authorize the belief, that the new substance, which is homogeneous in the wounds of all organs, may gradually become real nervous tissue. Farther, we cannot conclude that this new substance is not nervous, because its characters differ from the old nervous substance ; for the bones, when newly formed, also vary in form and structure from those which are old.*

Wounds of the encephalon, when attended with loss of substance, also cicatrize by a new substance there developed, which is unlike the normal substance of the organ. It is more yellowish, and more easily distinguished from the gray and the medullary substance. The yellow substance of the brain resembles it the most. Its tissue is loose and soft, and sometimes entirely mucilaginous. However, the circumvolutions of the brain are sometimes formed from it. It generally closes the wound entirely, its edges approaching the centre. Another circumstance very favorable to the cicatrization of wounds of the brain, is the enlargement of the ventricle on the diseased side, while neither life nor health are affected. We sometimes find a viscous or coriaceous matter within the new cerebral substance, which Arnemann thinks is formed by the coagulable lymph, thrown out from the wound of the temporal muscle. It is firmer and redder than the new cerebral substance, and is usually filled with new vessels.(1)

§ 204. The principal anomalies in the form of the nervous system are :

1st. Its absence, totally or partially. A deficiency of the whole system is rare,(2) and is usually attended with an imperfect development of the whole organism, which is undoubtedly caused by it.

A partial deficiency is more common. Usually a greater or less portion of the brain is absent, and it sometimes happens that the spinal marrow does not exist, or that a part of it is wanting. Sometimes the whole brain is deficient, while the spinal marrow is perfectly developed. This state, attended or not with the imperfect formation of the adjacent parts of the body, is called *acephalia*, or more strictly *anencephalia*. We shall mention its principal characters when we

* M. Flourens, in a Memoir in the *Ann. des Sc. Naturelles*, Feb. 1828, states that, having repeated the experiments of Fontana, Montana, Cruikshank, and others, on the reunion of the divided extremities of the same nerve, he sought to determine the effects resulting from uniting the ends of different nerves ; he therefore kept them in contact—Union took place in every instance. In some of the cases, the return of the function was complete ; in others, it failed. In all, the transmission of irritations by the united nerves was perfect.—*Am. Med. Journ.* no. vii., May, 1829.

(1) Arnemann, *Versuche über das Gehirn, und Rückenmark*, Gottingen, p. 187.

(2) The only case we know is that mentioned by Clarke, *Phil. Transact.* 1793, p. 154-164.

have described the brain.(1) We shall only say here, that the absence of the spinal marrow (at least such as might be considered original) has never been observed in a fetus where the brain was perfectly developed, and that anencephalia is more frequent in the female than in the male.

In regard to the nerves, they are rarely wanting. The first degree of this anomaly is the partial interruption of a nervous trunk ;(2) of this the nervous system of organic life (§ 182) sometimes furnishes examples.

The nervous system is never doubled, nor multiplied, at least when the body is not.

2d. An excess or deficiency of volume.

An excess in size is rare when the structure of the nervous system is otherwise normal.(3) As to the contrary state, an abnormal smallness, although the nerves never are deficient, this is not more common than original deviations of formation. Atrophy or wasting of the nervous system is seen more frequently ; it may be primitive, as in tabes dorsalis, or consecutive, and accompanied by the loss of the function of the organ. Thus, when the eye is destroyed, the optic nerve wastes. The nerve, however, then becomes not only thinner and finer, but its texture changes, it hardens, is grayer, and more transparent.

We may here mention the dropsy of the nervous system, where the solids have not the same relation to the fluids, which often accumulate in enormous quantities. This state is congenital more frequently than it is developed after birth. In the first case, the whole nervous system is generally affected ; in the second, it is confined to some of its parts, principally to the encephalon; its more intimate relations must be mentioned in the description of the brain and nervous system.

3d. Anomalies of situation and form, particularly if congenital, are very rare. These also belong to descriptive anatomy. Among the accidental, we should distinguish lacerations, to which the brain is exposed, from an effusion of blood within it. The changes which occur in this organ belong to special anatomy.

§ 205. Among *the alterations of texture* of the nervous system, we mention:

1st. Anomalies in the color. This is rarely seen, unless accompanied by other alterations of texture. The whole or a part of the nervous system, however, is more or less tinged with yellow in jaundice.

2d. The abnormal softness and hardness exist alone or together ; so that one portion of the nervous system is much harder and another much softer than usual.

Weinhold asserts that the nerves are unusually soft or fluid in persons affected with typhus.(4) The brain is sometimes softer and sometimes harder than usual in maniacs. Frequently, too, it is harder in some

(1) See our *Path. Anat.* vol. i. p. 195.
(2) See our *Path. Anat.* vol. i. p. 392.
(3) See our *Path. Anat.* vol. i. p. 392.
(4) Hufeland, *Prakt. Bibliothek*, vol. xxxi. p. 501.

points, and softer in others, in people disposed to epilepsy. In hydrocephalus, its parietes are generally thinner and softer.

§ 206. *New formations* in the nervous system are not rare. Repetitions of the normal tissue are extremely uncommon. Bones and fat are the only parts, to our knowledge, which appear, sometimes in the substance of the brain, more rarely in the nerves around them. But it is by no means uncommon to find accidental osseous tissue in the dura mater.

On the contrary, abnormal formations of different kinds are not rarely developed either in the substance or on the surface of this system, especially on that of the brain.

Encysted tumors connect these repetitions of the normal tissues with the new formations. They contain various liquids, and are more rare in the nerves than in the encephalon, particularly in the ventricles and choroid plexuses.

Very hard rounded tumors, of a yellowish white color, perhaps like the fibro-cartilages, as they have a fibrous structure, are sometimes found in the nerves,(1) and also in the brain. When developed in the nerves they occupy the intervals between their fibres.

The brain is also frequently the seat of white, hard, round tumors, very analogous to scrofulous tumors, which would doubtless be found also in other portions of the nervous system, if they were carefully examined. They are almost always united to the cerebral substance. Some other tumors, resembling fungous tumors, and which perhaps are a repetition of the mucous tissue, are more rarely found, but only in the brain. They are red, very vascular, soft, and adhere but slightly to the substance of the brain.

Finally, loose hydatids develop themselves both in the ventricles of the brain, especially in the lateral ventricles, and even in its substance. In treating of the special anatomy of the nervous system, we shall examine these anomalies more in detail.

OF THE SPECIAL ORGANIC SYSTEMS.

§ 207. After the description of the general organic systems follows that of the special (§ 16).

Among these we consider, 1st, The osseous system, inasmuch as several circumstances in the history of the other systems are to be fully understood only by an acquaintance with it, especially with its external form.

(1) Cheselden, *Anatomy of the human body*, p. 256, tab. 28.—Home, *An account of an uncommon tumor found in one of the axillary nerves*, in the *Trans. for the improv. of med. and surg. knowledge*, vol. ii. no. xi.—Spangenberg, *Sur les gonflemens des nerfs*, in Horn, *Archiv. für med. Erfahrung*, vol. v. p. 306.—Alexander, *De tumoribus nervorum*, Leyden, 1800.—Wood, *On painful subcutaneous tubercle*, in the *Edinb. med. and surg. journal*, vol. viii. no 31 and 32.

SECTION FOURTH.

OF THE OSSEOUS SYSTEM.

§ 208. The bones(1) are solid parts, of a yellowish white color, connected by different kinds of attachment, and so firmly united as to constitute a whole, representing exactly the form of the body. They may be considered, 1st, In regard to themselves; 2d, In relation to their connections with each other.

ARTICLE FIRST.

OF THE OSSEOUS SYSTEM IN THE NORMAL STATE.

I. OF THE BONES.

A. GENERAL REMARKS ON THE BONES.

§ 209. The bones differ principally from other organs by great hardness and solidity, which permits them in a measure to form the base of the whole body. These qualities render them susceptible of forming levers, on which the muscles act to produce motion. Hence they may be called the *passive organs* of *locomotion*.

§ 210. The great hardness of the bones is the immediate result of their chemical composition. In fact, they contain more of the phosphate of lime than any of the organic parts. A chemical analysis of the bones proves that they are formed principally of two substances; one soft and of an animal nature, the other hard and solid. The first is principally *gelatin*, hence the form of the bones, and their slight degree of flexibility. The other consists almost entirely of phosphate

(1) Most authors, who have written on the bones, have not only described them generally, but also each particular bone. We shall mention here the former only. Some treat of the bones only in their normal state, as A. Monro, *Anatomy of the bones and nerves*, Edinburgh, 1726.—Cheselden, *Osteography, or the anatomy of the bones*, London, 1733.—Bertin, *Traité de ostéologie*, Paris, 1754.—J. Sue, *Traité de ostéologie*, with plates, Paris, 1759.—Blumenbach, *Geschichte der Knochen*, Gottingen, 1812. On the structure of the bones in general we may consult Malpighi, *De ossium structurâ*, in his *Opp. posth.*, Venice, 1743.—D. Gagliardi, *Anatome ossium novis inventis illustrata*, Leyden, 1723.—Havers, *Osteologia nova, or some new observations on the bones*, London, 1691.—*Description exacte des os, comprise en trois traités*, by J.-J. Courtial, J. L. Petit and L. Lémery.—De Lasòne, *Mémoire sur l'organisation des os*, in the *Mém. de Paris*, 1751.—J. F. Reichel, *De ossium ortu atque structurâ*, Leipsic, 1760.—B. S. Albinns, *De constructione ossium*, in the *Annot. acad.* lib. vii. c. 17.—Scarpa, *De penitiori ossium structurâ commentarius*, Leipsic, 1799.—Malacarne, *Auctuarium observationum ad osteologiam et osteopathologiam Ludwigii et Scarpæ*, Padua, 1801.—As to the pathological anatomy of the bones, besides the works of Cheselden, Courtial, and Malacarne, the following are important to consult: A. Bonn, *Descriptio thesauri ossium morbosorum Hoviani*, Amsterdam, 1783.—*Musæum anatomicum Ac. Lugd. descriptum ab. E. Sandifort*, Leyden, 1793.—C. T. Clossius, *Ueber die Krankheiten der Knochen*, Tubingen, 1798.

of lime. From the latest and most accurate analysis of Berzelius,(1) the bones contain,

Of gelatin, completely soluble in water, - - - - - -	32.17
" insoluble animal matter, - - - - - - - - - - -	1.13
" phosphate of lime, - - - - - - - - - - - - -	51.04
" carbonate of lime, - - - - - - - - - - - - -	11.30
" fluate of lime, - - - - - - - - - - - - - -	2.00
" phosphate of magnesia, - - - - - - - - - - -	1.16
" soda and hydro chlorate of soda, - - - - - - - -	1.20

The proportions of these constituent principles, however, vary both in the same bones of different men, and in the different bones of the same man, to say nothing of the variations dependent on age and the state of health. Thus the petrous portion of the temporal bone contains in general more earthy substance than the other bones.(2)

§ 211. The color of the bones is yellowish white. We can make no general remarks in regard to their form; they vary so much in this respect we are obliged to divide them into at least three classes, *the long bones*, *the broad bones*, and *the short bones*. All these bones differ from each other, not only in form, but in texture: this, however, presents certain general conditions in all bones, which should be first studied, more especially as the three classes differ only by trifling shades.

§ 212. All the bones resemble each other in texture, inasmuch as they are formed essentially of fibro-cellular tissue, of which the fibres and cells are closer, and consequently less apparent at the circumference than internally. Hence we distinguish in the bones a cortical or *compact* substance, (*substantia compacta seu corticalis*,) and an internal called the *spongy*, or *cellular substance*, or the *diploe*, (*substantia spongiosa*, *cellulosa*, s. *diploe*, s. *meditullium*). But this distinction is not essential: for 1st, it does not exist when the bones are formed, nor during the early periods of their existence, since we find only the spongy substance. 2d. We sometimes see the compact substance change into a spongy substance, or at least all differences between them are effaced when their vitality is exalted by disease. Farther, if the compact substance of regularly formed bones be treated by chemical agents, and the lime be removed, we recognize they are formed in the same manner as the diploe. Finally, there is always an inverse relation between the quantity of the two substances in different parts of the same bone; that is, in thicker parts the compact substance alone exists, or at least in greater proportion than the other,

(1) See in Gehlen, *Journal für die Chemie*, vol. iii. part 1. p. 1. However, according to the analysis of Fourcroy and Vauquelin, (*Annales de Chimie*, vol. 47, no. 141,) of Hildebrandt, (Schweigger, *Journal für Chemie und Physik*, vol. viii. part 1, p. 1,) human bones seem not to contain magnesia.

(2) Several instances may be seen in Monro, (*Outlines of the anatomy of the human body*.) From the analyses of Davy in a subject, all the bones of the head contain more earthy substance than the long bones.

while in the parts which are more extended it forms only a thin layer, and incloses a considerable portion of the spungy substance.

§ 213. The fibres and laminæ which compose the bones are not simply applied one against the other, so as to extend the whole length, breadth, or thickness of a bone,(1) or to go from its centre to the circumference. They incline so many different ways, one against the other, and unite so frequently by transverse and oblique appendages and processes, that great anatomists have been deceived by this arrangement, and have doubted the fibrous structure of the bones. Nevertheless, this conclusion is not perfectly correct. Notwithstanding those curves and anastomoses of the fibres, the fibrous structure always remains very apparent, and it is correct to say that the dimension of length exceeds the other two in the texture of many bones. This predominance is very well marked during the first periods of osteogeny, for at a later time the fibres are so applied against each other that it is difficult to distinguish them. But these longitudinal fibres never exist alone;(2) there are many oblique and transverse ones, from the first periods of ossification, and they are even from the beginning so multiplied, that the number of longitudinal fibres is not so much greater as at a subsequent period, when the fibres approach nearer, so that the transverse become oblique, until at last, from the increase of bone, the latter at first view seems composed of longitudinal fibres only. The transverse and oblique fibres do not form a separate system; they continue uninterruptedly with the longitudinal, which they unite to each other.

§ 214. The fibres and laminæ, arranged in this manner, unite in several superimposed layers, and form the thickness of the bones;(3) these layers, it is said, are united only by fibres and intermediate laminæ, the mechanism of which, according to Gagliardi, who has imperfectly described them, is very complicated. It is true that continued maceration, the action of the air, and calcination, reduce the bones into several thin layers, adjusted to each other: it is also true that a part of a bone affected with necrosis is usually thrown off in a layer, varying in breadth and thickness; but these three agents act too violently and too destructively for us to draw any certain conclusion from the phenomena they produce. As to necrosis, the form of the sequestrum depends only on the extent and thickness of the diseased part.

§ 215. The bones present eminences and depressions which differ much in form and importance. The eminences are of two kinds. One species serves for the insertion of the muscles or ligaments, and is consequently always connected with the fibrous organs, since the muscles are never attached to the bones but by a tendon. The others relate to the kind of motion performed by the bones. The former are usually rough and irregular, and are destitute of cartilage; the latter

(1) According to Havers, *loc. cit.* p. 33–37.

(2) Hildebrandt pretends that the transverse or oblique fibres are formed after them, (*Anatomie*, vol. i. p. 77, § 54.)

(3) Gagliardi, Havers, Reichel.

are smoother, more regular, and surrounded with cartilage. The eminences which project and are long in proportion to the body of the bone, are usually called *processes*, or *apophyses* (*processus*, *apophysis*); the *tuberosities* (*tuber*), and *tubercles* (*tubercula*), are those which are shorter, but broad and uneven; the *styloid process* (*stylus*) is cylindrical and thin, and the *spinous process* (*spina*) is small, thin, sharp, and pointed; the *crest* (*crista*) is more extensive, smooth, and strongly projecting; *rough lines* (*lineæ asperæ*) are those which are extended, not very prominent, but so broad that we distinguish in them two *lips*, (*labia*,) as in some of the preceding.

The apophyses are designated by terms drawn from certain analogies. Thus a round articular process is called a *head* (*caput*), and a *condyle* (*condylus*) when flatter. The heads and condyles are usually supported by a narrow portion of bone, called the neck (*collum*, *cervix*).

§ 216. The *depressions* serve for the articulations of the bones with each other, for the insertion of muscles and ligaments, for the passage of vessels and nerves, or for the nervous system in general.

The first are supplied with cartilages, the second are roughened, and the third are always smooth and more or less round.

The *glenoid cavity* (*cavitas glenoidea*) is a shallow articular cavity; a deep one is called an *acetabulum*, or a *cotyloid cavity*, (*cavitas cotyloidea*.). The depressions, whether larger or smaller in the substance of the bone, and which have a narrow orifice, are called *sinuses* (*antrum*, *sinus*,) or *cells* (*cellula*) according to their size.

Most of those which serve for the attachment of muscles and ligaments, are called *pits*, (*fovea*, *sinus*.)

Those which lodge vessels or nerves are sometimes narrow, and called *grooves*, (*sulcus*, *semi-canalis*,) sometimes they are broader, and called *notches* (*incisura*) when they occupy the surface only. When they traverse the bone from one part to another they are called *fissures* (*fissura*) or *holes*, (*foramen*,) according to their size: if they extend some distance they are called *channels* (*canalis*) or *canals*.

We must here remark generally that the arrangement of the depressions for the passage of the nerves and vessels, is not always perfectly similar even in two sides of the same subject, since we sometimes find a hole or canal on one side, while on the other is only a foramen.

The different eminences and cavities are formed sometimes only by a single bone, sometimes by the union of pieces of several bones; the first is more common.

§ 217. Most of the important apophyses are formed by a special nucleus of bone which gradually unites with the rest of the bone, that is, with its *body*, and which is not entirely blended with it until the stages of its growth are completed. It is generally believed that the elevations and the depressions in the bones result from mechanical causes, from pressure and the traction of the organs which are attached to them, or which are there inserted. In fact certain circumstances seem to justify this explanation. Thus the corrugations for the insertion of the muscles are more apparent in proportion to the power of these muscles and their frequency of contraction: hence they are not very distinct in children, and always less so in the female than in the male. The origins of these corrugations are generally explained in this manner; but the solidity and hardness of the bones do not allow us to admit such a theory; probably the action of the muscles contributes only remotely to this result, increasing the nutrition in the whole part, and thus favoring the more perfect development of the bone. If these corrugations for the insertion of the muscles arose from a mechanical cause, we should not find depressions: but when examined with attention we often find a cavity in which the tendon lies, as is seen for example in the humerus, the radius, and the fibula. The depressions of the bones are produced immediately by the muscles opposing the development of the osseous substance in the place where they are inserted, so that when their activity is increased and their size augmented, the cavity of insertion becomes greater, because the development of the bone is prevented to a greater extent.

This is the only way in which we can admit that the furrows, destitute of cartilages, in which the tendons glide, are partially produced and enlarged by a cause purely mechanical. The tendon, which is formed at the same time as the bone, prevents the formation of the latter in the part corresponding to it, and opposes its development still more, in proportion as its surface is oftener compressed.

The presence of a nerve or vessel opposes the accumulation of cartilaginous or osseous substance in the part corresponding to it. The channels of the arteries are evidently caused by the pulsations of the vessels, which not only hasten absorption, but prevent the deposition of new nutritious matter. In the fetus, where the bones of the skull are united to each other less firmly, and do not inclose the brain so strongly, so that the vessels of the dura mater cannot press on them with so much force, the arterial channels are scarcely visible; they are very slight and superficial during the first year; but they gradually become deeper as the bones of the skull are more closely united, because the pulsations of the arteries then act on a single point. This is proved especially by the depressions, and even the openings in the bones of the skull, which correspond to the glands of Pacchioni, which must be considered as the remote cause of the disappearance of the bone in the places on which they act.

But the cavities developed within the bone and which open externally, as also those which communicate with the nasal fossæ cannot be attributed to mechanical causes, though Ackermann has pretended they are produced by the air. They depend necessarily on the mode of development of the bones in which they are observed. This is demonstrated because we trace them even in the fetus, because they are not developed in certain parts of the body to which the air has free access, and because their number, extent, and even existence in different animals, have not the least connection with the greater or less exposure to the air of the bones which contain them.

§ 218. The organic tissues which form an essential part of the structure of the bones, are 1st, *the periosteum;* 2d, *the vessels;* and 3d, *the medullary system.*

§ 219. The periosteum belongs to the class of fibrous organs. (§ 16.) It covers the bones entirely, and is attached to them by a very short cellular tissue, and also by the vessels which pass into the bones. The only points to which it does not extend, are those where the bones articulate with each other: it there passes from one to another, either in one piece or in several distinct fasciculi. The first arrangement is seen in the immoveable articulations, and the second in most of the moveable joints. In several bones, but not in all, the fibres of the periosteum are parallel to those of the bones which it surrounds, and the external are more extensive than the internal. The vessels ramify in its tissue before they penetrate the substance of the bones. It furnishes prolongations which line their course, but which do not unite to the medullary membrane: hence it performs a certain part in the formation of the bone, and when destroyed to a considerable extent, that portion of the bone below it dies, although generally at the surface. In fractures, the osseous substance is never regenerated until a new periosteum forms: thus it appears first in parts most remote from the fracture, where the periosteum has not been destroyed. These phenomena prove that the periosteum and bone are allied in regard to their mode of formation: but they do not authorize the assertion that in ossification the periosteum becomes bone.

§ 220. The opinion that bone is formed by the change of the periosteum, and not by the action of the vessels of this membrane, has been sustained by Duhamel,(1) and rests on the following arguments:

1st. In the fetus the periosteum of the same bone is membranous in some parts and osseous in others: it presents the first character in its extremities, and the second in its centre. It is thicker at the extremities, and is there composed of several layers.(2)

2d. Several prolongations of the periosteum penetrate between the apophyses and the body of the bone: the whole apophysis is even formed by the periosteum, as are also the adjacent ligaments and tendons.(3)

3d. In the fetus and during youth the apophysis is attached to the body of the bone by the periosteum alone, so that it is only necessary to remove this membrane to separate them.(4)

4th. The different colors of the osseous layers, when the animal has or has not been fed with madder, demonstrate the same thing.

(1) *Memoir on the bones, Mem.* 1 and 2, in the *Mém. de l'ac. des sciences,* 1741; *Mem.* 3, *ibid.,* 1742; *Mem.* 4-7, *ibid.,* 1743.

(2) *Mem.,* 1743, p. 132-164.

(3) *Ibid.,* p. 163.

(4) *Ibid.*

5th. The same remark applies to the formation of callus. There the periosteum swells around the fracture and becomes proportionally harder, especially in its inner part: during the first days, the hardened parts above the fracture may be removed with the periosteum; afterward this operation is no longer possible, and there then remains a layer of bone, while a portion of the tumor may be removed with the periosteum. Sometimes the external periosteum unites with the internal to produce callus.

6th. The periosteum is sometimes hardened in exostosis.

§ 221. But 1st., the statements under the first head are not perfectly true, for although in the fetus we always find a thin, gelatino-cartilaginous layer between the periosteum and the bone, this is never continuous with the periosteum. We never find the periosteum osseous in one part and cartilaginous in another.

2d. The prolongations sent by the periosteum into the bone, do not prove that these two organs are the same, and that the first is changed into the second. In fact, the periosteum is united more intimately to the cartilage than to the bone: but still this does not demonstrate the identity of cartilage with it and with the tendons.

3d. It is not true that the cartilage is attached to the bone only by the periosteum, for even after this membrane is removed, continuity still exists between the two organs as before, without any medium.

4th. The difference in color of the layers of the bone prove only that the bone is formed by depositions from without.

5th. The phenomena of the formation of callus prove only that the periosteum inflames from the influence of a mechanical cause which has acted in it, and that a new substance forms between it and the bone, in which the new bone is developed, and which adheres to the latter. On the contrary, attentive examination of the formation of callus demonstrates that in this case, as in that of primitive ossification, a cartilage is formed, in which a bone appears afterwards.(1)

6th. The periosteum does not always thicken in exostosis, and even when this thickening occurs, it proves nothing, as it may be merely a new phenomenon.(2)

Let us add also that bones often form without periosteum as in all abnormal ossifications.

§ 222. The vessels of the bones are not very large, and are generally of two kinds. Some arterial trunks, although few in number, penetrate even the substance of the bones; others ramify excessively in the periosteum before entering into their tissue. The first penetrate farther forward, and serve principally for the secretion of the marrow, or of a fluid analogous to it; for whenever there is a medullary organ, they expand in this membrane. They serve also to nourish the internal and looser tissue of the bone. The others remain in the external compact substance. These two orders of vessels, however, frequently anastomose together; so that when the trunks are obliterated, we find their

(1) *Mem.* 1741.
(2) *Ibid.*

branches and twigs full of blood, as in the normal state. There are as many kinds of veins to correspond to the different kinds of arteries. These vessels have also special holes through which they penetrate into the bone; those which give passage to the large trunks are called foramina (*foraminia nutritia*) of nutritions, although this term is not exactly applicable.(1) We do not find lymphatics, except on the surface of the bones; nor do we distinctly perceive nerves in these organs.

§ 223. The *marrow*(2) (*medulla ossium*) is inclosed within the bones; it is an oily or fatty substance, and its characters vary in different parts.

In the cavities of the long bones, which are entirely filled, and hence are called the *medullary canals*, it is thicker, more solid, more yellow, and

(1) The arteries enter the bones by three divisions: 1st, by ramuscules, which fill the capillary holes of the surface of the whole osseous system; 2d, by branches which enter by larger foramina in the surfaces of the short bones and in the extremities of the long bones; 3d, by branches called nutritious, which penetrate the bones through the foramina of nutrition. The 1st and 2d divisions of these arteries are mostly formed of capillary branches; they penetrate the osseous tissue, pass through it, and terminate in it exclusively: these are truly its arteries of nutrition. The 3d is composed of much larger branches, which proceed into the internal cavities of the bones, through the canals of nutrition. The branches which compose it are distributed to the medullary membrane, and seem unconnected with the nutrition of the osseous tissue, which they do not penetrate.

The first two divisions are not accompanied with any vein. We observe them, on the contrary, around the third, and they correspond exactly to the number and volume of the arteries which compose it; but they are not sufficient to return all the blood distributed to the bones by the three kinds of arteries, and carry back that only which was brought to the vascular membrane. The proper veins of the osseous tissue were discovered by Dupuytren (*Prop. sur quelques points d'anatomie, de phys. et d' anatomie path.*, Paris, 1803) in the bones of the skull. They have since been recognized in all the other bones of the body, whence they emerge by numerous openings of a diameter sufficiently large, through which we do not observe that any arterial ramification enters, even after the most successful injection; they are observed particularly in the flat and short bones, and in the extremities of the long bones. At some distance from where they emerge from the bones they terminate in the venous system. They arise from the osseous tissue by numerous radicles, which unite, like those of common veins, to form twigs, branches, and trunks, which, after passing through the spungy tissue, leave it, and penetrate the compact tissue to open into the adjacent veins, by a canal always smaller than that of which it is the termination. The osseous canals, through which they pass, are formed of compact tissue, which apparently extends from the surface of the bones to their interior. In these canals, directly covered by the membrane of the veins, are numerous channels, through which the simple veins pour the blood which had existed in the osseous tissue. As to the veins themselves, they are composed simply of the internal membrane of the venous system, folded into numerous valves. They have no cellular membrane externally. They resemble, then, the venous sinuses of the cerebrum, as the fibrous envelop furnished to the latter by the dura mater is replaced by bony walls, on the surface of which the thin, transparent, and unresisting internal membrane is closely applied, so as not to admit of motion, nor to exercise any action on the blood which traverses the venous canals.

There is a remarkable analogy between the spungy tissue of the bones and its venous canals, on one part, and the corpora cavernosa of the penis and clitoris, on the other. In fact, the veins are arranged to form the corpus cavernosum of the penis exactly in the same manner as the spungy tissue of the bones of the skull, and of the extremities of the long bones. Replace the osseous cells by a fibrous network, and line this network by the inner membrane of the veins, and we have an exact idea of the arrangement of the corpora cavernosa. In some anmials, the fibrous tissue does not exist, and the cavernous tissue is formed only by the veins, which then, by their numerous communications, resemble the spungy or reticulated tissue of the bones. F. T.

(2) Grutzmacher, *De ossium medullâ*, Leipsic, 1758.

contained in a proper and very thin membrane, which forms numerous small vesicles. Like the fat, it is composed of round globules, often varying in size; so that the medullary organ seems to be only a portion of mucous tissue. The membrane which contains the marrow has been called the *internal periosteum;* but it is distinguished from the true periosteum, the fibrous periosteum, although it resembles it in its great vascularity. In fact, it is in this that the nutritious vessels of the bones are expanded. (§ 222.)

The marrow of the broad, irregular, and short bones, that also in the ends of the long bones, differs much from that contained in the bodies of the long bones: 1st, because it is not surrounded with a membrane; 2d, because it has less consistence, and contains less fat; 3d, because it has a reddish color. It appears to be in immediate contact with the osseous tissue, and to arise from the vessels which penetrate within the bone.

We have not been able as yet to discover nerves in the medullary membrane; but, from the experiments of Duverney(1) and Bichat,(2) confirmed by us, it seems to be very sensible. Bichat says its sensibility is more marked as we approach the exact centre of the bone. We have not found this to be the case.(3)

While the bone is cartilaginous, there is no appearance of marrow. We cannot say, with Bichat, that the medullary organ exists before the canal, and that it is filled only with a cartilaginous substance, which is afterwards replaced by the marrow.

The marrow does not develop itself till ossification commences. But several years after birth it is much redder and more fluid than in the adult, and not fatty.

This state reappears in disease, especially when nutrition is interrupted to a great degree, as in patients affected with phthisis.

The functions of the marrow are very obscure.

We may consider it as diminishing the brittleness of the bones.

It is difficult to decide if its uses relate directly to nutrition. Some have thought this to be the case, because bones die when the marrow is destroyed; but this conclusion is not correct, since this phenomenon may depend solely on the intimate organic connection between the two organs.

We think the existence of the marrow is connected with the whole organism, rather than with one bone in particular, and, like the fat contained in the rest of the mucous tissue, that it is a provision of nutriment in reserve.

(1) *De la struct, et du sent de la moelle*, in the *Mém. de Paris*, 1700.

(2) *General anatomy*, vol. iii. p. 112.

(3) Experiments and pathological observations leave us in doubt in regard to the sensibility of the marrow, which some authors, and Bichat among the rest, have much exaggerated. Lebel, while extracting a sequestrum five inches long, most of which comprised all the thickness and all the circumference of the tibia, was obliged to tear the medulla, the surface of which was flesh-colored. He did not irritate it to discover to what extent it was sensible, but held it for some seconds; the sick person did not complain; and he was unable to determine what part it could take in the pain of extracting the sequestra. The medullary membrane was inflamed, and therefore was more sensible than in the natural state.—*Journ. compl.*, vol. v. pp. 312, 313. F. T.

§ 224. Although the bones are hard and solid, they have a certain degree of elasticity; this property varies according to circumstances. They cannot change their volume by the action of irritating substances, but have the power of extending and contracting to a certain degree. This change, however, is not transient: when they extend, there is almost always an increase in their mass; and when they contract, there is a diminution in volume. The first case takes place when they are mechanically extended, and depends on a separation of their constituent molecules. The other seems to take place even when there is an increase in mass; for instance, when a distended bone collapses, and an opening is obliterated by the wasting of the nerve or vessel to which it gave passage. A similar phenomenon is observed when the alveolar processes are absorbed after the extraction of the teeth.

In the normal state the bones have no animal sensibility; for the injuries which affect them cause no pain. Facts which seem to prove the contrary have been furnished by bones not entirely formed, or which are diseased, conditions in which sensibility is highly developed in them.

§ 225. This circumstance seems to contribute, at least in part, to the slowness with which ossification takes place. The bones are of all organs the last to appear, and arrive at perfection, either in the animal series or in the fetus; all their diseases progress slowly, compared with those of other organs. But, on the other hand, this circumstance contributes to render ossification the most perfect of all the formative acts of the body; for no other solid possesses the power of reproduction in so great a degree. Not only is a simple fracture united by a substance which, in form, chemical composition, and functions, is almost identical with the normal osseous substance, but portions of bone and whole bones, after having been destroyed, are repaired, not in fact in their form, but in their volume, their relations with the adjacent parts, and their functions, of which we shall treat more particularly when speaking of the anomalies of the bones.

§ 226. The bones, both in respect to form and chemical composition, pass through several periods of formation before attaining their term of perfection; and when they have reached it, they descend from it by several successive changes.(1) The changes which occur in them,

(1) Sue, *Sur les proportions du squelette de l'homme, examiné depuis l'âge le plus tendre jusq'à celui de vingt-cinq, soixante ans, et au-delà*, in the *Mém. prés. à l'Ac. des sc.*, vol. ii., Paris, 1755, p. 572–586.—H. Eysson, *Tractatus de ossibus infantis cognoscendis, conservandis, et curandis*, Groningen, 1659.—V. Coiter, *Tractatus anatomicus de ossibus fœtus abortivi, et infantis dimidium annum nati*, Groningen, 1659.—R. Nesbitt, *Human osteogeny*, London, 1753, in 8vo.—J. Baster, *De osteogenia*, Leyden, 1731.—A. Vater, *Osteogenia*, Wittemberg, 1735.—B. S. Albinus, *Icones ossium fœtus*, Leyden, 1737.—J. A. Ungebauer, *De ossium trunci corp. hum. epiphysibus sero osseis visis earumdemque genesi*, Leipsic, 1739.—B. S. Albinus, I. *De generatione ossis.* II. *Quædam de prima ossium natura disceptatio*, in *Annot. acad.*, l. vi.—Idem, *De generatione ossium*, in *Ann. acad.*, l. vii. no. 6, 1764 and 1766.—Perenotti, *Mémoire sur la construction et sur l'accroissement des os*, in *Mém. de Turin*, vol. ii. 1784.—C. F. Senff, *Nonnulla de incremento ossium embryonum imprimis graviditatis mensibus*, Halle, 1781.—J. F. Meckel, *Considérations anat. et phys. sur les pièces osseuses qui enveloppent les parties centrales du syst. nerv.*, in the *Journ. compl.*, vol. ii. p. 211.—M. Troja, *Osservazioni ed esperimenti sulle ossa*, Naples, 1814.—M. Medici, *Esperienze intorno alla tessitura organica delle ossa*, in the

from their first appearance to their period of perfection, are remarkable, because their different periods of development correspond, and often with surprising exactness, to permanent states in animals. Like all other organs, the bones are softer the nearer the fetus is to its origin. At first they are not firmer than the other parts. In a few weeks they harden; and are then cartilaginous, and become more and more consistent. The cartilages which at this period occupy the future places of the bones differ from the latter, as their structure is not fibrous, and as we can perceive neither cellules nor medullary cavities, and as they constitute a solid and entirely homogeneous mass; but this mass possesses the external form of the bone, and like it is covered with a periosteum. Towards the eighth week the vessels of some of these cartilages commence carrying red blood instead of the colorless liquid they hitherto contained. It is then that ossification really commences. First the cartilage becomes softer and looser, always at its middle part; it disappears finally, and in its place we see a fibro-cellular tissue, composed of gelatin and phosphate of lime. This change into cartilage and bone, does not commence in all the bones at once; but there is this constant relation between these two acts, that the bones whose cartilages appear first are the first to ossify, and that in each bone in particular the first osseous germs are found precisely in the points where the cartilages first show themselves.(1)

There are but a few bones formed of a single nucleus. In most of them we see different and separate osseous germs, which are connected together for a longer or shorter period only by cartilage, and which are gradually united; so that it is only when the whole body has acquired its growth that all traces of the primitive separation are effaced. In certain bones, as the sacrum, these traces never disappear. In regard to the order of ossification for the different parts and for the whole bone, there are general laws with respect to the form, size, and number of the nuclei of bone, and to the period when ossification commences, either generally or particularly; but we cannot discover the general cause of the succession to which entire bones and their different constituent parts are subjected in their appearance.

§ 227. The general laws of osteogeny are:

Opusculi scientifici, Bologna, 1818, p. 93-107.—Medici, *Considerazioni interno alla tessatura organica delle ossa, in riposta alle oppos. fatte del S. D. C. Speranza et dal S. A. Scarpa*, Bologna, 1819.—*Rapport de Cuvier sur le Traité des lois de l'ostéogénie*, by Serres, in the *Journ. compl.*, vol. iii. p. 67.—Lebel, *Réflexions sur la régénération des os*, same journal, vol. v. p. 309.—Schultze, *Considérations sur les premières traces du système osseux*, same journal, vol. vi. p. 113.—Béclard, *Mémoire sur l'ostéose*, in the *Nouv. journ. de médecine*, vol. iv. 1819.—Dutrochet, *Observations sur l'ostéogénie*, in the *Journ. de physique*, 1822, Sept.—See also the first note to this section.

(1) J. Howship has remarked that in many bones, especially in the diaphyses of the long bones and the central portions of the broad bones, ossification takes place immediately, that is, the osseous state is not preceded by cartilage. (See his *Microscopical observations on the structure of bone*, in the *Medico-chirurg. trans.*, vol. vi.-x, London, 1815-1819.) Béclard, (*Gen. Anat.*, trans. by Togno,) admits this opinion, and describes the progress of ossification very precisely in the following passage: "Ossification does not every where 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

1st. Ossification commences in the substance of the cartilage; so that the nucleous of bone is entirely surrounded with cartilage.

2d. Ossification begins in the centre of the whole bone and of each nucleus of bone. The bones increase from within outward; so that the external layers appear after the internal. This arrangement is demonstrated by experiments made by feeding animals with madder. When killed after this substance has been mixed with their blood, the internal surface of the bone is always white, the external red. We may in this manner produce a number of layers alternately white and red, by suspending and resuming the use of madder.(1) Still the substance of the internal layers is also constantly renewed; for if we kill an animal which is at first nourished without madder, but to whom the coloring matter is afterwards given, and then suppressed, the internal part of the bone is alone found red, and the external is white.(2)

The bones increase in length and breadth; so that the new substance is not only added to their extremities and edges, but penetrates the mass already existing. In truth, Hunter, having observed that two holes made in a long bone of a young animal were not separated from each other by its growth, has deduced another conclusion;(3) but Duhamel's experiments, which were made previously and with greater care, prove that the English anatomist was wrong, and that the development of the bones at the centre is much slower and arrested much sooner than at their extremities.(4)

3d. In the successive formation of the different parts of bone, (§ 226,) the largest appear the first. We should hence conclude that the largest bones are those which are first seen. But although, if we except the teeth and the small bones of the ear, the small bones appear

state. The other parts of the system are at first cartilaginous, and in them 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 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. In proportion as the bone increases, the cartilage, successively perforated by cavities and canals lined by sheaths and blood-vessels, gradually diminishes, and at length disappears. The canals of the cartilages 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 spungy cavities, invested with membrane, and filled with adipose marrow. The bone afterwards becomes less vascular as age advances." F. T.

(1) Duhamel, *Sur le dével. et la crue des os*, in the *Mém. de Paris*, 1742, p. 497, 498.

(2) Home, *Exp. and obs. on the growth of bones*, in the *Trans. for the imp. of med.*, vol. ii. xxiii.

(3) *Trans. for the imp. of med.*, vol. ii. p. 279.

(4) *Cinquième mémoire sur les os*, in the *Mém. de Paris*, 1743, p. 187, 188.

later than the large bones, we also remark that the middle-sized bones are usually formed before the largest. Thus the scapula, the bones of the pelvis, and the long bones of the extremities, appear long after the clavicle and the lower maxillary bone are formed; and there is a period when the clavicle, which in a full-grown man is scarcely one fourth of the size of the humerus, is equal to six times its volume.

4th. The bones and their different parts arrive at perfection in the order of their formation. Thus the two arches of the vertebræ appear long before the body, and their posterior extremities are fused together long before the anterior unite to the body.

5th. The cylindrical bones, with few exceptions, form and are perfected before the flat bones, and the latter before the short bones. Thus the clavicle, the ribs, the lower jaw, and the large bones of the extremities, are very far advanced when scarcely any traces appear of the occipital and frontal bones, which are flat bones, and the only short bone visible is the upper jaw. This law applies also to the constituent parts of the different bones. Several short bones, especially those of the carpus or the tarsus and the patella, contain no nucleus of ossification in the full grown fetus, and it is only at the sixth month of pregnancy that ossification commences in the sternal cartilage. The body of the cylindrical bones and the arches of the vertebræ are formed and developed much sooner than the processes of the former and the bodies of the latter: but the parts which are here the last to appear correspond to the short bones in every respect. This law is very remarkable, because it is intimately connected with the power of reproduction in the different bones. In fact, the bones which are formed and developed the soonest are the most easily and the most completely reproduced when they have been accidentally destroyed: the flat bones are reproduced with more difficulty than the long bones, and the short bones, slower than all the others. These two conditions seem to depend on the law, that the organic formation is founded on a force not differing from that on which the electrical phenomena depend, and which acts principally in the direction of the length.

6th. The order in which the bones are developed in the human fetus seems to depend on that according to which they appear in the animal series. We cannot doubt this in regard to the jaws and clavicle, which are so highly developed in the fishes, nor to the sternum, the bones of the pelvis, and the other bones of the extremities, which are developed so imperfectly in the fishes and the cetaceæ.

7th. The destination of the bones appears to exert some influence on the rapidity of their formation and development. This is instanced in the early appearance of the jaws, which are so much needed, and the slow development of the sternum and bones of the pelvis, which are the last to arrive at perfection, because the cavities which they circumscribe must necessarily be closed late.

8th. The same relation does not exist in the development of all the bones in regard to form and volume. In certain bones, particularly the long bones, the different pieces composing them do not unite until they begin to increase in length, or even till this is finished. In others, such as the short bones, several flat bones, and some irregular bones, all the parts are united long before the bones have attained their full growth. Even at the age of twenty, maceration detaches the epiphyses from the bodies of the long bones, while the pieces of the sphenoid, frontal, and occipital bones and of the vertebræ are united in the early periods of existence.

9th. The mode of development of each bone, in relation to its appearance and completion in the form and volume of its pieces, is in general subject to laws; but there are also exceptions to these laws, and these are more numerous in some bones than in others. Of all bones the sternum presents the most numerous and the greatest variations in regard to the number, size, form, and situation of the osseous nuclei which gradually produce it, and even also in regard to the time of their appearance. This phenomenon is more remarkable, as the sternum is the very last bone which appears; whence these variations in its formative type seem to occur, because the energy of the formative power begins in some measure to be exhausted. The bones too which form the arch of the skull are less constant in their development, since it is not rare that some of their component pieces are developed separately, and never unite to the others, which explains the formation of the ossa wormiana.

10th. The chemical composition of the bones is not the same at all periods of life. In general we may state as a principle, that the earthy substance is less in proportion to the animal parts, the younger the bone is. In a person even fifteen years old the proportion of the earthy to the animal substance was found to be nearly one fifth less than in an adult.(1)

11th. The structure of the bones is looser, more spungy, and softer in infancy, which coincides perfectly with their chemical composition. Thus, at first appears only a simple tissue of fibres and layers differently interlaced, in which there is no hard substance.

12th. As to the external form, the bones are rounder and less hard and angular in infancy than at a more advanced period; their eminences and depressions are also much less marked. In general, therefore, their surfaces are smoother and more uniform.

13th. The bones are more flexible and elastic in youth than in advanced age. Hence why external violence produces at this period only slight changes, curves, and impressions, while they afterward give rise to solutions of continuity. Hence fractures are more common in aged people.

§ 228. The great difference in every respect between the cartilage and the bone has induced anatomists and physiologists to seek out the cause of the change of cartilage into osseous tissue. To explain

(1) Davy (in Munro's *Anatomy of the human body*, Edinburgh, 1813, vol. i. p. 36.) found, for instance, that the femur in a child fifteen years old was composed of .53 of animal substance and .47 of earthy substance, and in an adult, of .375 of animal matter and .625 of earthy matter.

this phenomenon satisfactorily, two problems must be resolved, viz.: 1st. On what ground is there a period when cartilage is changed into bone? 2d. How does this change take place? It is more than doubtful if the first question is ever resolved with certainty. The phenomenon to which it relates belongs to a general law of every organized formation, that the fluids predominate the more, the nearer the fetus is to its origin. We may attach to the second, two different senses, and ask either a simple statement of the phenomena presented by the change of cartilage into bone, which has been treated of above, or the indication of the means by which this change takes place. But we cannot explain this phenomenon more readily than that of the successive changes which supervene in all the other organs. Besides, it is very singular that we should be lost in conjecture only in regard to the formation of bone, and that all the other organs, which present as great differences at different periods of life, are entirely neglected. The only thing certain is that all the theories of ossification are either vague or false; and that in the latter case, the more mechanical they are, the farther they are from the truth. Of this character are the following: that the arteries are filled with osseous juice, which obstructs and tears them; that the arteries of the cartilages gradually ossify; that bone takes the place of cartilage; that the periosteum gradually changes into bone; and that the cartilage is only penetrated by the osseous substance. Ossification essentially consists in the formation of a new organ different from cartilage. It is then an act of nutrition of an entirely different character which acts upon this part of the organism. The existing matter is taken up more rapidly in some places than in others; hence the formation of a medullary canal and of cellular and spungy tissue, instead of a solid, homogeneous, cartilaginous substance. But at the same time the act of nutrition itself changes; since a medullary organ and fibres composed of gelatin and phosphate of lime are formed. This change depends on that which occurs in the activity of the instruments of nutrition, the vessels designed for bringing and carrying away the nutritious fluid.

§ 229. When the bones have acquired their normal situation, and the different pieces which gradually unite to form them are fused in a single mass, they increase more or less in thickness also.

§ 230. But the thickness of the bones diminishes much in old age;(1) so that they lose their weight, and break more easily, as much for this reason as because they have become more fragile. The greater fragility depends principally on an increase of earthy matter; for dead bones are broken more easily in proportion as they lose their animal substance. Davy found in the occipital bone of an adult 64.0 of earthy matter, and 69. in that of an old man.(2) Still this rule does not seem to apply to all bones; at least Davy found that the

(1) F. Chaussard, *Recherches sur l'organisation des vieillards*, Paris, 1822.—Ribes, *Sur les changemens que le tissu osseux subit par les progrès de l'âge et l'infuence de diverses maladies*, in the *Bull. de la fac. de méd.*, vol. vi. p. 299.

(2) Davy, *loc. cit.*, p. 36.

lower jaw of an old person where the alveolar processes were entirely effaced contained 43.4 of animal substance and 56.6 of earthy matter, while the relation between these two substances was as 42.8 to 57.2 in a child, and as 40.5 to 59.5 in an adult ;(1) but the lower jaw of the old person was more fragile.

§ 231. The sexual differences of the bones are generally the greater thickness, asperity, and prominence, of the processes in man ; the smallness and roundness of their form in woman. But many of the bones differ also in the two sexes very strikingly : a change of form coincides with a difference of function, as especially in the bones of the pelvis. But these differences can be examined only in special anatomy. So too, and with greater reason, it is with the difference of races, as they appear principally in the form of the different bones.

B. PARTICULARS OF THE DIFFERENT CLASSES OF BONES.

§ 232. The different classes of bones, (§ 210,) beside the general characters of bones, present certain peculiarities which deserve to be studied.

§ 233. The *long* bones are those in which the dimension of length much exceeds the other dimensions. We find the extremities (*apophyses*) broader than the central part, the *body* (*diaphysis*) ; this increases their lightness and their articulating surfaces, and renders luxations more difficult. The body is generally cylindrical, but we can almost always easily distinguish three faces, separated from each other by more or less acute edges. Some of the long bones form, in a measure, the transition from this class to that of the flat bones ; for, although long and narrow, they are not thick ; whence they appear not round, but flat : such are, for instance, the ribs. The lower jaw resembles the flat bones still more. The bodies of these bones are never perfectly straight, or at least except in rare cases, and only during the early periods of life. They are usually a little arched or curved, and do not possess the same thickness in every part. The form of the extremities of each long bone varies according to its uses ; it is in direct relation with the greater or less degree of mobility in the limb whose base it constitutes. As to their internal composition, these bones are peculiar ; as their body is more or less hollowed, and the medullary organ exists in their cavities. These cavities are not found towards the extremities of the bone ; but in their place there is a loose fibro-cellular tissue, which seems developed at the expense of the compact substance ; since the latter diminishes, and is insensibly reduced to a thin layer, in proportion as the spungy substance accumulates ; while in the centre, where the latter does not exist, it is very solid, and it is one or two lines thick in the largest long bones. The ribs and lower jaw, which by their external form mark the transition of the proper long bones to the flat bones, differ also from the real long bones

(1) Davy, *loc. cit.*, p. 36.

by the absence of a medullary cavity. They are entirely filled with spungy tissue.

The long bones are principally found in the limbs, of which they form the base. They diminish in volume, and increase in number, as their distance from the trunk increases. The number, form, and other relations of these bones are essentially the same in the corresponding parts of the extremities. The upper parts are the most movable; still those which form the first articulation of the fingers and toes are more movable than those of the middle and anterior.

The cylindrical bones are generally formed of three pieces. We however find more in several of them. Of these pieces, one corresponds to the body, the other two to the extremities. The central piece developes itself long before the other two, and at the exact centre of the bone, in the form of a thin straight cylinder. The extremities do not ossify till after birth, and are not completely fused with the body until its growth is perfect. The spungy substance is not however confined to their inner parts: it appears also in the extremities of the body properly so called; but here it is finer and longer, and consequently is more fibrous, than in the extremities.

§ 234. The *flat* bones are nearly as broad as long, but they are less in thickness. Most of them are more or less convex on one face, and concave on the other: their outer and inner faces are usually parallel. This form depends on the functions they fulfill; for they serve especially to form cavities, which arise from a certain number of flat bones solidly articulated to each other. Many of them, especially those of the cranium, are surrounded with teeth, which, penetrating reciprocally, form the most solid species of articulation. These bones are not much thicker on the edges than elsewhere; the other flat bones, however, resemble the long bones, inasmuch as their edges are very thick, particularly in those points where they articulate to each other, and also in those where muscles are attached to them.

The compact and spungy substances are uniformly extended every where in the flat bones. The compact substance forms an internal and an external *layer* or *table*, (*tabula vitrea*,) between which the spungy substance (*diploœ*) is formed. In a few of the flat bones, especially the smallest, as the ossa unguis and the lower portion of the septum bone of the ethmoid, the spungy substance is deficient; and here the two tables are blended together into one. The proportion between the inner and outer substances is not the same in all. Thus, for instance, in the ossa ilia the external is much thinner and feebler, and the internal looser, than in the bones of the skull.

Still there are cavities more or less extensive in some flat bones; but their uses are not the same as those of the cavities found in the long bones. They are not filled with marrow, but contain air, open externally, and are appendages or prolongations of the nasal cavity.

Most of the flat bones arise by several points of ossification, which form one after another. There are at least two lateral nuclei, which unite sooner or later on the median line, as we see in the frontal bone, and even to a certain extent in the parietal bones. But in some others also these lateral parts gradually develop themselves by several points, as in the occipital and sphenoidal bones, the ossa ilia, and the scapula. Here likewise, as in the long bones, the apophyses, which correspond to the short bones also, constitute at first as many distinct pieces of bone. The flat parts also, which may generally be termed the *scaly* or *squamous portions*, (*squammæ*, *partes squammosæ*,) arise from several separate nuclei. The different nuclei of these bones almost always join in the articulations, where ossification takes place last, while when the pieces touch in other parts, they soon unite. This arrangement is seen in the development of the coxal bones (*ossa ilia*) and of the occipital bone, where it seems to favor the enlargement of the articular cavities, and perhaps depends partly on the mechanical action of the bones articulated on this point. The flat bones are formed not only by the successive union of several pieces of a certain extent, which remain separate a longer or shorter time: there are developed also at the circumference of the largest nucleus of bone, along its edge, and at various times, a number of other germs, which are entirely distinct, and very different in respect to number, size, and situation, and which gradually fuse with each other and with the principal piece, which primitively existed. Sometimes these small nuclei, and even larger pieces, those which are formed after a more constant type, remain insulated, abnormally: thus we see different kinds of wormian bones appear, which result for the most part from the development being suspended, and which occur most frequently in the parts where several bones come together so as to leave between them vacant spaces called *fontanelles*.

§ 235. In the *short* or *thick* bones no one dimension much exceeds the others. Their form is more or less rounded, and they are also distinguished from the other bones by their greater irregularity. In their tissue they resemble the flat bones and the extremities of the long bones, as they have no cavity, and the compact substance is every where filled with spungy substance. These bones are always united in great numbers, either lengthwise, as in the vertebral column, or breadthwise, as in the tarsus and carpus, and are so disposed that as a whole they have extensive motions, while they move upon each other but slightly. This is in part the ground of their great irregularity of form; for their surfaces present numerous elevations and depressions, which serve for the attachment of the ligaments. Some of these bones have a more complex form than others; and the same is true of their functions: thus each vertebra has a large opening, and resembles a ring, because intended not merely as a lever for the attachment of the muscles which are there inserted, but also as the reservoir of an organ, the spinal marrow.

There is a particular class of short bones, the *sesamoid* bones, which we shall mention when speaking of the fibrous system.

§ 236. Besides these classes of bones there is still a fourth, which may be called the *mixed bones*, for they seem produced by the blending of bones of several classes, principally of the second and third, being composed of flat and short portions. The sphenoid, temporal, and ethmoid bones are examples of this class; even the occipital bone belongs to it. The vertebræ mark the transition between it and the class of short bones. These bones are always developed by several nuclei, one of them having the characters of the short bones, and the others those of the flat bones. The latter are usually more numerous than the others. Almost all these bones inclose cavities which communicate with the nasal fossæ.

Finally, we will remark that comparative anatomy proves that the same bone changes its form in different animals in such a manner that it belongs to another class. These differences are not then very essential, and depend on the whole form.

II. OF THE ARTICULATIONS OF THE BONES.

§ 237. The articulations of the bones differ much in respect to their modes of union and to the extent of motion they permit. It is a general law, but subject at least to one exception, that the corresponding portions of bone are covered with cartilages (5th section) or with fibro-cartilages, (6th section,) and that accessory fibrous ligaments (7th section) extend from one bone to another, which circumscribe and cover the points surrounded with cartilage.

§ 238. Generally we may consider the difference of mobility and the arrangement of the modes of union as furnishing the base of a classification of the articulations. Still they are not perfectly identical, since the same degree of mobility may be obtained by different means. Thus, the bones which articulate by straight and even, or by very uneven surfaces, but which correspond perfectly, although not united, and which are firmly attached by very short and tense ligaments, have as little motion as those whose surfaces adhere to each other in all their extent by means of a mass of cartilage.

The best mode of classifying the articulations is according to the forms of their corresponding surfaces, and also to the arrangement of the means of union; since on these depends the difference in their degree of mobility.

§ 239. The forms of the corresponding surfaces, and the arrangement of the means of union, are such that the bones can or cannot play upon each other. In the first case, the surfaces not covered with cartilage are not united except at their circumference, and there is no mean of union between them; this is called a *movable articulation*. In the second case, a cartilaginous or fibro-cartilaginous mass extends from one surface to the other, and unites them together; this is called an *immovable articulation*.

§ 240. The *movable articulation*, or the *joint*, (*articulus*, *junctura*, *diarthrosis*,) presents several varieties, depending on the form of the contiguous surfaces. These may be referred to five principal forms:

1st. The *loose joint*, (*arthrodia*,) where a large globular extremity, or a head, fits a plain surface of small extent. The articulation of this species possessing the most motion is that of the humerus with the scapula. We must refer to the same class those of the fingers and toes with the carpus and tarsus, and the radius with the humerus. Other things being equal, the motion is more free as this head is larger in relation to the surface to which it is applied, and as the head is rounder, and this surface is flatter. Farther, the form of the articular surfaces being the same, the degree of motion varies much, according to the tension and the greater or less number of the ligaments.

2d. *Enarthrosis* is where a large head corresponds to a deep rounded cavity. Many anatomists do not consider this species as a separate articulation, but call it an arthrodia. The articulation of the femur with the iliac bone and of the lower maxillary bone with the temporal bone, are examples. Here too the motions are freer, more capable of being performed in all directions, and more extensive in each direction, as the contiguous surfaces are rounder.

3d. The *turning joint*, or *hinge joint*, (*ginglymus*.)(1) It consists in such an arrangement of the articular surfaces as will admit of motion in only one direction; so that the bones can only approach and recede from each other, be flexed or extended. This effect is produced in two modes. Sometimes a simple surface having an oblong protuberance corresponds to another surface which presents the same form hollowed, and from one of the bones a considerable process extends on each side, which permits no motion except that from before backward: such is the articulation of the foot. Sometimes one of the articular surfaces has two lateral heads, separated by a large hollow; and that which corresponds to it presents on the sides two hollows, between which is an elevation: we see an instance of this in the articulation of the humerus with the upper extremity of the ulna, and in that of the femur with the tibia. The articulations of the first phalanges with the second, and of the second with the third, of the fingers and toes, are between these two forms. We see in the first, the middle cavity and the eminence which corresponds to it are replaced by external processes. Still the articulation of the first offers a slight and indistinct index of the second form.

4th. The *rotatory joint*, (*rotatio*, *diarthrosis*, *trochoides*.) The corresponding surfaces are small sections of a cylinder, and one of the bones turns on its axis, at the same time revolving on that of the bone with which it articulates. But the motion is never sufficiently free for one of these bones to turn entirely on its own axis; and even where the arrangement of the surfaces would permit it, as, for instance, where the articular surface of one of the bones extends all round its extremity, there are other arrangements, dependent on the structure of the bone itself, which permit it to make at most but a semi-revolution on its axis. We see instances of this joint in the articulation of the upper and lower extremities of the radius with the ulna, and that of the first cervical vertebra with the odontoid process of the second.

(1) Isenflamm resp. Schmidt, *De ginglymo*, Erlangen, 1783.

5th. The last kind of this movable articulation is the *close joint*, (*amphiarthrosis, diarthrosis, s. junctura stricta, ambigua, synarthrotica.*) Two straight or differently formed articular surfaces, having numerous elevations and depressions which exactly correspond, are forcibly applied against each other by short ligaments, which go from the circumference of one to that of the other. The usual consequence of this arrangement permits only an almost imperceptible sliding of the connected surfaces. This kind of articulation belongs particularly to the short bones, which unite to form in some measure a single bone flexible in several parts. We see it in the carpus, the tarsus, the vertebral column, and the ribs.

§ 241. The *immovable articulation* (*synarthrosis*) also offers several varieties in its form and degree of immobility. As the corresponding osseous surfaces are generally united in all their extent by a cartilaginous or fibro-cartilaginous mass, they can never glide upon each other: still the bones are sometimes slightly displaced, from the length and elasticity of the mass which unites them, and the flatness of their corresponding surfaces. Several anatomists admit also a third kind of articulation, between the movable and the immovable joint, called the *mixed*, or *semi-movable*, (*articulatio mixta, amphiarthrosis, symphysis.*) But, as this articulation is essentially the same as the immovable in respect to the arrangement of the uniting substance, and as the articulations which become immovable by age were at first movable, when, the intermediate mass being softer and larger, the extremities of the bones were placed at a greater distance from each other, it appears more proper to consider the mixed articulation only as a species of synarthrosis. The different varieties of the latter are,

§ 242. 1st. *Symphysis.* It consists of two plain surfaces, united by a mass more or less thick and elastic, which allows them to separate and approach each other insensibly. When this intermediate mass is cartilaginous it is called *synchondrosis*, and *synneurosis*(1) when it is ligamentous or fibro-cartilaginous. The articulation of the different parts of the sternum is an instance of the first, and that of the ossa pubis and of the ossailia with the sacrum, of the second.

§ 243. 2d. The *suture*, (*sutura*,)(2) an articulation found only in the head. It consists essentially in the union of long narrow surfaces or edges by a very thin layer of cartilage, whence results an entire want of motion. The degree of this immobility varies with the arrangement of the contiguous surfaces. The principal kinds of sutures are,

a. The *false suture*, or *harmonia*, (*harmonia, sutura spuria*,) in which edges perfectly straight, or at least but slightly serrated, are connected: such are the ossa unguis and ossa nasi with the adjacent bones and with each other.

(1) This is not the usual acceptation of this word; but we ought not to attach any other meaning to it when we wish to mark the two kinds of symphysis by the nature of the mass which unites them.

(2) Duverney, *Lettre concernant plusieurs nouv. obs. sur l'ostéologie*, Paris, 1689.—Bosc, *De suturarum cranii humani fabricatione et usu*, Leipsic, 1755.—Gibson, *On the use of the sutures in the skulls of men and animals*, in the *Mem. of the society of Manchester, second series*, vol. i. 1805, p. 317-328.

b. The *true suture*, (*sutura vera*,) which also presents several varieties, according as the joint becomes more solid from the multiplicity of the points of contact.

Immediately after the harmonia comes,

1st. The *scaly* or *squamous suture*, (*sutura squammosa*.) The surfaces of the two adjacent bones are gradually formed like a swallow's tail, the one being sloped to receive the other for a considerable extent. At the same time the contiguous surfaces are more or less serrated, but the processes are feeble: we will mention as an instance the articulation of the temporal bones with the occipital bone.

2d. The *serrated suture*, (*sutura serrata*.) Small and plain projections and cavities alternate with each other, both from above downward and across, along the perpendicular and narrow edge, and correspond to similar cavities and processes of another bone; so that each bone presents a double range of elevations and depressions. The upper part of the frontal suture is almost always formed after this type.

c. The *dentated suture* (*sutura denticulata*) also arises by single processes and cavities, which alternate with each other on a perpendicular edge; but the elevations are higher and the cavites deeper, and they form only one series. We see an instance of this arrangement in the sagittal suture.

d. The *margined suture* (*sutura limbosa*) much resembles the preceding; but the processes and cavities are larger, and are often subdivided. It sometimes happens also that the processes of one bone are fitted obliquely to those of another. Still the first condition is the most essential, as the second also occurs more or less in the preceding sutures. The occipital suture belongs to this series.

Here we must observe that these four kinds of sutures with teeth pass from each other by insensible shades. Thus, the inferior part of the frontal suture generally makes the transition from the squamous to the dentated suture, since the frontal bone glides under the parietal bone to a considerable extent; but the oblique portion by which the two bones are united is separated from the rest of the surface by a very sensible prominence, and its internal part is in fact perpendicular.

We find also in the same suture different parts, each of which belongs to the last three sutures, and others which cannot be referred to any. We should particularly consider that the same suture does not belong to the same class in all skulls. The sagittal and even the lambdoidal suture is sometimes only a dentated suture, while the frontal suture is often a very complex margined suture, and in other cases extends almost in a straight line. Even the squamous suture of the temporal bones is sometimes changed into a dentated suture. Generally, when one suture is more complex and consequently more solid than usual, the others are so in the same proportion, and *vice versâ*; so that the bones of the skull are articulated more firmly in some subjects than in others. It is also a rule, that one and the same suture is far more complex on its outer than on its inner face, where it usually forms nearly a straight line.

The sutures are found only in the head, and arise necessarily from the manner in which the bones of that part are developed; for ossification commences there in several points at once, and the bones increase by the addition of new osseous substance to their outer circumference. Hence also they are often effaced in one point or another when the bones are entirely developed. Before this period the dentated edge which exists in them, and by means of which the parts of bone are attached to each other, is very impoitant to the solidity of the articulations. Thus we find similar irregularities on these surfaces of bone, not provided with cartilage, which are joined so as to glide slightly on each other: as the bones of the pubis, the iliac bones, &c.

§ 244. 3d. *Gomphosis* is where a bone implants itself like a wedge in the cavity of another, which embraces it closely, envelops it in most of its length, and retains it very solidly, although they are not united. This kind of articulation is seen only in the head: the insertion of the teeth in the jaws is an instance.

§ 245. The movable articulations do not change much during life, while those which are immovable, as at least the sutures and gomphosis, vary considerably. In the early periods, large spaces, filled by the internal and external periosteum, exist between the bones which are separated by a layer at first thin and mucilaginous, and afterward cartilaginous. Still their edges are more unequal during the early periods of uterine existence than in the adult, because the rays of bone which leave the point of ossification to go there are very numerous, and separated from each other. But this form does not seem to prove that the tendency to produce these sutures is manifested from that time, since at an earlier period, when the edges of the bone are already approximated, they are much straighter, and even more so than when the development is perfect. The edges do not even touch in a fully grown fetus, and we observe between them, in those parts where the several angles of the bones are afterwards united, large spaces called *fontanelles*, (*fonticuli*, *fontes pulsatiles.*) Even after the bones are in contact with each other, we may establish as a general law, that the sutures gradually become more complex by age, and acquire still more solidity, not only by the increase of the principal processes, but by the formation of secondary processes on their surfaces.

This union of the bones by sutures, which becomes in time more and more intimate, finally degenerates into complete fusion. There are general laws for the manner in which this fusion takes place, and the greater or less frequency with which certain sutures disappear; but there are none for the period at which it commences.

The general law relative to the manner in which this fusion occurs is that the internal edge of the sutures disappears before the external edge. It is a common thing in young subjects to find all the sutures of the head effaced internally, while they are perfectly preserved externally. We never observe an opposite arrangement. So, too, one suture never disappears in all its extent at once; but obliteration usually commences at a single point, whence it gradually extends to the whole suture.

In regard to the second general law, the bones of the face are blended together much more rarely than those of the skull. Even among the latter there are some which are united much oftener than others. But we shall reserve the details on this subject for the section in which we shall examine the bones of the head particularly.

What proves the impossibility of assigning any general law in regard to the period when the obliteration of the sutures commences, is that they are sometimes found entirely effaced in the fetus at birth, that they are sometimes though rarely fused during the early years of life, and that they are not unfrequently perfectly preserved in old subjects; generally, however, the suture disappears only at the latter periods of life, while they fuse partially on the internal face very soon after the individual is perfectly developed; and also in most subjects who have attained the age of thirty, the whole suture or some parts of it disappears on this side.

Gomphosis changes very much during life; for the teeth are at first much smaller than the cavities which receive them, and which do not as yet compress them.

ARTICLE SECOND.

OF THE OSSEOUS SYSTEM IN THE ABNORMAL STATE.

I. OF THE BONES.

§ 246. The bones not unfrequently vary from the normal state in respect to all their characteristic qualities.

The primitive deviations of formation(1) are not equally common in all the bones. Those of the cranium, and among them the occipital bone, are those which offer the most, and the bones of the extremities those which present the fewest. These defects of formation consist generally in a suspension of the development; and their frequency must at least be ascribed in part to the circumstance, that in many animals, even those allied to man, the bones of the skull seem to stop regularly at these degrees of evolution. It is, however, remarkable, on the other hand, that the bones of the face usually vary little from the normal state to produce analogies with animals: for instance, the perfect development of the intermaxillary bone is very rare. It is not probable that such a difference depends on the high perfection of the brain of

(1) Sandefort, *De ossibus, diverso modo, è solitâ conformatione abludentibus*, in the *Obs. anat. path.*, lib. iii. c. 10, lib. iv. c. 10, p. 136–141.—Van Doeveren, *Observationes osteologicæ, varios naturæ lusus in ossibus humanorum corporum exhib.*, in the *Obs. acad. specim.*, Leyden, 1765.—Rosenmüller, *De ossium varietatibus*, Leipsic, 1804.

man, since the anomalies of the skull are generally attended with the imperfect development of this viscus.(1)

§ 247. The deviations in formation of the bones which may supervene at all periods of life are, first, *solutions of continuity*.

The bone is broken either by a cutting instrument, when there is a *wound*, or by a bruising body, which causes a *fracture*, (*fractura.*)

The solution of continuity may be *total* or *partial*. The fracture is *transverse*, *oblique*, which is most common, or *longitudinal*. When the development is perfectly complete, they supervene with equal facility in all parts of the bone; but when the epiphyses are not yet united, they are usually detached by mechanical lesion, or by those diseases which destroy the tissue of the bones. (2)

The parts may heal in both cases, not merely when there is simply a solution of continuity, but also a comminuted fracture, when the bone is broken into several pieces, and there is a considerable loss of substance. The detached fragments sometimes unite, even when placed in contact with healthy portions.

The progress of formation is exactly the same as in normal ossification.(3) A gelatinous substance is effused around and between the fragments, which gradually hardens, and becomes cartilage, within which several nuclei of bone afterwards appear, which fuse with each other and with the broken parts, surrounding those also which have been perfectly detached. At the same time the fragments and splinters become round, so that the adjacent parts may not be wounded by their asperities.(4) To produce this formation of new osseous substance, it

(1) Most of the principal deviations of formation in the bones are mentioned in the first volume of our Pathological Anatomy, under the heads *Anencephalia*, *Hydrocephalus*, *Hernia cerebri*, &c.

(2) Reichel's monograph on this subject is excellent, *De epiphysium ab ossium diaphysi deductione*, Leipsic, 1769.

(3) Boehmer, *De ossium callo*, Leipsic, 1748.—Id., *De callo ossium è rubiæ tinctorum pastu infectorum*, Leipsic, 1752.—Haller, *De ossium formaturâ*, in the *Opp. min.*, vol. ii. p. 460.—P. Camper, *Observationes circa callum ossium fractorum*, in the *Essays and observations phys. and liter.*, vol. iii., Edinburgh, 1771.—Bonn, *De ossium callo annex. ejusd. descr. thess. oss. morb. Hovian*, Amsterdam, 1783.—A. H. Macdonald, *De necrosi et callo*, Edinburgh, 1799.—Béclard, *Propositions sur quelques points de médecine*, Paris, 1813.—Breschet, *Quelques recherches historiques et expérimentales sur le cal*, Paris, 1819.—J. Sanson, *Exposé de la doctrine de Dupuytren sur le cal*, in the *Journ. univ. des sc. méd.*, vol. xx. p. 131.

(4) The most ancient explanation we possess on the mode in which these solutions of continuity of the bones unite, attributes this consolidation to a kind of viscous fluid, more lately termed the *osseous juice*, or the *coagulable lymph*. According to the ancients, this fluid exuded from the surfaces of the fracture, gradually became consistent, and reunited the fragments in the same manner as isinglass unites two pieces of wood. This opinion prevailed in the schools until the middle of the eighteenth century, when it was opposed by Duhamel, who published the results of his experiments. Haller's opinion was like that of the ancients. He thought to gain more knowledge by experiments, which were made by Dethlef under his direction, and which confirmed him in his opinion. He ascribed the callus to a juice coming from the fractured surfaces and from the marrow, a fluid which is effused around the fragments, gradually thickens, becomes cartilaginous, and then osseous, while the periosteum does not concur to re-establish the continuity of the broken bone. Haller, in describing the mode in which callus is formed, says that this operation resembles ossification; that the effused gluten, coming from the vessels or tissues of the broken surfaces and from the marrow, soon becomes consistent,

is not necessary that the corresponding faces of the layers of bone,

and assumes the characters of cartilage; that this cartilaginous substance passes to the state of bone when its vessels are sufficiently dilated to allow the red blood to penetrate its thickness, and brings a saline matter which forms osseous points, which successively are increased in extent, and finally pervade all the cartilage. In another place, Haller pretends there is from the commencement a gelatinous matter, and shortly afterwards a cartilage, within which a ring forms, which ossifies the first, extends to the processes, and breaks the cartilage, which retreats before it, and of which it is divested as of an envelop. This last mode of considering callus is very incorrect, and it will be easy for us to show it. Macdonald asserts that all the authors who have written before Haller, and even this great physiologist himself, are deceived when they pretend that the gelatinous matter of callus changes into cartilage. Haller, however, does not exactly say it forms cartilage, but that at a certain period we see organic molecules appear, which are not blood, and that when all the gelatinous mass has become opaque and elastic, it is then regarded as cartilage. Macdonald seems to think that the gelatinous substance never changes into cartilage, but that the matter considered as cartilaginous is a real, soft, flexible bone, which is afterwards hardened by the phosphate of lime. He thinks, from his experiments, that the newly formed bone is originally soft, elastic, easily divided, and curved, in a word, that it resembles cartilage. The proofs brought forward to demonstrate the osseous nature of this substance are that in nourishing an animal with madder, the callous substance reddens; but this phenomenon does not appear in the cartilages. He supports his opinion too by the chemical analyses of the cartilages made by Allen. Finally, he has discovered the error into which Duhamel has fallen in attributing the formation of callus to the ossification of the periosteum. John Hunter, whose talent has thrown light upon so many points of physiology, considers callus as the result of the organic development of extravasated blood, and of its transition to the state of bone. J. Howship has lately developed Hunter's ideas more fully, and supported them with experiments. Hunter asserts that at first the space between the fragments of the bone and the surrounding parts is filled with blood coming from the ruptured vessels, that this blood coagulates, and that by an organization vessels are formed in it. Adhesive inflammation takes place at the ends of the fractured bones, and then a peculiar process commences. Inflammation supervenes also in the splinters which are still attached to the bone and the surrounding parts. It produces in them a disposition to interstitial absorption, by which the angles of the fragments are smoothed down, their extremities soften, and become conical; now all these changes favor the ossification which is about to commence. Howship admits that Hunter's ideas are more correct than all which has been said in respect to callus, and that they agree in several essential points with his experiments. The conclusions he draws from his own researches are, that the first effect of the fracture is the extravasation of blood in the thick parts around, and that this varies in quantity with the degree of contusion or of complication. This blood is effused principally in the tissue of the periosteum, and increases its thickness. It is effused also in the medullary canal and between the fragments, where it is variously changed, and becomes the centre in which the ossification of the callus commences. The red color which pervades the periosteum gradually disappears; this membrane becomes firmer, and by degrees assumes the appearance of cartilage. The mode of progress in this union of fractures seems to show that the principal object is to prevent all possibility of motion between the parts. The callous matter is deposited on the surfaces of the bones, near the parts where union ought to take place, then on the circumference of the ends of the fragments and in the medullary cavity. The deposit of the blood, and the successive degrees through which it passes before it becomes an osseous substance, are remarked on the circumference of the ends of the fragments sooner than in the spaces which separate them. To give the ideas of the author better, we shall say that the fracture by this process becomes very solid before the union or the osseous cicatrix between the fragments is finished. In this respect Howship agrees perfectly with Dupuytren and also with Breschet; and we would remark that these facts had been published in France, either by Dupuytren or Breschet, and after numerous experiments, before the appearance of Howship's memoir. Finally, we say that if the fracture be compound, the vital operations to repair the injury are divided: on one side callus is deposited, on the other we see a manifest attempt to remove all the parts of the bone which have been separated, and where the circulation no longer exists. This elimination is conducted by the internal surface of the periosteum, which becomes granulated, extremely vascular, and poswhich are separated from each other, should be in contact; for the

sesses a great absorbing power. The analogy between this theory and the ancient mode of considering callus has caused us to speak of it in the same paragraph. Duhamel believed that the periosteum is to the bone what the bark is to the tree, and that fractures are often united by the agency of the membrane of the marrow. He thought it was the swelling of the periosteum and of the membrane of the marrow, their extension from one fragment to another in order to join and unite by ossification, which produced callus, and formed around the fractured bones sometimes a single sometimes a double ring, which fixed them firmly while it united them. This opinion has many advocates and many critics; still we must acknowledge the exactness of many observations of Duhamel, and admire in his experiments a precision not to be expected from a stranger to medicine. Duhamel's theory, although false, has doubtless been useful to science, as it has drawn the attention of physiologists to the cicatrization of bones, and we owe to it the researches of Haller, Dethlef, Bordenave, Troja, &c., on the same subject. Fougeroux adopted, without any restrictions, the ideas of Duhamel, and endeavored by his experiments to reply to the attacks of Haller and Bordenave. The opinion defended by him was no longer quoted, except as matter of history, when Dupuytren revived Duhamel's opinion, and extended his ingenious theory to observations on pathological anatomy. He has known not only the periosteum to ossify, but also the laminar tissue, the ligaments, and even the fleshy part of the muscles, to form a sort of osseous ring, which kept the fragments together, and preserved their relations. According to Dupuytren, we must admit two distinct epochs in the formation of callus, or rather two calluses which succeed each other in their formation. The first, which he calls the *provisional callus*, is completed when the medullary system of the two fragments is united, and a kind of osseous button exists within them which joins them, and the periosteum has formed externally, either alone or with the cellular tissue and even with the muscles, a ring which surrounds the extremities of the fragments, and adheres to them. Hitherto, the surfaces of the fracture are not yet united, nor even altered in the midst of the newly formed osseous tissue which constitutes the first callus. The solidity and resistance of the latter are less than those of the bone; hence if a new fracture occurrs in the same bone, it will be exactly where the first existed. When, after four or five months at most, the medullary canal begins to form again in the part where it was obliterated; when the accidental osseous substance produced by external ossification contracts and diminishes in volume; when the periosteum, the cellular tissue, and the muscles, return to their natural state, or cease to be ossified, if the adaptation be perfect, and if there be no irregularity between the fragments; finally, when the union takes place in the two ends and even on the surfaces of the fragments, then commences the second callus, or the *definitive callus*, which is not perfected till after eight months. This last period is characterized by the return of all the parts to their primitive state. This theory, however, which resembles that of Duhamel in several respects, since it assigns the periosteum as the seat of callus, differs from it much. In fact, Duhamel did not consider the osseous state of the periosteum as a provisionary state, while Dupuytren regards it only as a means to oppose the displacement of the fragments, and to favor the formation of the proper callus. He admits and demonstrates that fractures are united by two successive calluses, the one temporary or provisional, occurring on the outside of the bone and in the adjacent tissues, the other definitive, and situated in the medullary canal and at the ends of the fragments, as well as in the space which separates them. Dupuytren's theory is of the highest importance in its practical application to surgery, as it throws much light on the treatment of fractures. Bordenave was the first who regarded callus as a cicatrix analogous to that of the soft parts, that is, a cicatrix produced by granulations which proceed from one fragment to meet those of another, unite, and then receive the calcareous salt which gives the character of bone to the substance of the cicatrix. At first, the bones pour out from their broken extremities a fluid which is the primary matter of their union. This fluid gradually thickens, assumes the form of bone, and when the dilated vascular tissues furnish vessels which open in it, the canal becomes similar to the bone itself. Some modern authors, as Bichat and Richerand, have also regarded callus as a cicatrix analogous to that of the soft parts, and depending upon the development of granulations which unite, and receive the phosphate of lime, to reëstablish the continuity of the osseous tissue. Callisen thought that callus was formed by vessels arising from the broken extremities, and extending between the fragments, and by the final deposit of osseous matter, that is, of the phosphate of lime. He explained by an enlargement of the vessels the union in a cure is as perfect when they are simply at the side of each other, pro-

single callus of adjacent bones fractured simultaneously, as is sometimes seen in the leg and fore-arm. Bonn rigorously omits all explanation, and confines himself to the statement of what he has observed. His remarks rest entirely upon dissections of human bodies, and on a large number of wet or dry morbid preparations. Bonn does not appear to have experimented on animals; but he has sought to enlighten himself by analogy and by facts observed by others. He maintains that callus while imperfect is ligamentous and membranous. Callus, he says, at first resembles flesh; it then acquires the consistence and tenacity of leather. But its transition to bone is never preceded by the formation of real cartilage. Perfect callus is organized and identified with the bone: sometimes it is found entirely solid, as in diseased bones, and again it is softened and dissolved by caries. J. Bell describes callus as being formed at first by a soft and flexible substance, situated between the fragments which it unites. It is the reëstablishment of the continuity of the vessels of the bone which produces it. Samuel Cooper, adopting all J. Bell's opinions, defines perfect callus to be a new bone, or osseous substance, which unites the ends of a fractured bone. Peter Camper thought that in the union of fractured bones the fragments united by a double callus, one external, formed from gelatin furnished by the vessels and osseous fibres, which condenses below the periosteum, and afterwards becomes osseous substance; the other internal, produced by the lengthening and separation of the inner layers of bone, or the expansion of the compact tissue of the bones, to obliterate the medullary canal. Troja has seen the ends of a fracture covered in a few days with gelatinous matter, which soon became abundant, and was gradually converted into cartilage, then into bone. He has also observed, a swelling of the periosteum till a certain period when the thickness of this membrane diminishes, an internal ossification filling the medullary cavity near the fracture, and an external ossification which always exists. The facts related by Troja are strictly correct; a careful observer, he states candidly what he has seen, and does not, like Duhamel, follow a favorite and exclusive idea. The results of his experiments are similar in many respects to those obtained by Breschet.

Having thus briefly stated the different opinions of authors with regard to the formation of callus, we shall now mention the principal facts established by the numerous experiments of Breschet, premising, however, that the apparent discrepances in the opinions of writers in regard to callus, gradually disappear when its peculiar nature is studied. We then easily discover the cause of error, and the points where observers have given too great latitude to isolated facts, or have admitted them as general. Perhaps, also, as Beclard says, the differences of opinion arise from the fact that the researches have not been made at every period, or at the same periods of union of the fractures. Breschet considers callus as depending, 1st, on the extravasation and the coagulation between the fragments of a little blood furnished by the ruptured vessels. 2d. On a fluid at first viscid, secreted and effused between the periosteum and coming from the neighboring tissues more or less connected in the fracture of the bone, and also from its broken surfaces. This formative lymph, (which may be compared to that exhaled from the edges of a wound of the soft parts, or that produced from several surfaces by inflammation, and which constitutes the membranous formations,) is at first mixed with a little blood; but afterward it is secreted alone, and when the periosteum is altered or destroyed, it is effused or filtrates into the interstices of the fibres of the soft parts around the fracture, and there thickening, forms a callus external to the fracture. 3d. On the gradual thickening of these fluids, (the blood and the formative lymph,) they unite gradually, and form stronger adhesions between the parts, which inflame and become real secretory organs. Considering abstractly the inflammation of the tissues near the fracture, we may compare the viscid fluid mixed with a little blood and its successive changes, to the camb of plants, and the changes which this organic principle of vegetables presents when effused between the bark and the woody part, or when secreted to cicatrize the wounds of vegetables. 4th. On the swelling and moderate inflammation of the periosteum and adjacent soft parts, on the cicatrization of these parts, and sometimes on the deposition of matter within their layers. 5th. On the contraction of the central cavity of the bone, on the softening of the ends of the fragments, and on the deposit of a substance similar to that which collects in the periosteum, or in the plates of the tissues adjacent, in the medullary cavity, and between the ends of the fragments. 6th. On the condensation of this matter, on its organization by the development of the vessels. At first it has a granulating appearance, it then assumes a fibrous consistence, next a cartilaginous appearance, and finally becomes bone. These changes are observed, first, external to the fragments, vided no foreign substance is interposed between them, and that they are kept in contact. It matters little, too, whether the fragments which are approximated belong to the same or to different bones: the cure is not less perfect; only anchylosis exists.(1)

In all these cases, the extremities of the bones become round, and are completely closed. The bone becomes entirely solid where it was fractured, and its medullary cavity is divided into two halves. Hence a single bone in fact forms two. It is more solid in the place of the fracture, than in any other part, so that it is rare that a bone breaks there a second time, although the life of the osseous cicatrix is more feeble than in other bones.

to constitute the provisional callus, and afterwards appear in the cavity of the bone, and between the ends of the fracture. 7. On the return of the soft parts which surround the fracture to their primitive state, after the callus has successively passed through all the degrees we have mentioned. This return takes place only after the re-establishment of the medullary canal, and this canal is re-established, only when the osseous substance by which the extremities are joined, is entirely solid. Then, the external callus which was formed first, gradually diminishes, and finally disappears, if the fragments have been accurately joined and there is no displacement. But if there be a displacement either in the length or direction of the axes of the two fragments, then the ends of the fracture continue closed, the medullary canal is not re-established, the newly formed external osseous matter, instead of being absorbed, remains to strengthen the callus, and its greatest quantity corresponds to the portion where there is the most displacement, and where the efforts to be resisted by the bone are the greatest. When we seek to compare the development of callus with the cicatrization of the soft parts, we find they differ greatly, if we admit the existence of granulations. But these pretended granulations are only illusory. We can easily demonstrate the identity of the process of nature, to unite all the tissues accidentally divided. One difference seemingly offered by callus, compared with the cicatrization of the soft parts, is the development of a substance, which exists only for a time, and which is formed externally to the fragments, in the medullary cavity. This substance is, perhaps, much more marked in the bones only because it is formed by a firmer and consequently by a more perceptible substance, or because it remains a longer time, and its quantity is in relation to the resistance it must present to give the bones all their force and all their solidity. We may say also, that the duration of its existence depends on the trifling degree of vitality of the bones, and on the slowness with which it is re-absorbed, or on its great utility. In fact, it serves not only to cicatrization, but also opposes the displacement of the parts; it maintains their relations, and lessens, in some measure, the disadvantages resulting from a want of contact or correspondence between the ends of the fragments. If we could observe fractures when the relations of their fragments were unchanged, and the ends of the bones were unmoved, and these bones were provided with a power of vitality similar to that of the soft parts, we should probably see in the formation and arrangement of the callus, a perfect similarity with the cicatrization of the other tissues. The practical consequences to be drawn from these experimental researches on callus, are, that the union of the fracture is not real, till the definitive callus is formed, and that then the organ can fulfill its functions without danger of unnatural curves. The provisional callus situated principally between the bone and periosteum, is only to retain the parts together, to favor the formation of the definitive callus. The first callus once formed, all apparatus may be removed; but immobility is necessary, and when the second callus is completed, the organ has regained its firmness, and can fulfill all its functions. In the treatment of fractures, then, two periods exist: in the first, we employ means to reduce it, and to hold the fractured parts together; in the second, the affected parts remain at rest, and the dressings of the fractures are removed; it coincides with the definitive callus.
F. T.

(1) H. Park, *Account of a new method of treating diseases of the joints of the knee and elbow*, London, 1783.—*Cases of the excision of carious joints, by H. Park and P. F. Moreau, with observations by J. Jeffray*, Glasgow, 1806.—Wachter, *Diss. de articul. extirp.*, Groningen, 1810.—Moreau, *De la résection des os*, Paris, 1816.—Roux, *De la résection, des os*, Paris, 1822.

When the conditions are perfectly normal, the subject is in good health, and the fragments of the broken bone are placed in contact, the osseous substance is never produced in excess. If a portion of bone has been entirely removed, as in amputation,(1) the extremity of the stump becomes round, shrinks a little, and covers itself with a compact substance more or less dense. The fractures and injuries of the bones, however, are not always cured so completely, nor do we always see bones which have been destroyed to a greater or less extent by any cause whatever, completely regenerated. The causes of this difference are dynamical or mechanical. To the first class belong, 1st, age; 2d, general weakness; 3d, diseases which affect the bones, as the scurvy and rickets, especially the former; 4th, the concentration of the formative power in some other organ, which prevents the union of a fracture(2) during pregnancy, and the period of lactation, although it does not always operate.(3) The same causes, especially the first, dispose the callus to soften, particularly when the fracture has not been long united.

The second class of causes comprises all that prevent the pieces of bone from touching, as an absolute defect in fitting them, and the continual derangement of the fracture by the motions of the part. Hence the reason that fractures of the ribs and patella are not often perfectly healed.

In these cases an artificial joint (*articulus abnormis s. artificialis*,) is formed, and the limb is useless, at least in some measure, since it is deficient in firmness.

The state of the parts is not always the same in the artificial joints.(4)

Sometimes the fragments adhere by means of a ligamentous or cartilaginous mass.(5) Sometimes they remain separate, and are connected like the moveable joints, by a capsular tissue.(6) Finally, sometimes muscular or tendinous fibres are formed between them. The first state resembles the symphyses, and the second the synovial joints.

(1) P. G. Van Hoorn, *Diss. de iis, quæ in partibus membri, præsertim osseis, amputatione vulneratis, notanda sunt*, Leyden, 1803, p. 36-129.—Brachet, *Mémoire de phys. pathol. sur ce que de vient le fragment de l'os, aprés une amputation: in the Bulletin de la soc. méd. d'émulation*, Paris, 1822.

(2) Alanson, in the *Med. obs. and inq.* vol. iv, p. 414.

(3) Fab. Hildan, *Obs. cher.* cent. v. *obs.* 87; cent. vi. *obs.* 68.—Hertod, in the *Eph. A. C. D. I.* no. 1, *obs.* 25.—Schurig, *Syllepsiologia*, 1731, p. 517.—Alanson, *Med. obs. and inq.*, vol. iv, n. 37.

(4) Wardrop, *Case where a seton was introduced*, etc.; in the *Med. chir. tr.* vol. v. p. 367.—Salzmann, *De artic. analogis quæ fracturis ossium superveniunt*, Strasbourg, 1718.—H Kuhnholz, *Considérations sur les fausses articulations*, in the *Journ. compl.*, vol. iii, p. 289.

(5) Van Dœveren, *Spec. obs. acad.*, p. 204.—Walter, *Anatom. Museum*, vol. ii. no. 650-656.—Morand, *Descript. du cab. du roi*, in Buffon, *Hist. nat. gén.*, vol. iii. p.. 76. pl. i.—Cooper, in the *Med. records and researches*, vol. i.—Bonn, *Thes. oss. morb*, clxx, clxxxiii, clxxxiv.—Langenbeck, *On the formation of false articulations consequent to fractures*; in the *Neue. Bibl. für Chirurgie*, Gottingen, 1815, cah. i, p. 94, 95.

(6) Koehler, *Beschreib. von Loder's Præparaten*, p. 66--105.—Walter, *loc. cit.* n. 651, 652, 653, 654, 656, 657.—Home, *Trans. of a soc. for the impr. of med. and surg. knowl.* vol. i. p. 233.

In the latter case the extremities of the bone are rounded, smooth, and here and there are cartilaginous. Usually, one is excavated, and the other is elevated, so that they represent, the first the cavity of a joint, and the other its articulating head.

The extremities of the bones are sometimes swelled, but usually this is not the case. The capsule of the joint secretes synovial fluid. Sometimes cartilages and unnatural bones form in these false joints, similar to those not unusual in the natural joints.(1)

When dynamical causes oppose the formation of callus, it is formed when they cease to act, although its formation may be very slow; for instance it may continue during the whole period of pregnancy. When the obstacles are mechanical, the ends of the bones are almost always cicatrized, and the cure takes place by the efforts of nature alone. The formation of callus, however, may be stimulated by proper means, which are not the same in all circumstances, but all of which tend to the same end, that of changing the cicatrized surfaces into a recent wound, and of stimulating the vitality of the bone locally.(2)

These phenomena are seen not only in fractures of a single bone, (3) but even in those of two adjusted to each other.(4)

§ 248. The power of reproduction in the bones develops itself with more energy, when an entirely new bone is formed in the place of an old one, which by some means has become dead. It is not the reproduction of the bone, but its death, which constitutes the essence of the disease *necrosis;* for, the regeneration is always accidental, and is never a disease, although it almost always attends the death of bone.

This power is seen particularly in the cylindrical bones, which possess it in the highest degree.(5)

The principal conditions of their reproduction are as follows:

When a part of a bone is dead, which does not necessarily imply a

(1) Home, *loc. cit.*, has given the best description of an artificial capsular joint of this kind.

(2) White, *Cases in surgery*, London, 1770, p. 69-93.—Inglis, *Obs. on the cure of those unnatural articulations which are sometimes the consequences of fractures in the extremities;* in the *Edinb. Med. Journ.*, vol. i. p. 419.—Rowlands, *A case of an un-united fracture of the thigh cured by sawing off the ends of the bone;* in the *Med. chir. tr.* vol. ii. n. v.—We find an excellent account of the different modes with several interesting cases in Wardrop's Memoir mentioned above.—Delpech, art. *Cal*, in the *Dict. des. sc. méd.*, vol. iii. p. 451--453.

(3) As Boyer thinks, *Lecons sur les les malad. des os* vol. i. p. 69.

(4) White, *loc. cit.*, p. 79.—Wardrop. Inglis.

(5) The principal works on this interesting subject are, Chopart, *De necros. ossium theses anat. chir.*, Paris, 1776.—Louis, *Sur la nécrose de l'os maxill. inf.;* in the *Mém. de chir. de Paris*, 1772, p. 355, Paris, 1782.—Troja, *De novorum ossium in integris aut maximis, ob morbos, deperditionibus, regeneratione experimenta*, Paris, 1775.—David, *Observ. sur une maladie connue sous le nom de nécrose.*—Weidmann, *De necrosi ossium*, Erfort, 1793.—Russell, *Practical essay on a certain disease of the bones called necrosis*, Edinburgh, 1794.—Koeler, *Experimenta circa regenerationem ossium*, Gottingen, 1786.—Macdonald, *De necrosi et callo*, Edinburgh, 1799.—Macdonald, in Crowther, *Pract. obs. on the diseases of the joints*, London, 1808.—Macartney, in Crowther, *Practical observations on the diseases of the joints*, London, 1808.—Charmeil, *De la régénération des os*, Metz, 1821.—Knox, in the *Edin. med. and surg. journal*, 1822, and 1823.

great change in its form, color,(1) or chemical composition,(2) it is detached from the healthy portion, because nutrition does not extend beyond the limit which separates it, and absorption acts more rapidly upon it.

But at the same time the formation of a new bone commences. It results from a considerable development of the vessels of the periosteum, and of the adjacent cellular tissue, which also becomes softer. As the bone dies, a gelatinous fluid is effused in all the surface between it and the periosteum. This fluid gradually thickens, and is changed into real osseous substance. It first becomes cartilaginous, and afterwards, but rarely in less than twenty-four days after the commencement of the disease, points of bone are seen in the cartilage. The new bone finally unites and fuses with the healthy parts of the old bone.

As the progress of these two actions, the mortification and the detachment of the old portion of the bone, and the formation of the new bone, and its union with the sound extremity of the old bone is nearly equal, the patient does not generally lose the use of his limb, although it often happens that the body of the old bone is entirely detached. But it is sometimes lost, because the dead bone detaches itself before the new bone has time to unite with the healthy portions. Besides, since when the old bone dies it detaches itself from the periosteum, and as the new bone forms below this membrane which is usually uninjured, to which it unites by the anastomoses of their respective vessels, and as the tendons are inserted in the periosteum, it is natural that these latter, when detached from the old bone, should be inserted in the new, as is usually the case.

Even when the periosteum dies, these essential conditions are not changed, for it is replaced by a new periosteum, formed from the surrounding cellular tissue.

The newly formed bone perfectly resembles the old one in several respects : it also differs in some.

Its hardness, length, and connections with the neighboring parts are the same ; but its form and thickness differ. It is generally larger, because it surrounds the old bone, around which it forms. It is more or less shapeless and massive, and its fibres are not so regular. Its surface is very uneven and very rough, because not included in the primitive plan of the organization. It has then, like all accidental ossifications, a form less distinctly marked, and which would be even less so if the ancient bone did not serve as a model. The thickness of the new bone is sometimes very considerable. It often exceeds an inch in the large bones, as the humerus and femur. Usually it is increased in this manner; when the the dead portion is thrown off from within the new bone, in one of the ways we shall mention directly, the cavity of the latter is almost always obliterated, by the increase which continues within, so that no regular medullary canal remains, and the new bone is entirely solid.(3)

(1) Weidmann, *De necrosi ossium*, p. 19.
(2) Davy, in Monro, *Outlines of the anatomy of the human body*, vol. i. p. 39.
(3) Russell, 60-63.

Although this is common, it does not always take place; for sometimes a regular medullary canal is found, extending the whole length of the bone, but possibly this is formed afterward.(1)

The old dead bone seldom, in fact never, remains in the cavity of the new bone.(2) Sometimes it gradually disappears; sometimes it comes out of itself, either in one portion, or in different pieces, or it is removed by art. It passes off through several smooth, round openings, which penetrate entirely through the new bone into its cavity, and communicate with the skin by fistulous openings, which do not close till after the sequestrum is thrown off, being continued by its irritation, as a foreign body.

We must remark, that the commencement of the openings appears when the new bone is first formed, for we can perceive in the gelatin which is effused, dry and opaque points, which soon change into them.

The death and reproduction of a cylindrical bone rarely extend beyond its body, and its spungy extremities remain unaffected, although the whole body perishes. This phenomenon is seen not only in youth, when the body and the extremeties form separate and distinct bones, but also in the advanced periods of life, at least very often.

The bone never perishes in its whole thickness: often and from the nature of the causes, only its internal or its external portion decays. The first case may be confounded with the mortificatoin of the whole bone, because then it usually happens that the remaining part swells also, and openings are established for the separation of the dead portion. Still it may be distinguished, not only because the exfoliation is almost always smaller in every respect, but because the outer surface is very rough, while in a bone which has decayed in all its extent, this surface is very smooth.

The flat bones not unusually die; but they are not generally, or but very imperfectly, reproduced. If they grow anew, the progress of nature is essentially the same. But the new bone does not surround the old one, as in the cylindrical bones, and it is in fact formed by the growth of the edge, which has preserved life. The short bones also rarely die, and are as rarely regenerated.

§ 249. The deviations of formation of the bones, which are developed at all periods of life, are in regard to their mass and volume. They result in the unnatural enlargement or diminution of these organs.

The bones are, perhaps, of all organs, the most subject to an unnatural enlargement. Sometimes they increase in all their circumference, which constitutes *hyperostosis*. Sometimes only a tumor is developed in some part of their extent; this is called *exostosis*. Then their structure is normal, or it is altered: the latter is most common. The bone,

(1) Russell, *loc. cit.* in the appendix, case 1st.

(2) Voigtel says, (*Pathol. anat.* vol. i, p. 195) that "the new bone is seldom hollow, covering the remains of the old bone, which are loose within it, as in a tunnel;" but in all the cases he reports, the cure was not perfect, as the openings of the new bone were not closed.

when altered, is sometimes looser and more spungy; sometimes harder, more solid and heavier than usual. Swelling of the bones, with diminution in density, is called *spina ventosa*.(1) Swelled bones are at first more spungy; but when cured, they become harder and more solid. *Osteosteatoma*, or *exostosis steatomides*, resembles exostosis, and probably often, if not always, is an imperfect swelling of the bone, with a change in its chemical composition.(2)

The bone rarely diminishes in size, unless the other organs are similarly changed, as when the process of nutrition is deranged from paralysis. A change in their mass is observed less rarely, and this state is almost always accompanied with a change in their chemical composition.

§ 250. The diseases of the last kind, which cause anomalies by a spontaneous alteration in nutrition, lead so much more naturally to alterations in texture and chemical composition, that their influence is rarely exerted on the form alone. On the other hand, the form appears more or less changed in the anomalies of the bones, where the prevalent character consists in a change in texture and chemical composition. The principal changes in the texture of the bones are as follows:

1st. Inflammation, and its consequences, which differ from those seen in other organs, by their slow progress. Thickening, often also exostosis, especially the swelling of the bones, attended with diminution in their density, (*spina ventosa*) are manifestly the results of inflammation, terminated by *exudation*. Suppuration is called *caries*, and mortification, *necrosis*. The principal phenomena of this last have already been mentioned.(§ 248.)

2d. Diminution of hardness and solidity, of which there are different degrees. In rachitis, this exists in the slightest degree: the bones are soft, spungy, flexible, and curved, either in the places where they are acted on by muscles, whose power they cannot resist, or in those where they sustain some weight. At the same time they receive more blood. The periosteum undergoes analogous changes. The chemical composition is not every where the same. In fact, we do not always find the same relations between the respective proportions of phosphoric acid and lime, as sometimes there is too much,(3) and sometimes too little(4) acid; and again, the proportion between the animal substance and the earthy portion varies much. Sometimes the quantity of animal matter is much enlarged, so that its relations are as 74.26 . and even as 75.8 : 24.2 :(5) or finally as 79.54 : 20.5.(6) Sometimes it does not differ from what is found in the normal state, and is even less, being as 25.5 : 74.5 :(7) although the bones are spungy. These differences

(1) Augustin, *De spinâ ventosâ ossium*, Halle, 1797.

(2) Hundertmark, *Osteosteatomatis casus rarior*, Leipsick, 1757.—Herrmann, *De osteatomate*, Leipsick, 1767.

(3) Jager, *Diss. acid. phosph. tanquam morb. quorumd, causs. prop.*, Stuttgardt, 1793.

(4) Ackermann, *Comment. med. de rachitide*, Utrecht, 1794.

(5) Davy, *loc. cit.* p. 38.

(6) Bostock, in the *Med. and chir. trans. of London*, vol. iv, p. 38.

(7) Davy, *loc. cit.* p. 39.

are probably owing to the degree, and especially to the period, of disease; but they at least prove that rachitis does not essentially consist in a deficiency of earthy matter. This disease is seen in children particularly. In rachitis the bones are generally, proportionally speaking, too short and too thick: the head is larger, and the points of ossification of the bones of the skull are very distinct.

In *softening of the bones* (*osteomalacia*, *osteosarcosis*) this state exists in a higher degree. The bones then become still softer, fleshy, or lardaceous, so that they may be easily cut. Their cellular structure disappears, and they become a homogeneous substance. At the same time they are more or less swelled. They present curves which are greater in proportion as the bone is softer. This is more frequent in females. The teeth are usually but not always free from it.(1) The results are deformity and crookedness of the extremities, or of the whole body, according as the disease of the bones is partial or general, and according as the bones yield to the efforts of the muscles, and to the weight of the whole body.

A state resembling this is the excessive *brittleness* of the bones, although it sometimes arises from an excess of earthy matter. This fragility is often so extensive, that the bones break from the least exertion, as from turning in bed, &c. It not unfrequently attends the softening of the bones, but it is usually found alone. The diseased bones do not lose their cellular structure, as in osteosarcosis, but it often becomes more distinctly marked. The principal causes of this state of the bones are general diseases which are of long duration, which affect to a greater or less extent all the systems, as scurvy, cancer, and syphilis.

II. OF THE ARTICULATIONS OF THE BONES.

§ 251. The joints vary from the normal state in two ways. The corresponding ends of the bones may be too loosely or too firmly united with each other.

§ 252. The too slight union of the bones may result from rupture or forcible extension, or from the relaxation of the means of union. These different states give rise to *luxation*, (*luxatio*,) which consists essentially in the separation of the movable extremities of the bones united together, and in the contact of a movable with an immovable bone in a place which is not normal, towards which it has been drawn by the muscles placed near the joint. Luxation takes place more easily, and consequently is more frequent, as the motions of the bones are more extensive; and it is usually attended with distension of the ligaments when it happens to the movable articulations, but they are broken if the joints are less movable.

It always occurs naturally in the direction where the resistance of the articulating surfaces, the ligaments, and the adjacent parts, is the least.

(1) J. S. Plank, *De osteosarcosi commentatio*, Tubingen, 1782.

When the bone does not resume its natural place, either by itself or the assistance of art, a new joint is formed, and the old one disappears. The bone with which the dislocated bone comes in contact usually forms a superficial hollow, which is covered first with periosteum, and afterward partially or wholly with cartilage, the edge of which is more or less turned over. At the same time the articulating head becomes flatter and more unequal than before, and often partially or wholly loses its cartilage, being pressed against the other bone by the muscles.

Sometimes a cavity is formed in the bone which was provided with an articulating head, to which corresponds a proportional head which grows on the surface of the other bone.

The immovable articulations are sometimes dislocated, or are less firm from an original deviation of formation.

The latter is seen in hydrocephalus, and when the bones of the pubis are not joined. The former, if we except the symphysis pubis at the end of pregnancy, arises only from mechanical violence, the action of which is sudden and strong, or slow and gradually increasing.

In congenital and normal separation, the uniting medium is distended or lengthened; it is ruptured when they are separated accidentally.

§ 253. An unnatural solidity in the joints constitutes *anchylosis:* (1) this is *false* (*A. spuria*) when the means of union are only contracted or too stiff, and *true* (*A. vera*) when the bones which were separated in the healthy state are joined together by osseous matter. The consequence of anchylosis is the immobility of parts once movable.

In this case, either the fibrous ligaments are ossified, or osseous substance is deposited below them, and unites the surfaces of the two bones like a bridge, or the two bones are fused together in the whole extent of their corresponding surfaces, so that the cartilage which incrusts them and the compact substance disappear, and we find only a spungy substance, uniformly extending the whole length of the bone. The first two forms are found naturally in old age. The last is seen after inflammation and suppuration of the ends of the bones.

Sometimes, without any known cause, a tendency to ossification shows itself in several, and even in all the joints; which is attended with stiffness of the whole body.

ARTICLE THIRD.

OF ACCIDENTAL OSSIFICATION.

§ 254. The accidental devolopment of bone is a very frequent phenomenon,(2) and is seen principally in certain systems, but is not ge-

(1) J. T. van de Wynpersse, *De ancylosi*, Leyden, 1783.
(2) J. van Heckeren, *De osteogenesi præternaturali*, Leyden, 1797.

nerally manifested till the latter periods of life. It appears especially in the left side of the heart, and in the system of the aorta, particularly its inner membrane (p. 151). It is not much more unfrequent in the serous membranes. It is seen less frequently in the fibrous organs, among which the periosteum furnishes the most examples. Accidental bones often form also in the internal genital organs, especially the uterus, in some fibrous bodies, in the thyroid gland, and in the ovaries.

Accidental ossifications present themselves under two different forms. Sometimes the osseous substance forms a connected whole with the parts in the midst of which it is developed, a part of the substance in which the bone forms, is changed into it. Sometimes it forms a separate body, a new formation, which is connected with the part in which it is rooted only by the relation of nutrition, and sooner or later is insulated when this relation ceases.

Accidental ossifications of the first kind are developed principally in the vascular system, and in several parts of the serous system. The second species is usually seen in the synovial capsules, and in the natural and the accidental mucous bursæ; and also in several serous membranes, especially the tunica vaginalis testis.

The latter forms more or less extensive layers which project but little or not at all above the surface of the parts in which they are developed. The former have the form of round bodies with peduncles, and are developed most frequently in those joints exposed to frequent concussions: they are sometimes single, sometimes very numerous, and always communicate at one time or another with the synovial membrane.

Finally, these accidental osseous productions pass through the same periods as the normal bones.(1)

(1) Broussais, in his *Histoire des phlegmas. chron.*, Paris, 1808, vol. i., attributes these accidental substances, both *osseous and calcareous*, to a chronic inflammation of the lymphatics. This opinion was revived by him in 1816, in his *Examen*. Boisseau, admitting inflammation as the most common cause of accidental ossification, thinks that it occurs only when inflammation is followed by a diminution in nutrition, and that we cannot admit the continuance of the inflammatory state in a tissue which is accidentally ossified. (*Réflexions sur la nouvelle doctrine médicale*, in the *Journ. univers. des sc. méd.*, vol. vii., 1817, p. 43.) In answer, Broussais distinguishes two kinds of accidental ossifications: 1st, the inorganic osseous concretions, the secondary results of a low degree of irritation, which form in the extravasated lymphatic fluids, or in tissues partly disposed to vital inflammation; 2ndly, the pure and simple ossifications without previous alteration of the organization, consisting in those anomalies of nutrition consequent upon the progress of age. (*Journ. univ. des sc. médic.*, vol. viii., p. 156.) Gimelle afterward established that these accidental osseous substances *never* have the form nor the structure of the primitive bones, and that *accidental ossification is always the result of a chronic inflammation*, which, using the vital properties of an organ to exalt them above their natural type, changes the intimate nature of the affected part, and communicates to it the power of incrusting itself with phosphate of lime. (*Mémoire sur les ossifications morbides*, in the *Journ. univ. des sc. méd.*, vol. xviii., 1820, p. 5.) Rayer has since advocated the opinion that morbid ossification is always the result of an inflammatory process. He divides it, 1st, into that which occurs in a tissue of the primary formation, where the form and structure are not changed, so that it cannot be mistaken; 2d, into that develpeod in an accidental tissue which has experienced no change; and 3d, into that which supervenes in a primitive or accidental tissue, which has been changed most fre-

SECTION V.

OF THE CARTILAGINOUS SYSTEM.

ARTICLE FIRST.

OF THE CARTILAGES IN THE NORMAL STATE.

§ 255. The *cartilages* (*cartilago*)(1) are solid, hard, smooth, slippery, very elastic, whitish, and apparently homogeneous bodies, possessing neither fibres nor laminæ.

§ 256. They form an organic system, which does not exert the same influence in the organism at all periods of life, since in the early periods, we find them in the places of the bones, but they gradually disappear. Hence the cartilages are divided into the *permanent* (*C. permanentes*) and the *temporary*, (*C. temporariæ*,) a distinction which is not exact, as many cartilages which are included in the first series, become bone in most subjects, although in fact much later than the others, and always incompletely. The term temporary cartilage is usually applied to those only which are replaced by bones, and which thus disappear completely at about the same period in all individuals. When the temporary cartilages are changed into bone, the permanent cartilages are found principally, 1st, at the ends of those bones which touch each other, whether movably or immovably articulated; 2d, in the parietes of certain canals.

We can make no general remarks in regard to the forms of the temporary cartilages, as they assume those of the bones, which afterwards take their places. But the permanent cartilages, except the arytenoid and those small ones found between the thyroid cartilage and the hyoid bone, are very thin in proportion to their breadth and length, or at least in respect to one of these dimensions.

quently into a fibrous or a cartilaginous substance. (*Mémoire sur l'ossification morbide considérée comme une terminaison des phlegmasies*, in the *Archives générales de Médicine*, vol. i., 1823, p. 313 and 489.) Hence we may judge that the history of abnormal ossifications is still very obscure. This name very probably comprises numerous accidental productions, which should be considered only as calculous concretions. In order that an abnormal formation should justly come within the osseous system, it must possess life, that is, it must be attached at least by vessels to the rest of the organism, and its structure must perfectly resemble that of the normal bones. But these two conditions are found, perhaps, only in the formation of callus, the regeneration of the bodies of the long bones, and the ossification of certain parts of the fibrous tissue. F. T.

(1) G. Hunter, *Of the structure and diseases of articulating cartilages*, in the *Phil. trans.* n. 470, vi., p. 514-521.—Hérissant, *Sur la structure des cartilages des côtes de l'homme et du cheval*, in the *Mém. de Paris*, 1748; p. 355.—Delassone, *Sur l'organisation des os*, in the *Mém. de Paris*, 1752, p. 253-258.—J. G. Haase, *De fabricâ cartilaginum*, Lèipsic, 1767.—C. F. Doorner, *De gravioribus quibusdam cartilaginum mutationibus*, Tubingen, 1798.—B. C. Brodie, *Pathological researches respecting the diseases of the joints*, in the *Med. chir. tr.*, vol. iv., no. xiii., § 5.—Laennec, *Sur les cartilages accidentels*, in the *Dict. des sc. méd.*, vol. iv., p. 123-133.

§ 257. The outer surface of the cartilages situated on the ends of the bones, is sometimes unattached; they are then called *articular cartilages*, (*C. articulares.*) Sometimes these cartilages form a layer, the two faces of which are united with the bones. They are then called the *cartilages of the sutures*, (*C. suturarum.*)

§ 258. The *articular cartilages* are found in all the movable joints: they line the corresponding extremities of the bones, imitating their forms perfectly, and are united with them so closely, that one can break the bone sooner than separate them. The cartilage, which exists at first in the place of bone, is perfectly homogeneous, yet, when the latter is entirely developed, the articular cartilage is not a prolongation of it, since there is no continuity of tissue between them, even after the gelatin and the earthy salts have been liberated from the bones by acids. The loose surface of these cartilages is smooth because it is connected with the internal layer of the articular membrane. This arrangement diminishes remarkably the friction consequent upon motion.

The articular cartilages are generally a little thinner on their circumference; this is particularly seen in those attached to the extremities of the bones which project very much, as the heads of the humerus and femur. On the contrary, the articular cartilages of the cavities which receive these heads are thickest on their edges, and are often strengthened in that part by a cartilaginous band. The cartilage has a uniform thickness in all other points of its surface.

§ 259. The second kind of the cartilages which are placed between the bones, form a simple, very thin band, situated between two adjacent bones, which they unite to each other so as not to permit the least motion. These cartilages have usually a conical shape, and are broader on their external than on their internal face. This arrangement explains, at least in part, why the sutures of the bones of the head, in which the cartilages we speak of are found, always disappear on the inner sooner than on the outer face of the skull.

The costal cartilages form in some measure an intermediate section between these cartilages and those of the second class; for their posterior extremities are connected with the ribs, like the articular cartilages, while their anterior ends articulate with the sternum, which is itself covered with an incrustation of cartilage. Some are even united to this bone by an articular capsule also. Besides, they differ from all the others, because their length much exceeds their breadth and thickness.

§ 260. The cartilages of the second class are much more independent than those of the first, for they constitute the base of certain organs which are almost entirely formed by them. Thus the larynx is chiefly composed of cartilages, and the form of the trachea depends principally on that of the cartilaginous rings which form its parietes. The same may be said of the cartilages of the nose and the ear. Hence the forms of these cartilages differ more than those of the preceding. In fact they form sometimes layers, sometimes rings, and sometimes thick masses.

They vary also in tissue; some, as those of the larynx, the trachea, and the septum of the nose, are much harder than those of the alæ of the nose, of the ear, and of the eyelids. They are generally more flexible than the cartilages which are connected with the bones. Many of them, which articulate together so as to admit motion, as for instance in the larynx, present articular processes lined with capsular ligaments and retained in place by fibrous layers which are continuous with the perichondrium: but most of them are united only by this membrane, by mucous tissue, and the membranous expansions which extend from one to another.

§ 261. Although at first view the cartilages do not seem to have an organic tissue, (§ 255,) nevertheless, by having recourse to different processes, such as continued maceration and the action of acids, we can demonstrate more or less clearly, that they are formed of fibres and of layers. This tissue is slightly flexible, so that it breaks if we endeavor to bend it. The cartilage putrifies with difficulty: it is one of those substances which resists decomposition the longest.

All the cartilages, however, have not the same tissue; among those which are attached to the bones, the articular cartilages are formed of a multitude of short fibres, which are implanted in the circumference of the bones, and become softer towards their unattached extremity. The costal cartilages are composed of oval laminæ, adjusted to each other from within outward, and kept in place by the transverse fibres. Morgagni(1) pretends that the cartilages of the larynx, or at least the cricoid and arytenoid cartilages, often have a cellular structure, and inclose marrow, even although they are not ossified. We have never observed any thing like this.

§ 262. The chemical composition of the cartilages resembles that of bone: they are formed of an animal substance and of phosphate of lime; but the proportions of these two principal constituents, perhaps also the nature of the animal material, are different. In fact, from the latest researches of Davy,(2) the articular cartilages contain,

Of albumen, - - - - - - - -	44.5
" water, - - - - - - - -	55.0
" phosphate of lime, - - - - - -	0.5

According to Allen,(3) on the contrary, the animal matter is also of a gelatinous nature, and the earthy material, mostly a carbonate of lime, forms only one hundredth part of the whole mass. Hatchett says, they are formed of coagulated albumen, containing some traces of phosphate of lime.

§ 263. The cartilages have no vessels which carry red blood, although in cutting them we often perceive vessels distinct from their substance. Lymphatics have not as yet been discovered in them. They are destitute of nerves.

§ 264. All the cartilages, if we except the articular, are enveloped with a fibrous membrane called the *perichondrium*. This membrane

(1) *Advers. anat.*, i., an. 23.
(2) In Monro, *Outlines of anatomy*, vol. i., p. 68.
(3) Macdonald, *De necrosi et callo*, Edinburgh, 1799, p. 104, 105.

is connected with them in a mechanical or dynamical relation, less intimately than the periosteum is with the bones. The articular cartilages are destitute of this perichondrium, and their unattached face is blended with the synovial membrane.

§ 265. The cartilages are very elastic: hence they are found in those places where this property is required; for instance, in the ends of the long bones, in the parietes of those cavities which change their size and which should never collapse, as the nose, the organs of voice and of respiration. They possess, however, but a slight degree of contractility and dilatability. Their want of nerves explains their entire insensibility in the normal state. The phenomena of life progress in them with extreme slowness.

§ 266. During the early periods of existence the cartilages are mucous and soft. They gradually become consistent, and are finally very brittle. Towards the middle of life they are more elastic, because then they are more distant from the two opposite states in which they are met with at the beginning and end of existence.

As certain cartilages, those called *temporary*, ossify regularly and very early, so too some of the permanent cartilages are totally or partially changed into osseous pieces: at least this happens very often in regard to some of them; but they generally ossify much later than the others. Those which present this phenomenon most frequently are the cartilages of the larynx, and less frequently those of the ribs, and the rings of the trachea. It is never seen in those of the nose, the ears, or the eyelids. This change is very rare in the articular cartilages. Still we must mention here those uncommon cases where all the joints are fused in a greater or less degree at an advanced age, and where, consequently, all the articular cartilages are ossified. Between the permanent and the temporary cartilages, we may rank to a certain extent those which unite two bones together in such a manner as not to allow motion, for they also change into osseous substance, and hence the sutures disappear, although the change occurs almost always long after that of the temporary cartilages. The form of the connected surfaces of the bones appears to influence this change to a certain extent, although it occurs where the points of contact are more numerous and closer, as in the dentated sutures, or within the skull, sooner than between smooth faces, as around the unguiform bones, between the upper maxillary bones, &c. But this law is evidently obedient to other laws also: for on one side the two portions of the lower jaw, whose surfaces touch in the same manner as those of the upper jaw, always unite early; so on the other side, we often see superficial sutures, as the squamous, disappear, while others which are very deep and supplied with numerous indentations are permanent.

The proportional size of the cartilages remains about the same at all periods of life: those of the sutures are the only exceptions to this rule. In fact, during the early periods of existence, while the bones of the head play on each other, and while their teeth are not inserted into each other, these cartilages are broader than they are afterwards.

ARTICLE SECOND.

OF THE CARTILAGINOUS SYSTEM IN THE ABNORMAL STATE.

§ 267. The cartilages rarely present anomalies(1) in regard to their external or internal form: their deviations of formation are rarely congenital and usually result from anomalies presented by the bones and ligaments.

We may consider as congenital deviations of formation the deficiency of certain cartilages, for instance those of the ribs.

§ 268. The slowness of the vital phenomena which marks the cartilages generally (§ 265) is seen also in the manner of their action on external morbific causes, and the degree of their power of repairing a loss of substance, their reproductive power. The wounds of the cartilages do not heal, like those of other parts, by the union of their divided surfaces. Long after the accident, these surfaces present no change which indicates the least tendency to union: they are smooth and level; but the parts which cover the cartilage, especially the perichondrium when it exists, adhere, and form the new substance which is deposited between the lips of the wound. Hence why it so often happens that a cartilage destroyed in any manner is never reproduced, although layers of cartilage are sometimes developed on the surfaces of the false articulations. But this last phenomenon is not common. Articular cartilages are rarely or never formed in the new articular cavities which appear after luxations. In fact in the false joints consecutive to fractures, we sometimes find cartilages between the disunited ends of the bones, and farther the artificial joint is formed because they are not ossified: but, in this case, it is not a cartilage which is reproduced, nor even a permanent cartilage which forms, but only a temporary cartilage, or rather a new bone, the development of which has been arrested.

When the articular cartilages are destroyed, the most favorable occurrence is the fusion of the contiguous surfaces of the two bones, and the formation of anchylosis.

For these reasons, inflammation of the cartilages is unfrequent, and very slow: they resist the action of deleterious causes longer even than the bones; and the changes which occur in them seem to be passive and chemical, rather than active and vital, since cartilages, when separated from the body and exposed to the same agents, are affected in the same manner.

We shall not here discuss the opinion of Laennec, who admits that destroyed cartilages may be regenerated. We consider those thin points of articular cartilage usually found in several articulations at

(1) Dœrner, *De gravioribus quibusdam cartilaginum mutationibus*, Tubingen, 1798.—Cruveilhier, *Observations sur les cartilages diarthrodiaux et les maladies des articulations diarthrodiales*, in the *Archiv. génér. de méd.*, Feb. 1824, p. 161.

once in the same subject, as new productions of cartilage, as real cicatrices, which are never as thick as the old cartilage. But it is not proved, that these thin points do not arise from a wasting of the cartilage; and the circumstances in which we have sometimes observed this phenomenon, render this last opinion not improbable.

§ 269. Active changes also occur in the cartilages. These take place particularly in those which do not concur in forming the articulations, because they receive more vessels, and enjoy a more active existence. In fact the cartilages not unfrequently inflame, and this inflammation terminates in ossification. The articular cartilages rarely experience these alterations, but they are not always exempt from them: thus in diseases of the joints, they become red, partly lose their density, soften, and swell. Inflammation most generally terminates in suppuration and the destruction of the cartilages, which it is remarkable does not necessarily produce the formation of pus. It is probably from these changes that the wasting of the articular cartilages takes place.

The cartilages are exposed to induration and ossification, anomalies of which we have spoken above, (§ 266.) When in this state they become subject to the usual diseases of the bones. They inflame, become carious, die, and are thrown off. This phenomenon occurs not unfrequently in some cartilages of the larynx, particularly in the arytenoid cartilages. We must not confound this with the formation of a white substance, probably urate of soda, which develops itself in the place of the articular cartilages, when the latter disappear from the effects of gout.

§ 270. The cartilages not unfrequently develop themselves accidentally. In general, when this anomalous formation is seen, we may admit a tendency to accidental ossification. The solidity, form, and situation of these accidental cartilages vary much. They differ so much from each other in the first respect, that Laennec thought to make two classes, the perfect and the imperfect. But this classification hardly seems admissible; for the difference is purely gradual and accidental, and every thing would induce us to think that it depends entirely upon the period when the observation is made. Farther, the accidental cartilages are presented under three principal forms:

1st. As broad layers adhering more or less strongly by their two faces to the parts in which they are found. This form is the most common. Accidental cartilages of this kind are developed principally between the internal and the fibrous tunics of the arteries, generally on the external face of the internal membrane of the system of red blood, and on the outer face of the serous membranes, so that as this resembles very much the internal membrane of the vessels, the formation of the cartilaginous layers may be considered one of the most usual morbid alterations.

2d. In the form of more or less round, irregular, and more or less solid masses, which are imbedded in the substance of the different organs, especially the uterus, the thyroid gland, and the ovaries.

3d, As rounded, flat, smooth concretions attached to fine filaments, and which are often separated from the parts whence they arise, so that they seem perfectly loose. This kind of accidental cartilage occurs particularly in the internal face of the synovial membranes. They are more rare in the serous membranes. It is the first degree of the formation of accidental articular bones. (§ 254.)

SECTION VI.

OF THE FIBRO-CARTILAGINOUS SYSTEM.

ARTICLE FIRST.

OF THE FIBRO-CARTILAGES IN THE NORMAL STATE.

§ 271. By *cartilages* we usually understand all those hard substances found between the bones which cover their surfaces, and some other parts mentioned before, (§ 260.) But the substances placed between the bones differ much from each other. Hence we early perceived the necessity of dividing the cartilages into several classes, according to their texture, or at least we did not forget to remark that all have not exactly the same texture. Haase divides them into three classes: 1, the cartilages formed entirely of a dense cellular tissue; 2, the ligamentous cartilages, (*C. ligamentosæ*) ; 3, the mixed cartilages, (*C. mixtæ.*) Bichat considers the second class as a distinct system, and he has given to it the name of fibro-cartilage—and has made three subdivisions of it, viz. 1. *The membranous fibro-cartilages*, as those of the nose, the ear, and the trachea. 2. *The articular fibro-cartilages*, comprehending the loose interarticular cartilages, and those which adhere intimately to the bones by their two faces, as those found between the vertebræ and the ossa pubis. 3. *The fibro-cartilages of the tendinous sheaths*, which cover the bones in those places where the tendons glide over them. But it is unquestionably more exact to refer the first division to the cartilages properly so called, as they have the same structure. We ought also to add to the two subdivisions a third, that of the annular fibro-cartilages, which Bichat has not mentioned.

The best classification of the fibro-cartilages is one in respect to their form and situation, and which admits of their being divided into three classes: 1st. Those fibro-cartilages the two faces of which are either wholly or at least in a great part loose, and the edges of which are united to synovial capsules, the *movable articular fibro-cartilages.*

2d. Those which have one of their faces loose, and adhere to the bone by the other. These are, *a.* long and grooved, as the fibro-cartilages of the tendinous sheaths ; and *b.* or circular, as those which border the edges of the joints, and which may be termed the *annular fibro-cartilages.*

3d. Those which have both faces entirely attached to the bones between which they are placed.

§ 272. The intermediate fibro-cartilages are found principally in those joints which are exposed to frequent and extensive friction, as that of the knee, of the clavicle, and of the lower jaw. They divide the articulation more or less completely into two parts, because they are parallel to the two articular faces between which they are extended. They are united more or less distinctly by fibrous parts to the circumference of the capsule or to the articular cartilages. Still they always remain movable, so that they can change their situation in the different motions of the joints; hence they diminish compression and the concussion experienced by the articular cartilages in motion. They are usually circular and bi-concave, that is thicker at the circumference than the centre. But the semilunar fibro-cartilages of the knee-joint are hollowed, and extremely thin on one of their edges. Only one is usually found in each articulation; but that of the knee is an exception in this respect, as it sometimes contains two.

§ 273. The fibro-cartilages of the tendinous sheaths cover the bones in those places where the tendons glide over them; hence they generally have a long grooved form. They are developed in the periosteum, and are usually composed of interlaced fibres, the direction of which is contrary to that of the sheath itself and of the tendon. They are generally thin, but become much thicker in certain points, and vary in this respect in all parts of the same sheath. Where they are unusually thick, we observe a corresponding development of a fibro-cartilaginous or osseous tissue in the tendon which glides upon them. We may easily be convinced of this in the place where the tendon of the tibialis posticus passes under the head of the artragalus to be inserted into the scaphoid bone. This arrangement, then, forms real articulations in those parts where considerable friction takes place. Something similar is seen in the crucial ligament of the first and second cervical vertebræ, where it passes behind the odontoid process of the second.

§ 274. The annular fibro-cartilages are composed of circular fibres, arranged around the circumference of the rounded articular cavities which admit of extensive motions, as those of the ossa ilia and the scapula. They always grow thinner from their base to their loose edge: they confine the motions of the joint by deepening its cavity, but not so much as an edge of bone would.

§ 275. These fibro-cartilages, which adhere on both sides to the adjacent bones, are formed of fibres, the direction of which is perpendicular to the surfaces between which they are extended, and form the articulations called *symphyses*, (§ 242.) Their form depends upon that of the osseous surfaces which they are intended to unite. Hence they are almost circular between the bodies of the vertebræ, irregular between the sacrum and ossa ilia, and oblong and square between the ossa pubis. They are inserted in the first two cases by broad surfaces, and in the third by narrow edges.

§ 276. The texture of the fibro-cartilages is composed, as their name indicates, of a cartilaginous and of a fibrous substance. These two masses are easily distinguished from each other, and form more or less regular alternate layers. This arrangement is particularly well marked in the intervertebral fibro-cartilages. Here in fact there is much more of fibrous substance than in the other fibro-cartilages, and it forms white, concentric, and solid layers, between which a brownish cartilaginous substance seems deposited principally in the middle, while externally it is converted into real crucial ligaments. On the contrary, in the inter-articular cartilages and in the cartilages of the tendinous sheaths, the cartilaginous substance exceeds the fibrous so much, that this latter is hardly perceptible, and we might say that it has been injected into the other, so that it does not seem so regularly arranged. These fibro-cartilages then are allied still more closely with proper cartilages.

It is a general law that the fibrous substance in a given portion of the fibro-cartilage exceeds in a greater or less degree the cartilaginous substance. Thus in the fibro-cartilages of the vertebræ, as also those of the pubic and sacro-iliac symphyses, the cartilaginous substance gradually diminishes towards the circumference, and finally gives place entirely to the fibrous substance. Several interarticular cartilages, as those of the knee, are attached to the adjacent bones by fibres evidently ligamentous.

§ 277. The tissue of the fibro-cartilages, in relation to the organic systems which form it, does not materially differ from that of the cartilages and of the fibrous organs.

§ 278. The same remark may be made in regard to their properties, as they combine those of the two systems. The fibro-cartilages are as elastic, but less hard and more flexible, and less brittle than the true cartilages. Their extreme solidity causes them to tear with great difficulty. They retain the bones to which they are attached very firmly together, and favor the gliding of the tendons. This circumstance, added to this that they are but slightly sensible to outward impressions, renders them capable of resisting the influence of external agents longer than the bones. Thus we sometimes see the bodies of the vertebræ almost wholly destroyed by chemical or mechanical causes, as for instance by an aneurism of the aorta, while the intermediate fibro-cartilages which unite them remain almost untouched. Some fibro-cartilages undergo periodical changes not seen in the real cartilages: they become less dense, softer, and moister, and hence allow more motion in the parts which they unite. This is seen particularly in the fibro-cartilages of the pelvis during pregnancy.

§ 279. The fibro-cartilages in the early periods of life, notwithstanding their softness, resemble the cartilages which appear at a later period, because at this time the gelatinous substance much exceeds the fibrous substance in all parts of the body. This is proved by the intervertebral fibro-cartilages and that of the symphysis pubis. As the age progresses on the contrary, the fibrous substance predominates more and more over the cartilaginous. Hence, partly on this account, the fibro-cartilages are much softer and more flexible in infants than in old men, and hence too, in great part, the stiffness attendant upon old age.

The ossification of the fibro-cartilages in advanced age is not rare. In fact the vertebræ are often united with each other by means of an osseous substance; but this union depends more rarely on the ossification of the fibro-cartilages than on the formation of layers of bone on the circumference of the two faces which look towards the bodies of the vertebræ. But we have sometimes observed ossification of the intervertebral fibro-cartilages, and have then found on dividing the vertebral column longitudinally, that several vertebræ were fused together, and were blended in one mass. The same is true of the symphysis pubis, and the sacrum is often united with the ossa ilia.

ARTICLE SECOND.

OF THE FIBRO-CARTILAGES IN THE ABNORMAL STATE.

§ 280. In respect to morbid alterations, the fibro-cartilages resemble the cartilages and fibrous organs, in the nature of which they equally participate. They are but slightly subject to disease: yet the observations of Palletta(1) and Brodie(2) establish that inflammation and suppuration sometimes affect them, even before attacking the bones with which they are connected.

§ 281. We not unfrequently see a substance perfectly resembling the fibro-cartilaginous tissue formed in some parts of the animal economy. This substance most generally assumes the form of round masses, very distinct from the surrounding mucous tissue and the substance of the organs. Such are the substances which grow in the internal genital organs of the female, and especially in the uterus, in old maidens; these formations, usually termed schirrous, but wrongly, adhere but slightly to the substance of the uterus, generally project above its surface, and are easily extirpated; when cut across, they are seen to be composed of different layers and always of two substances irregularly intermixed, the cartilaginous and the fibrous. These accidental productions have more tendency to ossify than the normal fibro-cartilages: but this tendency to become bone does not depend entirely upon their size. Bodies similar to them in every respect are met with, between the vagina and the rectum, in the ovaries, the bones, the thyroid and the thymus glands, and more rarely under the skin.

(1) *Advers. chirurg. prima*, p. 189.
(2) In the *Med. chir. trans.*, vol. iv., p. 258.

SECTION VII.

OF THE FIBROUS SYSTEM.

ARTICLE FIRST.

OF THE FIBROUS SYSTEM IN THE NORMAL STATE.

§ 282. The fibrous system (*systema fibrosum*) was first considered generally and separately by Bichat. The term "*fibrous system*" is not sufficiently distinctive, as the fibrous structure is at least as well marked in many other systems, especially in the muscles and nerves; but as these are already named, and it would be difficult to imagine a better term, and as it expresses the principal character of the system, it may be preserved without inconvenience.

A. GENERAL REMARKS.

§ 283. The peculiar characters of the fibrous system are, *a structure evidently fibrous, and a white silvery and brilliant color. It receives few vessels, and probably has no nerves. It is but slightly elastic, and is entirely destitute of contractility and of sensibility.*

§ 284. This system is expanded generally through the body, but nevertheless does not form an entire whole; for although a communication may be demonstrated between those of its portions immediately continuous with the bones and muscles, those which are connected to some glandular organs are on the contrary entirely separated from the others.

§ 285. The external form of this system is not the same in all the parts which it embraces, but these may be referred to two. In one, the dimensions in length and breadth are almost equal, and much greater than the thickness. This is the form of the fibrous membranes, (*membranæ fibrosæ*.) The organs which present it are, 1, the periosteum; 2, the dura mater of the brain and spinal marrow; 3, the fibrous capsules; 4, the fibrous sheaths of the tendons; 5, the aponeuroses; 6, the tunica sclerotica; 7, the capsule of the corpora cavernosa of the penis and clitoris, and that of the urethra; 8, that of the testicles; 9, that of the spleen; 10, that of the kidneys.

§ 286. In the second class of fibrous organs, the thickness is greater in regard to the other two dimensions, and these fibrous organs are called *fascicular*, (*Organa fibrosa fascicularia*.) This class comprehends only the parts connected with the bones or the muscles, viz. 1st, *the tendons*, and 2d, *the ligaments*.

§ 287. If we except the fibrous membranes of some of the glandular organs, we may easily demonstrate that all the fibrous organs are closely connected together. The different parts of the system communicate by the periosteum (§ 285): hence it may be considered as its common centre. In fact, 1. The cerebral and spinal dura-mater fulfills also the functions of a periosteum to the bones of the cranium, and to the vertebræ, as it lines their internal faces, and the canals it furnishes to the nerves are continuous with the periosteum which covers the external face of these bones. 2. The tunica sclerotica communicates with the dura mater by means of the fibrous sheath of the optic nerve which is furnished by it. 3. The fibrous membrane of the penis and clitoris interlace with the periosteum of the ossa ischia. 4. The fibrous capsules, ligaments, sheaths, and tendons, are also united with the periosteum. It is even by means of this membrane alone they hold to the bones, from which they are entirely detached if it be removed, especially during the early periods of life.

This explanation of the fibrous system, the idea of which belongs to Bichat,(1) is more natural than that of Clarus,(2) who pretends the envelop of the muscles is its centre. According to this anatomist, the entire muscular system is surrounded by a common, shining, fibrous envelop, the internal face of which gives off prolongations which circumscribe each bone and muscle, and are called the periosteum, the perichondrium, and the perimysion, or which (as the intermuscular ligaments) form only layers and extend from the bones to the muscles. Clarus pretends that his opinion is preferable to that of Bichat, because it considers all the envelops of the different organs as so many prolongations of one single envelop. But it is evident, that this general external layer does not exist, for although all the muscles have a mucous envelop, this by no means possesses the characters of fibrous tissue, so that the communication which Clarus admits between the real fibrous sheaths, which circumscribe for instance the muscles of the upper and lower extremities, and the mucous sheaths of several muscles, as those of the abdomen, the latissimus dorsi, the trapezius, &c., and those too of the deeper muscles, or even between these sheaths and those of the different fasciculi and the fibres of each muscle, is entirely forced, and cannot be admitted from ocular demonstration.

§ 288. The peculiarities of fibrous tissue consist in its being formed of very apparent fibres which have different directions, in its grayish or whitish color, and silvery lustre; they are very solid and powerfully resist external mechanical impressions. In several parts of the body their fibres are irregular, and cross each other in different directions. They are arranged thus in the dura mater, the anterior periosteum of the sternum, and in many of the posterior ligaments the ossacrum and the ossa ilia. But they are generally regular, and their direction is that of the motions performed by the parts, to the union of which they contribute more than any other organ; consequently also in the same direction as they are contracted and relaxed.

(1) *Gen. Anat.* vol. ii., p. 263.
(2) *Annalen des klinischen Instituts zu Leipzig*, vol. i., p. ii, p. 156.

§ 289. Besides these peculiar fibres, the fibrous organs contain also mucous tissue and vessels. The mucous tissue forms a layer which envelops them externally, and exists also more or less abundantly between their fibres. If we judge from what exudes from these organs while drying, this tissue contains also fat, although it is not perceptible in their recent state. The number of the blood-vessels is not the same in all places: in some parts of the system they are numerous, while in others but few exist. We cannot clearly demonstrate the presence of nerves.

In regard to chemical composition, the fibrous system is formed entirely of *gelatin*.

§. 290. The fibrous tissue is but slightly elastic in the recent state, but becomes very much so when dried. It does not admit of great and sudden extension. Hence, 1, the strangulation which results when parts which are more or less completely surrounded by fibrous organs are distended ; 2, the fibrous organs tear when suddenly or forcibly distended ; on the contrary, they yield very much to a slow and gradual extension without tearing, as is seen in dropsies, pregnancy, luxations, which take place gradually, &c. In these instances,they become thin to a greater or less extent. But we must not confound with this state an increase in their mass, their thickening, which arises from a morbid increase of nutrition ; this sometimes exists alone, and is sometimes attended with distension, and almost always succeeds diseases of the adjacent organs, of the synovial membranes, of the eye, testicle, &c.

Nor are the fibrous organs capable of a sudden contraction : they however gradually contract after unusual distension.

These organs are very solid, and it requires great force to tear them. They tear on account of their slight degree of extension, for when ruptured they are not, or but slightly elongated. They do not extend more than they contract under the influence of stimulants. In the normal state, they are sensible not to chemical, but to mechanical irritations.

The fibrous system serves, in great measure, to protect, to envelop, and to unite the organs it embraces. Its properties are perfectly in accordance with this function. It intimately adheres to the parts it covers and unites ; thus the tendons are firmly fixed to the bones and the muscles, and the ligaments to the bones. But this adhesion is not equally strong in every part. Thus the periosteum is attached to the bones less intimately than the above-mentioned organs are to each other.

§ 291. In the early periods of life, the fibrous system is soft, very flexible, extensible, of a pearly lustre, and homogeneous, and its fibrous structure is not developed till towards the end of uterine existence ; its fibres are fewer and more separated in the beginning. Some fibrous organs are proportionally thinner than they afterwards are, as the dura mater, the tunica sclerotica and the periosteum. Others on the contrary are smaller, as the tendons. The parts which unite it to the adjacent parts are much less solid in the early periods of life than at an advanced age ; thus the periosteum is more easily detached from the bones, and the tendons are less firmly united with the muscles and the bones. They gradually become hard, solid, dry, and yellowish. The stiffness and immobility which characterize old age depend principally on this state of the membrane. Does the fibrous system ever change into other organs? It has been thought that this was the case with some of its parts, and that the periosteum among others changed to bone, (§220, 221.) On the other side, it has been thought that other fibrous organs, for instance the tendons, were formed from the muscular substance. But this last opinion is as unfounded as the other, as we shall demonstrate, when speaking of the muscular system. Although the fibrous system becomes more consistent in old age, still it does not regularly ossify, and in man especially it does not tend much to this change. The fibrous organs most often found ossified, are several ligaments, especially those of the vertebral column. We have some xyphoid cartilages of old men, where all the ligaments of the vertebral column and ribs are ossified. Sometimes all the articulations are united in this manner, so that the whole body becomes incapable of motion. We may adduce too the ossification of the proper ligaments of the scapula, which are not unfrequent. Accidental depositions of bone in the dura mater are more frequent; but they depend less on the ossification of the fibrous substance than on a real production of bone on its surface, and appear in fact less adherent to the dura mater than to the arachnoid membrane which lines it. The falx is the place where they most frequently occur. It is remarkable that ossification of the tendons is so rare, because, in the animal kingdom, for instance, in many birds, insects, crustaceous animals, and to a certain extent in fishes, the change is connected with the normal development.

B. SPECIAL CONSIDERATIONS.

§ 292. The fibrous organs form, 1, envelops; 2, they unite certain organs; or 3, they fulfill both these functions at once. The fibrous organs of the first kind are membranous; the second, on the contrary, sometimes assume this form, and sometimes that of fasciculi, according as the form of the organs with which they are related demands.

§ 293. I. The fibrous envelops are, 1, the dura mater of the brain and spinal marrow; 2, the periosteum and the perichondrium; 3, the tunica sclerotica; 4, the tunica albuginea, and the membrane of the ovaries; 5, the envelop of the corpus cavernosum; 6, the capsule of the kidneys; and 7, that of the spleen.

The most remarkable properties of these envelops are, 1, they have the form of sacs, which surround the organs placed under them. These sacs are not entirely closed, like those of the serous membranes, but have openings in points, which correspond to the entrance or departure of vessels, nerves, and excretory ducts.

2d. If the organ they cover is composed of several layers, or if other membranous expansions exist which are necessary to the performance of its functions and its preservation, the fibrous envelops form the most external layer. In this manner the dura mater and the tunica sclerotica are disposed. They determine then, more or less, the form of the organs they surround.

3d. Their form and their relations with the organs placed below them are not always the same in every part. Some appear as simple sacs, as the tunica sclerotica, the capsule of the kidneys, and the periosteum. Others form compound sacs. These last in their turn are divided into two series: sometimes in fact they give off from their internal face prolongations which do not penetrate even the interior of the organ, as is the case with the falces and the tentorium of the cerebellum. Sometimes they send through the substance of the whole organ a reticular tissue, which forms to a certain extent its base, as is seen in the corpus cavernosum of the penis and the clitoris, and in the spleen and the testicle.

4th. They have not a uniform thickness. There is no constant relation between it and the volume of the organs. Thus the fibrous coat of the eye, of the testicle, and of the ovary, is much thicker than that of the spleen or the kidney, and almost as thick as that of the brain and the spinal marrow.

5th. All the fibrous membranes have not exactly the same internal structure. In some, as the periosteum, the dura mater of the brain and the spinal marrow, and the envelop of the corpus cavernosum, the fibres are more distinct than in others. Most of them are formed of but one layer, but the dura mater has two, which may easily be entirely separated in the early periods of life.

6th. Nor is their mode of union with the parts they surround every where the same. The dura mater of the brain and spinal marrow have no connection with the organs which they envelop; on the contrary, the tunica sclerotica, the renal capsules, and the tunica albuginea are more or less intimately united to the subjacent organs by mucous tissue. In the corpus cavernosum, the spleen, and the ovaries, the union is still more intimate, as the capsule sends prolongations into the very tissue of these organs. This is the case too with the periosteum, although its fibres have no part in the composition of the bones.

But we observe in respect to this, periodical differences, which may generally be referred to the greater proportional thickness of the fibrous envelops, during the early periods of life, and to the greater looseness of their attachments to the parts below.

§ 294. II. The fibrous parts which serve at the same time as envelops and means of union, form the transition of the fibrous organs of the first to those of the third series. They usually have the form of membranes.

These are, 1, The aponeuroses; 2, the sheaths of the tendons; 3, all the fibrous ligaments; 4, the fibrous capsules of the serous membranes; 5, the fibrous capsules of the mucous membranes.

§ 295. A. The *aponeuroses* are of two kinds. They serve as a covering to the muscles. They are almost always united to these organs, but some surround other muscles besides these, and many form, in concert with the muscles to which they adhere, envelops for other organs, and make the parietes of certain cavities.

§ 296. The aponeuroses of the first kind may be called *muscular bands*, (*fasciæ musculares.*) Their principal characters are as follows:

a. They sometimes form canals, or sacs, which inclose one or more muscles. From their internal faces are detached fibrous sheaths which extend to the bone, separate the muscles from each other, are often of considerable thickness, almost always give origin to muscular fibres, and are termed *intermuscular ligaments*, (*ligamenta intermuscularia*.) Sometimes they cover the muscles on one side only. The aponeuroses of the extremities, of the deep muscles of the back, of the recti muscles of the abdomen, are examples of the first arrangement; the second occurs in several muscles, where the tendons which are inserted into the bones extend to a part of their surface, gradually becoming thinner.

b. They form general envelops only in the extremities. But special envelops exist in many parts, as the aponeuroses of the deep muscles of the back, and the sheath of the recti muscles of the abdomen.

c. These muscular bands are more or less evidently formed of several layers of fibres which vary in direction, or are even formed of several folds, as for instance the sheath of the recti muscles of the abdomen.

d. Their thickness is not uniform; but it is relative not to the volume of the muscles they cover, but to the greater or less freedom of motion required. They are much thicker and firmer in those places where the motions must be more limited, and where the parts require to be maintained more firmly in their respective positions. Thus the aponeuroses of the palm of the hand and the sole of the foot, are the strongest of all the muscular bands. We may consider too as accessory means, certain ligaments which cannot be separated but by destroying their fibres with a scalpel, as the ligaments of the wrist, &c.

We ought in fact to arrange here the fibrous sheaths of the tendons, for they do not differ from the ligaments, and communicate with the muscular envelops.

e. Usually they have special tensor muscles, or the tendons of the muscles, which serve for other functions, and which are attached to the bones, adhere to them, and are even blended with them. Thus the crural aponeurosis has a proper tensor muscle, and the palmar aponeurosis has two. The tendon of the glutœus maximus is continuous with the crural aponeurosis, that of the biceps flexor cubiti with the aponeurosis of the fore-arm—that of several muscles of the thigh, with the fascia of the leg. The plantar aponeurosis is the only exception to this rule in man. The functions of these muscles are to make tense the aponeurotic expansions in which they are inserted, and thus fix more solidly the muscles situated below them.

f. They are generally united to the subjacent muscles very loosely; we must however except their tendinous upper extremities, which are usually blended with them, and which even seem to arise from them, an arrangement which increases the extent of the surfaces to which these latter are attached.

§ 297. The aponeuroses of the second kind, are attached like the preceding by their circumference to the tensor muscles. They are distinguished from the latter by the relations between them and the parts below them. We shall take as an example the aponeurotic expansion on the anterior face of the abdomen and that on the external face of the cranium. The first is made tense by the broad muscles of the abdomen, of which it forms the anterior tendon, and by the pyramidal muscles, and the second by the frontal and occipital muscles. All these muscles may be considered as digastric, having two bellies separated by a large central tendon.

§ 298. B. The *fibrous sheaths of the tendons* (*vaginæ tendinum fibrosæ*) are membranous expansions forming semi-canals, the loose edges of which attach themselves to corresponding edges of one or several bones which are slightly turned over, so as to produce entire channels in which the tendons glide. These tendons are very long in proportion to the muscles to which they belong, and are kept firmly in place by these sheaths.

Their general characters are:

a. They are very thick and solid, and are formed of very apparent transverse fibres, except near the joints, where they are extremely thin and interrupted, and are formed of oblique fibres which cross.

b. They and that portion of bone to the edges of which they are attached, are always lined by the synovial membranes, which, on their outer surface, are reflected on the tendons.

c. They allow a passage to one or several tendons; most generally to several, but this presents two different modifications. Sometimes the canal is subdivided by intermediate fibrous partitions, which are attached to separate processes of bone, so that there are in fact as many sheaths as there are tendons; this is seen on the back of the hand. Sometimes there are no subdivisions, and the different tendons are attached to each other by the projection of synovial membrane, and are, in fact, inclosed in the same sheath. This is the arrangement of the tendons of the palm of the hand and phalanges. We call the sheaths of the first kind *compound*, and those of the second kind *simple*.

We have already remarked that these two kinds of sheaths are continuous with the aponeurosis of the extremities.

The tendinous sheaths and the fibrous agents of union are usually developed in the direction in which the hand and foot are flexed, more than in any other. The former are observed only in the extremities of the limbs. The extensor muscles of the toes and fingers are retained in place in the carpus and tarsus, only by compound tendinous sheaths. In the palm of the hand, on the contrary, besides the strong fibrous sheath under which the tendons of all the flexor muscles pass, there is a proper sheath for the two flexor tendons of each finger or toe.

This difference depends, 1st, on the difference in the number of the flexor and extensor tendons; for each finger or toe has two of the former and only one of the latter; 2d, this arrangement of the extensor tendons is compensated by the union with them of the interosseous and the lumbricales muscles; 3d, ruptures of the flexor tendons occur more easily than those of the extensor tendons, and their consequences are more serious.

§ 299. c. The *fibrous ligaments* have sometimes the membranous and sometimes the fascicular form. The former constitute the fibrous capsules, while the second form the proper fibrous ligaments. All these organs have this in common, that their two extremities extend from one part of the osseous system to another, and both unite with the periosteum; that they are formed in great part of longitudinal fibres; and that they are usually strengthened by their union with other tissues.

§ 300. The *fibrous capsules* are always placed outside the synovial capsules, and extend from one bone to another. They are rarely perfect: such are only found in the shoulder-joint and hip-joint. But certani synovial capsules, as that at the articulation of the elbow, are strengthened by fibres which arise from their edges, and expand in their central portions. The fibrous capsules adhere very strongly to the synovial capsules; we must, however, except the places where the latter are reflected on the cartilages, and where they are united only by an abundant and loose cellular tissue. They form sacs open at their two extremities.

§ 301. The *fascicular fibrous ligaments* go from one bone to another, or, which is more rare, they are extended between two different points of the same bone. They expand, 1, on some parts of the synovial capsules, with which they are more or less intimately united; or, 2, they pass over the fibro-cartilages which connect two bones, or extend from one process of bone to another, passing directly on the symphyses or at some distance from them; or, 3, they are only extended between two bones, and do not strengthen the synovial capsules. To this last species belong several ligaments of the vertebral column, those which unite the sacrum and ischium, &c. They make the transition from those of the first species to those which go only from one point to another of the same bone; and the more, as the bones between which similar ligaments exist are entirely motionless or nearly so. These last ligaments serve also to multiply the surfaces of attachment for the muscles, as well as to unite the bones. The ligaments which attach themselves to different parts of the same bone, sometimes turn all around another bone, like a ring, as is seen in the annular ligament of the radius and the transverse ligament of the atlas, and they unite two adjacent bones, and at the same time confine their motions. Sometimes they proceed only from one eminence to another, as those situated between the coracoid and acromion processes; an arrangement which affords attachments to muscles, and protection to vessels and nerves.

The relations between the ligaments and synovial capsules are generally such as we have stated; that is, the ligaments cover the capsules externally; but sometimes they exist within them, which generally happens when the weight to be supported requires great solidity, as in the hip- and knee-joint. These two articulations are, however, the only instances where internal and external ligaments are found. Internal ligaments never exist without external ligaments; while the existence of the latter does not necessarily imply that of the former. The external ligaments being almost always situated on the sides of the joints, so as not to prevent their motions, and to be neither compressed nor stretched, they are called *lateral ligaments* (*ligamenta lateralia*) and also *accessory ligaments* (*ligamenta accessoria*): but this latter term is nothing; for the strength of the articulations depends on them, and the synovial membranes is only to facilitate the gliding of the surfaces.

The general form of the ligaments is oblong; they are rarely triangular. Their length generally exceeds their breadth, which in turn is more than their thickness. Usually they extend in a straight line; sometimes they are annular, and turn on the bone as around an axis.

§ 302. D. Among the proper serous membranes, the pericardium and tunica vaginalis testis are the only ones on which a special fibrous layer is distributed, although others also, as the peritoneum, are covered in several parts by the aponeuroses of the muscles which surround them. The fibrous layer of the pericardium is very thin, and is continuous below with the fibres of the tendinous centre of the diaphragm. These are the *sero-fibrous* membranes.(1)

§ 303. E. We may class among the capsules of the mucous membranes the fibrous tissue which descends along the external face of the mucous membrane of the trachea, uniting its cartilaginous rings; but we do not think a similar tissue may be admitted in the ureters, the vasa deferentia, and the Fallopian tubes.

§ 304. III. The *fibrous agents of union* are those fibrous parts which unite organs separated from each other. Many ligaments which do not serve to strengthen and to protect the serous membranes, those for instance observed in different parts of the vertebral column, or between the sacrum and ossa ilia, make the transition from the fibrous capsules to the fibrous organs which only serve as a means of union, and in reality belong to this class, formed principally by the tendons.

§ 305. The *tendons*(2) are that portion of the fibrous system which unites with the muscular system. We ought to refer to it several muscular aponeuroses, and the aponeuroses of the second kind, (§ 296, 297,) which are only broad tendons. We could then divide the tendons into long, and broad or flat.

The tendons are always united to the muscles by one point at least, and sometimes by two opposite points of their surface. In the first case, their other extremity is attached to a solid and hard part, usually to a bone, rarely to a cartilage. When their two extremities are united to the muscular substance, they are called *tendinous intersections*, or *intermediate tendons*, (*intertendines, tendines intermedii.*) From this arrangement digastric or polygastric muscles are formed, or, to speak

(1) Bichat, *On the membranes.*
(2) Isenflamm, *Bemerkungen über die Flechsen*, in the *Beyträge für die Zergliederungskunst*, vol. i., Lespsic, 1800.

more precisely, as many separate muscles as there are bellies. This is observed particularly when, as often happens, the tendinous intersections, are intimately united with the adjacent parts, be it either to bone or to other tendinous organs.

The tendons always extend much beyond the point where they are entirely disengaged from the muscular substance. They not only cover a part of the outer surface of the muscle and extend, gradually growing thinner, and terminate by an edge more or less broken or by a kind of pyramid, but they go still deeper into the organ, in the middle of which they are seen for some distance after they have become invisible on the surface. It is thus that often, in the penniform or semi-penniform muscles, the tendons which appear very short externally pass almost through the length of the muscle.

These two circumstances increase the extent of the surfaces in which the muscles are inserted, and consequently their firmness.

One part of the tendon which covers a portion of the muscle is usually situated on its external face. This arrangement belongs not less to the common than to the intermediate tendons. Hence the muscular fibres which are attached to them almost always proceed from within outward.

The direction of their fibres corresponds perfectly to that of the fibres of the muscles, or it is between that of the latter, whether the muscular fibres are attached to the two sides of the tendon or only to one.

Usually the tendons are a little flat, and are rarely round. They enlarge at their two extremities, not only on the side where they partially cover the muscles, but also where they are attached to the bones.

Most of them are single in their whole extent, and are rarely divided. The latter arrangement offers several peculiarities:

1st. The tendon presents an opening through which pass other tendons belonging to the deeper muscles, which go to be attached to a part situated before the perforated tendon. This arrangement serves principally to prevent the perforating tendons from deviating: an instance is seen in the superficial flexor muscles of the fingers and toes.

2d. The tendon divides at its extremities, and is attached by several slips.

This arrangement occurs at both extremities, but it is much more common in the end next the muscle than in the other. When met with at the extremity towards the bone, this end sometimes divides into two equal parts, which are attached to the same bone, as is seen at the anterior extremity of the common superficial flexor tendon of the fingers and toes; sometimes it divides into several slips, which are attached either to different parts of the same bone, or to the adjacent bones, or to the bones of the adjacent parts.

The superior tendon of the rectus femoris muscle, and the inferior extremity of the anterior tendon of the external oblique abdominal muscle, offer examples of the first arrangement; the tendons of the tibialis posticus and of the peronæus longus muscles are instances of the second; and finally, examples of the third are seen in the tendons of the common flexors and extensors of the fingers and toes. But we must observe that here the muscles rather than the tendons divide, and that each muscular belly produced by this divison has its proper tendon. In the flexor digitorum communis longus and in the flexor hallucis longus we see the contrary arrangement.

Usually this division causes several bones which have little motion on each other to be moved by a single muscle. Sometimes also, as the tendon of the external oblique muscle of the abdomen, it serves for the passage of certain organs; so that it approaches in every respect the perforation of the tendons.

On the other hand, we sometimes see the tendons of several muscles unite in one, and attach themselves together to a movable point. For instance, in the biceps flexor and triceps extensor muscles of the arm, the quadriceps extensor and the biceps femoris muscles, and finally the long and short common extensors of the toes.

§ 306. The fibrous system contains in several parts fibro-cartilages and bones, which resemble each other much, as fibres penetrate more or less the tissue of the latter. They are especially common in the tendons, but are not rare in other parts of the fibrous system; and we may refer to them even the fibro-cartilages to a certain extent.

We have no better name for these than *tendinous cartilages* and *bones*.(1) The most constant is that met with high up in the knee, in the tendon of the extensor muscle of the leg, the patella. They are found also in the hand and foot, in the articulation of the first phalanges of the thumb and the large toe with the carpus and tarsus, and in the tendons of the tibialis posticus and of the peronæus longus. They are sometimes found in the tendons of the other fingers and toes, even in the anterior joints. They are observed less frequently in the upper tendons of the gastrocnemii muscles, or at the articulation of the elbow, in the tendon of the triceps extensor. Their form is flat and slightly rounded. The distance which separates them from the insertion of the tendons is very slight. Their external and lateral faces are intimately blended with the substance of the tendons; the internal is incrusted with cartilage, and turned towards one of the two bones which move on each other, or is connected with both at once. In the carpus and tarsus they are almost always arranged in pairs one at the side of the other, while in the knee and in other places, even in the anterior joints of the toes, they are unmated, and their form is more or less broad. They are generally situated in the joints, opposite the contiguous ends of the bones, in the tendons which correspond to the movable part in which the muscle is inserted by means of these, and on the side of which flexion takes place, excepting always the patella and the corresponding bone which is sometimes found in the elbow.

(1) Bichat calls them *sesamoid bones;* but this term is improper, because it has long been applied to other bones of a different character.

Hence it is easy to see that these bodies serve in part to prevent the compression of the tendons, especially in rapid motions. But their principal use is to change the direction of these same tendons and to enlarge their angle of insertion, which adds very much to the power of their muscles.

ARTICLE SECOND.

OF THE FIBROUS SYSTEM IN THE ABNORMAL STATE.(1)

§ 307. With regard to the reproductive power of the fibrous tissue, we would observe that wounds and lacerations, with or without loss of substance, do not heal by the formation of an analogous substance, but by the formation of a less firm, less solid, and whitish tissue, which is neither brilliant nor perceptibly fibrous. Hence fibrous ligaments are not produced in unreduced dislocations. Nevertheless, a condensed cellular tissue replaces more or less perfectly the destroyed fibrous substance, and its properties differ little from those of the latter.

§ 308. Among the deviations from the normal state, primitive deviations of the external form are rare, and usually attend anomalies of the other tissues. Among these we arrange, for instance, the absence of the tendons of the abdominal muscles, that of the ligaments of the vertebral column, and that of the dura mater of the brain and spinal marrow, &c., in a congenital fissure of the abdomen, of the vertebral column, and of the skull, and that of the tendons and the muscles of a finger, when the finger itself is wanting. But the fibrous organs are seldom deficient, when the other tissues with which they combine to form a part are present—for instance, the tendon alone of a muscle is rarely absent, or the tunica sclerotica, when the other membranes of the eye exist. Perhaps we should refer to this anomaly the absence of the round ligament in the ilio-femoral articulation, although it is almost always remarked in circumstances which render it very probable that this part has been destroyed.

The consecutive or accidental deviations of formation, are, 1st, *lacerations* which are seen particularly in the ligaments and tendons. The ligaments of the joints which have little motion are more exposed to them than any other, when these joints are dislocated. Lacerations of the tendons supervene principally after violent and sudden efforts of the muscles to which they are attached, especially when the tendon itself is firmly fixed: they are sometimes incomplete when they do not comprehend the whole thickness of the tendon. The other deviations of form are, 2d, *rigidity*, and 3d, *relaxation*, which like the preceding state may become the cause of dislocation.

(1) Götz, *De morbis ligamentorum ex mutatâ materiei animalis formâ et mixturâ cognoscendis*, Halle, 1798.

§ 309. The alterations in the texture of the fibrous organs are, 1st. *Inflammation*, which rarely terminates in suppuration or gangrene, but more frequently in the thickening of the substance of the organs. Thus the fibrous ligaments alter in white swellings, although they are not by any means the only seat of this affection,(1) in which they lose their silvery lustre and their fibrous structure; when the disease is advanced, the mucous tissue which surrounds the capsule of the joint, the capsule even, and the cartilages and bones, are inflamed and suppurate; new formations of different kinds are developed around and within the capsule: finally the fat and the synovial fluid of the joint are hardened and thickened. Still, notwithstanding these changes, the disease seems often to affect the fibrous ligaments primarily, for these organs are the only ones which are found altered at its commencement.

2d. The production of heterogeneous substances within them or on their surface. Under this head we comprise the soft gelatinous tumors, and the hard, solid, and cartilaginous tumors of the periosteum, and the fungous tumors of the dura mater—a name which comprehends very different diseases.(2) In osteo-steatoma, another term which comprises morbid states of different characters, the periosteum is sometimes affected primarily, often alone, and always when the bone is diseased: the first undoubtedly happens when fibro-cartilaginous bodies are developed around the cartilages and the bones.

§ 310. Is the fibrous substance produced accidentally in the body? In fact there are accidental formations in which they occur: those for instance developed in the uterus, ovaries, thyroid gland, &c.; and Bichat states that which is sometimes found in the uterus and fallopian tubes is an anomalous repetition of the fibrous structure, because composed of yellow fibres. But we have never observed that these accidental productions perfectly resembled fibrous organs, and they seem to be more closely connected with the fibro-cartilages—hence why their history is placed after that of the latter.

(1) A Monro, *A white swelling of the knee*, in the *Edinb. med. essays and obs.*, vol. iv. p. 242.—T. Simpson, *Remarks on the white swellings of the joints*, ibid. p. 246.—J. A. H. Reimarus, *De tumore ligamentorum circa articulos, fungo articulorum dicto*, Leyden, 1757.—B. Bell, *Treatise on the theory and management of ulcers, with a dissertation on white swellings of the joints*, Edinburgh, 1778.—J. Russell, *Treatise on the morbid affections of the knee-joint*, Edinburgh, 1802.—C. Crowther, *On the disease of the joints, commonly called white swelling*, London, 1808.

(2) Louis, *Mémoire sur les tumeurs fong. de la dure-mère*, in the *Mém. de l'Ac. de chirurg.*, vol. v. p. 1.—Wenzel, *Ueber die schwammigen Geschwülste auf der äussern Hirnhaut*, Erfort, 1811.—Walther, *Essai sur les fongus de la dure-mère*, in the *Journ. compl. du Dict. des sc. méd.*, vol. vii. p. 118.

SECTION VIII.

OF THE MUSCULAR SYSTEM.(1)

ARTICLE FIRST.

OF THE MUSCULAR SYSTEM IN THE NORMAL STATE.

A. GENERAL REMARKS ON THE MUSCULAR SYSTEM.

§ 311. The muscular system is composed of bundles of reddish soft fibres, which of all organs change their volume and form with the most facility, and thus produce motion, and occasion the displacement of the body or of some of its parts.

§ 312. All the muscles possess these characters, whatever may be their difference in form. They may, however, be divided into two principal classes, which are founded on the connection between their activity and the actions of the intellect. These classes are the *voluntary* muscles, such as obey the will, and the *involuntary* muscles, which do not recognise its power. The muscles of these respective classes differ much in their external and internal forms; but these differences do not exclude general considerations, as Bichat thought.(2)

§ 313. The muscles are composed of fasciculi, placed at the side of and upon each other; and whatever the form of the muscle may be,

(1) The principal works on the general history of the muscles are:

1. On their structure and their functions—Barclay, *On muscular motion of the human body*, Edinburgh, 1808.

2. On their normal structure—Muys, *Artificiosa musculorum fabrica*, Leyden, 1741.—Prochaska, *De carne musculari*, Vienna, 1778.—Prévost et Dumas, *Mémoire sur les phénomènes qui accompagnent la contraction de la fibre musculaire*, in the *Journ. de physiol. expér.* vol. iii. p. 301-339.—Dutrochet, *Observations sur la structure intime des systêmes nerveux et musculaire, et sur le mécanisme de la contraction chez les animaux*, in his *Recherches anatomiques et physiologiques sur la structure intime des animaux et des végétaux et sur leur mobilité*, Paris, 1824.

3. On their abnormal structure—Schallhammer, *De morbis fibræ muscularis*, Halle, 1799.

4. On their irritability—Zimmermann, *De irritabilitate*, Gottingen, 1751.—Haller, *Mém. sur la nat. sens. et irrit. des part. du corps hum.*, Lausanne, 1756-1759.—Weber, *De initiis ac. progr. doctr. irritab.*, Halle, 1783.—Gautier, *De irritabilitatis notione, naturâ et morbis*, Halle, 1793.—*Croonian lectures on muscular motion*, in the *Phil. trans.*, ann. 1738, 1745, 1747, 1751, 1788, 1795, 1805, 1810, 1818, etc.—J. C. A. Clarus, *Der Krampf*, Leipsic, 1822.—Lucæ, *Grundlinien einer Physiologie der Irritabilitat des menschlichen Organismus*, in Meckel, *Deutches Archiv. für die Physiologie*, vol. iii. p. 325.—G. Blane, *On muscular motion*, London, 1788; and in *Select. dissert.*, London, 1822.—Barzelotti, *Esame di alcune teorie sulla causa prossima della contrazione moscolare*, Sienna, 1796.—H. Mayo, *Anatom. and Physiological commentaries*, London, 1822.

5. On their mechanical laws of motion—Borelli, *De motu animalium*, Leyden, 1710.—Barthez, *Nouvelle mécan. des mouv. de l'homme et des animaux*, Carcassonne, 1798.—Roulin, *Recherches sur les mouv. et les attitudes de l'homme*, in the *Journal de physiol. exp.*, vol. i. and ii.

(2) *Gen. Anat.* vol. ii. p. 327. "*The general muscular system very evidently forms two great divisions—. We shall not then consider them together.*"

its length exceeds any other dimension. These fasciculi are themselves composed of *fibres*, which result from an aggregation of *filaments*, called muscular filaments. The fibres and filaments are as long as the fasciculi, so that in them the length exceeds the other dimensions. As to the fasciculi, they do not usually extend the whole length of the muscles, but go more or less obliquely from one edge to another, or from the two edges towards the centre. The fasciculi, fibres, and filaments are angular rather than round, and at the same time, particularly the fibres and filaments, are a little flat.

The whole muscle, or its smallest filament, is composed of two substances, the muscular substance properly so called, and an envelop of mucous tissue. The latter, which is termed the *muscular sheath*, (*vagina muscularis*,) surrounds the whole muscle and afterwards divides into large tubes, which circumscribe the fasciculi, and again divide anew into other smaller tubes for the fibres and filaments.

§ 314. Opinions in regard to the texture of the muscles vary much. The formation of these organs is doubtless such as has been described: but we wish to know, 1st, if there are more subdivisions than we have mentioned; and 2d, to determine what is the formation of the finest filaments in respect to size and mechanical texture.

§ 315. In regard to the first, very artificial systems have been imagined. Muys, for instance, states, the fasciculi are composed of fibres, these of fibrils, and these last of filaments. There are three orders of fibres, the large, middle, and small. The large are composed of the middle, and these of the small fibres. There are also three classes of fibrils, the large, which unite to form the fibres; the middle, which produce the preceding; and the small, which are composed of filaments. Finally we have large filaments to give rise to small fibrils, and others which are smaller and of which the preceding are formed. According to this system, each fasciculus will be formed of eight subdivisions.

But this description is unnatural. True, we can usually divide the larger fasciculi into others which are smaller: but these can be reduced only to fibres, as the fibres can only to filaments, so that we have only three subdivisions. A fasciculus is each subdivision of a muscle visible to the naked eye, and it rarely varies in the same muscle. The fibres which form it become visible by boiling. They are not all of the same thickness, as some are three or four times as large as others. The filaments, on the contrary, are about the same thickness in all the muscles, so that their number in the fibres varies considerably.

Authors do not agree in estimating the thickness of the filaments. They usually make it considerable. Some(1) consider it 1-7th or

(1) Prevost and Dumas subdivide the muscular fibre into three orders, calling *ternary fibres* those which are seen on dividing the muscle lengthwise; *secondary fibres*, those which are obtained by dividing the ternary; while the *primary* fibres are produced by mechanical alterations of the secondary. Dutrochet, to avoid confusion, proposes to confine the term *muscular fibre*, to those filiform organs which immediately compose the muscles; to give the name of *muscular fibrils*, to those smaller filiform organs which are observed in the intimate tissue of the muscular

1-8th, some(1) 1-5th, some(2) a little more than 1-3d of that of a globule of blood. Others, on the contrary,(3) suppose it even greater than that of these same globules, stating it to be 1-40th of a line, while a globule of blood is estimated at 1-3000th of a line. We can account for these differences only by supposing that the filaments have not the same size in every part, (although observers generally assert the contrary,) and by supposing that the observations have not been made upon one separate filament.

§ 316. What is the texture of the filaments? Opinions vary perhaps more upon this subject than in regard to their volume. We may ask:

1st. Are these filaments the primary elements of form, or are they composed of other elements? The fasciculi, fibres, and filaments often appear wrinkled transversely, and to a greater or less depth. Very different explanations have been given of this circumstance. Some authors attribute it to the crisping of the mucous tissue, the vessels, and the nerves surrounding the muscular fibres, and which in certain circumstances, especially when boiled, contract so much from place to place, that they seem jointed, although we cannot really divide the filaments into smaller parts placed lengthwise.(4) Others consider this phenomenon as dependent on this, that the filaments are strangulated from place to place and articulated, or because they are formed from an assemblage of globules or small cells, disposed longitudinally and imbedded in mucous tissue.

fibres, and the organization of which we cannot distinguish; and finally to term those rectilinear collections of globular corpuscles observed in the intimate tissue of muscular organs, the *articular muscular corpuscles.* These last corpuscles correspond to the primary fibres of Prevost and Dumas. F. T.

(1) Prochaska, *loc. cit.*, p. 198.

(2) Autenrieth, *Physiologie*, vol. iii. p. 335.

(3) Sprengel, *Institut. physiol.*, vol. ii. p. 125.

(4) The Wenzels have determined that each fibre is composed of round and extremely small corpuscles. The microscopical observations of Home and Bauer represent the muscular fibre as identical with the particles of the blood deprived of their coloring matter, the central globules of which are united in filaments. Prevost and Dumas have obtained the same result. These globules are united by a hard jelly or mucus, invisible from its want of color and transparency. They are united, like a rosary, and form the primary fibre, while a fasciculus of such formations arranged in a similar or nearly similar manner, produces, according to them, secondary fibres. This arrangement, noticed for the first time by Leuwenhoek and Hook, has been observed also by Milne Edwards, and Dutrochet. The latter, while examining the muscular fibres of the crab, observed that they are composed of transparent fibrils arranged longitudinally, with numerous globules in their spaces: these globules are filled with a transparent fluid, which penetrates between their surface of fibrils, to which they seem to adhere but slightly; for we see fibrils entirely destitute of them. The union of these fibrils and corpuscules, which he calls *muscular*, constitutes in his opinion the tissue of the muscular fibre, termed by him the *fibro-corpuscular muscular tissue.* He adds that we often perceive corpuscules without fibrils: this he terms the corpuscular muscular tissue: his opinion is also, that very probably the fibrils, the intimate structure of which we cannot observe, are composed of this corpuscular muscular tissue, either articulated or homogeneous, but so small that it escapes the eye aided even by a microscope. F. T.

We have often observed this appearance, which causes the muscular filaments to appear jointed. We have especially remarked in several insects, that the muscular fibres were contracted from part to part so regularly, that they resembled rosaries. But, we have usually recognised that in men they were united, were equally thick and slightly flattened. As to their component substance, we have never found it perfectly homogeneous; but it always appears formed of darker globules or points, contained in a clearer medium; these must not be blended with those large swellings produced by coagulation.

2d. Whether these filaments are or are not formed of globules, are they hollow or solid? This question has been answered, sometimes in one way, and sometimes in another, and always in accordance with some theory, but it is hardly susceptible of a satisfactory solution from the smallness of the objects. Most probably they are solid.(1)

§ 317. The muscles receive numerous large vessels. They are generally supplied by several arterial branches, which arise from one adjacent trunk. These vessels do not penetrate into the muscle constantly in one place, and generally they enter nearer the centre than the extremeties, and on the inside rather than on the outside. The branches at first proceed in the mucous tissue along the fasciculi; they soon divide into an ascending and a descending branch, which continue to ramify to its smallest subdivisions; but the smallest vessels perceptible by the microscope, are larger than the muscular filaments.(2) The several twigs, and even the branches, frequently anastomose together. The veins form two systems; the deep seated veins, which accompany the arteries, and the superficial veins, which proceed alone. They seem to have fewer valves here than in other organs, for they are easily injected from their trunks.

Although the muscles contain large vessels, their red color does not depend on the blood which circulates in them, but on their peculiar substance. In fact:

1st. The muscular substance is paler in the fetus, and also in reptiles and fishes, and even in the different muscles of the same animal, especially in birds, and likewise in man, when we compare the muscles of vegetative with those of animal life, although in both the vessels are the same in size and number, and even although they are larger, and the blood which they contain is redder in the former.

2d. The muscles of the cold-blooded animals have a reddish tint.

3d. This color changes in diseases, while the number and the capacity of the vessels remains the same.

4th. The color of the muscles does not change in those experiments, where that of the blood varies much. If respiration be suspended so as to prevent the change of venous into arterial blood, or if venous blood be injected into the arteries, the muscle preserves its reddish tint, although the color of its blood is altered.

(1) This is also the opinion of Rudolphi. Link thinks differently, because he believes the muscular fibre to be hollow. Mascagni considers it formed of small cylinders, the walls of which are composed of absorbents filled with a glutinous substance. F. T.

(2) Fontana, *Ueber das Viperngift*, p. 392.

5th. The truth of this proposition is supported by analogies drawn from other organs.

§ 318. The nerves(1) of the muscles are also very large. Most of the nerves of the cerebral system go to these organs. Usually the large muscles receive several branches, while the small muscles have only one. The nerves of all the muscles are not of a proportional size. (§ 174.) The vessels and the nerves generally proceed together. The latter ramify like the vessels between the fasciculi and the fibres, but they cease to be visible before them, doubtless because it is impossible to fill their extreme branches, so as to make them apparent.

§ 319. The forms of the muscles are very different. Usually they are *solid* or *hollow*, that is rolled on themselves. We may say that of all the organic systems, these parts differ the most from each other in size, although otherwise similar in structure. In fact, in no other do we observe a difference like that existing between the almost invisible muscles of the small bones of the ear, and the glutæus maximus.

§ 320. In regard to chemical composition, the muscles are formed principally of fibres; but they contain also *albumen*, *gelatin*, *osmazome*, the *phosphate of soda, of ammonia, and of lime*, the *carbonate of lime, and an uncombined acid*, which Berzelius calls the lactic acid.

§ 321. The muscles are soft, but slightly elastic, and are easily torn after death, so that then they are but slightly solid; but they are distinguished from all other organs by the extraordinary development of their power to change their volume and form, to contract and to extend. This property is termed *irritability* (*irritabilitas*), and it is brought into action by agents which have no effect on other organs. It is more convenient to call it with Chaussier *motility* (*vis musculi insita, vis propria, agilitas, motilitas*.(2)

§ 322. The particulars of muscular motion which belong to general anatomy are,

1st. *The phenomena, the changes of the muscles while in action.*

(1) Prevost and Dumas have observed that when a nerve enters a muscle, it appears to ramify very irregularly, unless it discovers a marked tendency to direct its branches perpendicularly to the muscular fibres, although they cut them also at right angles. As the nerve thus ramifies, it enlarges, and its secondary fibres separate, and are distributed exactly as when deprived of their neurilemma. It then resembles a net of fibres, from which other filaments are separated and enter the muscle perpendicularly to its proper fibres. But here sometimes there are two nervous trunks parallel to the fibres of the muscle which pursue their course at some distance from each other, and mutually transmit small filaments which pass across the space of the muscle between them, intersecting it at right angles. Sometimes the trunk of the nerve is itself perpendicular to the muscular fibres, and the filaments which it gives off expand in this direction, pass through the organ and return, forming a kind of web. In all these cases the branches of the nerves are parallel to each other, and perpendicular to the fibres of the muscle: they either return to the trunk which furnishes them, or go to anastamose with an adjacent trunk, so that they have no termination, and their relations are the same as those of the blood vessels. This last fact contradicts all previous opinions. F. T.

(2) Some modern writers, among others Gruithuisen, (*Anthropologie*, p. 230-236, p. 361-364) and Lenhosseck (*Medicinische Jahrbücher des Oesterreichischen Staates*, vol. v. part. i. p. 97-122, part ii. p. 41-64), have attributed to the muscles a particular sense, called by them the muscular sense, or the sense of motion but this evidently depends on the general perception termed by Reil *cœnaesthesis*. In all the sensations we experience during muscular action, there is nothing peculiar which may be compared with what we experience from the senses. F. T.

2d. The conditions necessary to produce this action.

§ 323. I. The phenomena of muscular action are, 1st, the muscle shortens or lengthens.(1) For a long time the shortening of the muscle was thought to be its only change when in an active state. When it acts, its fibres perform in a single place, or at several points at once an oscillatory motion which causes the surface to appear wrinkled: this gradually extends to all its parts, and its usual effect is to bring the two extremities nearer each other, and to diminish the distance between the parts to which it is attached. It is difficult to determine if there takes place an alternate motion from the extremities to the centre, and from the centre to the extremities, until the latter predominates,(2) or if, as is more probable, there is only a motion from the extremities towards the centre, so that the alternative mentioned by authors is purely apparent, and depends on a momentary contraction of the fibres which resembles a kind of oscillation.(3)

(1) Prevost and Dumas, who think that when the muscle contracts it is unaltered except in the direction of its fibres, attribute its shortening to the sudden flexion of these fibres in a zigzag form; in other words, to the curves of its constituent parts. They have observed that the summits of these curves are always situated in those parts where the nervous and muscular fibres intersect each other at right angles. Dutrochet made the same remark at the same time, but he has gone farther. Prevost and Dumas understood by contraction only the sinuous curve of the muscular fibre considered in its mass. They have remarked that it shortens without any flexion, but they consider this shortening as the result of what Bichat calls *contractility of tissue;* they have not attempted to state the mechanism by means of which this last property is brought into action. They admit in the muscular fibre *a state of rest*, which it assumes whenever no cause tends to lengthen it, and think that is only when the fibre is in this state in its elastic shortening, that it becomes susceptible of curving, to shorten again, or in other words, to contract. Dutrochet's observations relate principally to this pretended *state of rest*. He has observed that the shortening of the fibre without any flexion depends upon the sinuous curve, upon the very minute folds of the internal tissue of this fibre, which lengthens by the unfolding of this tissue, and shortens preserving its straightness by the twisting or folding of this same internal tissue; that the fibre exists in what Prevost and Dumas improperly term a *state of rest*, when this inner folding is at its maximum; and that then only begins the development of a second phenomenon, that of the sinuous curve of the fibre; which shortens, and becomes curved by a mechanism similar to that which had effected its shortening, while its straightness was preserved; the difference is this, that, in the first case, the phenomenon presented by the fibre is internal, while in the latter it is external. Thus Prevost and Dumas considered one part of the pheuomenon of muscular contraction, that which preserves the straightness of the fibre, as resulting from a simple elasticity foreign in some measure to life; while Dutrochet represents the curve of the intimate tissue of this fibre as being as vital as its curve in the mass, since the latter is the result of a fixed and permanent elastic state, of the elasticity with which the intimate parts of the fibre tend to preserve a certain curve which they have assumed by the fact of the immediate cause of life, but the vital contraction of the fibre while straight results from an elastic state, which varies in degree, and even ceases to exist to a certain extent, by the fact of its relaxation. Prevost and Dumas think that it is by means of this shortening without a curve in the fibre, that the contraction of the membranous muscular organs, such as those which exist in the parietes of the intestinal canal, takes place, whence they conclude that the contraction of these organs differs entirely from that of the muscles of locomotion. Dutrochet deduces on the contrary from his observations, and the usual course of nature which constantly unites simplicity and uniformity of cause, with variety and fruitfulness of result, that this difference does not exist, and that in both cases contraction depends on the curve of the muscular tissue, on an elastic state the cause of which is vital. As to the cause itself, he differs from Prevost and Dumas, as we shall mention hereafter. F. T.

(2) Haller, *Elem. phys.* vol. iv. p. 471.

(3) Barthez, *Nouv. El. de la sc. de l'homme;* 1706, vol. i, p. 117.

Probably also when it has contracted as much as possible, the muscle does not remain perfectly still and motionless, but this apparently permanent state, is in fact a rapid succession of small contractions and extensions.(1)

In shortening, the muscle swells and becomes thicker.

Its color when in a state of contraction and of relaxation remains the same; it would seem then that its vessels contain as much blood in one case as in the other. *Rapidity* and *power* of action are both very great in the muscles. Speaking, singing, running, &c., prove the quickness with which they act. The weight they can raise, notwithstanding their force is diminished by different circumstances, proves their power to be great.

But the phenomena of muscular contraction are not the only ones which are active. The muscles possess also an active power of elongation or extension.

The phenomena which prove this proposition are, for instance, the motions of the iris, the firmness of muscles spasmodically contracted, which almost always remains even after death, while if contraction was the only vital act, it would cease at death, and relaxation would follow; the different states of the iris which is usually closed after death, but is sometimes much dilated; the stomach is always flabby, but often also contracted in its whole extent, or in some points only, with so much power that it is distended with difficulty, and finally, the force with which the heart dilates. All these facts are explained in a forced and unsatisfactory manner, if we suppose that elasticity alone contributes to extension.

This opinion is still more probable, because the contractions of the muscles cease or diminish from the influence of the will, and we cannot admit this effect has been produced solely by the action of the antagonist muscles, which have counterbalanced the efforts of those to which they are opposed.

But we cannot demonstrate that extension is the only vital act which the muscles perform, and that they contract simply because they are elastic; for contraction is their first change, when they are acted on by a stimulus.

The muscles have then the power of *active extension* and *contraction*. Barthez(2) has attributed to them a third, called *the fixed power of location*, which consists in the power of remaining a greater or less length of time in a state of contraction; but this power is illusory, for contraction is the essence of all the phenomena on which this is founded.

§ 324. It is asked now, if when the muscle has changed its form, as has been stated, it changes also in mass and volume, that is, if it loses in thickness as much as it gains in length, and in case the loss is real, in what manner the change in mass or volume is effected?

(1) Swammerdam, *Bibl. nat.*, p. 845.—Roger, *De perpetuâ fibr. musc. palp.*—Woollaston, *Croonian lecture*, in the *Phil. trans.*, 1810.

(2) *Nouv. élémens de la sc. de l'homme*, 1806, vol. i. p. 131.

The muscles may augment or diminish in mass. Each of these two theories has its supporters.

Glisson,(1) Goddard,(2) Swammerdam,(3) and Erman,(4) bring forward the following experiments in support of the hypothesis, that when the muscle contracts it diminishes in volume. They take a hollow muscle, for instance, the heart of a frog : it is inflated, tied, and then introduced into a syringe, terminating in a narrow canal, and containing a colored liquid. The liquid lowers during the contractions of the muscle, and on the contrary rises when they cease. The heart of the frog, filled with blood, and torn from the body of the animal, becomes smaller during contractions, and larger when it is dilated. The same phenomena present themselves, but less sensibly, when a heart is deprived of blood, and without a ligature is introduced into the pipe. But in these experiments made on hollow organs, it might happen also that the cavity only experienced this alternate enlargement and contraction, or that the fluid contained was compressed or expanded.

Other experiments have been made to arrive at the same results with the solid muscles, either with some of these single organs, or with entire limbs. A muscle is introduced into a tube, and to its nerve is attached a small silver wire, which passes out through an opening in the cork, or the nerve is preserved sufficiently long to pass out of the tube. Now if the nerve be irritated directly, or by a metallic conductor, the fluid is depressed when the muscle is convulsed. But from the avowal of Swammerdam, the level of the water does not often vary in this experiment, and the change which sometimes occurs may be satisfactorily explained by the attraction exerted upon the liquid by the silver wire, or by the nerve.

The experiments with entire limbs are : a man plunges his arm into a large funnel-shaped tube ; the orifice is completely closed, filled with water, and the arm is moved, the level of the water is depressed during the motion, and rises when the arm is at rest. But these phenomena do not prove what the experimenters intended in making them ; for the size of the limb ought to diminish, because the veins are empty, and blood is expelled from them by the action of the muscles. Besides, the contraction of some muscles is attended with the relaxation of others, so that it is always doubtful whether the diminution in size is owing to one or the other of these two states. On the other hand, the level of the liquid did not vary in a vessel filled with water, into which the half of the body of an eel had been plunged, and made to execute the most lively motions.(5) The same phenomenon has been observed when the experiment has been repeated with the lower portion of the body of frogs.(6)

(1) *Opp. omnia*, 1691, vol. iii. p. 191.
(2) *Phil. trans.*, vol. ii. p. 356.
(3) *Bibl. nat.*, p. 846, 847.
(4) In the *Abhandlungen der Aakademie der Wissenschaften von Berlin*, 1812, 1813, p. 155-170.
(5) G. Blane, *Lecture on muscular motion*, p. 253.
(6) Barzellotti, *Esame di alcune moderne theorie intorno alla causa prossima della contrazione muscolare*, Sienna, 1796.

Neither is the increase in the size of a muscle proved by the pains which arise in the arm surrounded by a cord,(1) as this phenomenon only proves that the muscle which contracts becomes thicker.

As the experiments which are adduced in support of the first two opinions demonstrate nothing evidently, but far from it, and as they often furnish no result from whence we could conclude either that the muscle diminishes or increases, it remains probable at present that the change in the form of the muscle is not connected with a change in its mass.(2) But this law is not proved by the experiment in which the motion of the legs of a man, placed on the edge of a beam, do not cause his body to lean to the side of the leg which moves,(3) nor by the assertions of physiologists, who pretend that there is no alternative, because the muscle shortens in proportion as it becomes thick.(4) Experiment in fact demonstrates nothing, because certain muscles relax in the proportion as others contract. The assertion supposes a demonstration of what is yet doubtful. The recent experiments of Erman(5) seem in fact to favor the hypothesis, that the muscles diminish during contraction ; for when parts of eels were put into a cylinder filled with water, and having at its upper part a glass tube, the contractions produced by a chain communicating by one pole with the spinal marrow, and by the other with the muscles of the part, caused the liquid to sink evidently in the tube; and when they ceased, the liquid again ascended as much as it had sunk. One objection only can be made to this experiment, which is, that some muscles relax, while others contract ; but the structure of the fish permits us to say, if the muscles of one side of the body only are contracted, all those of the separated portion are truly contracted, and this portion may be considered as forming but one muscle.

The color of the muscles is absolutely the same in action and repose. Some think it more pale when they act, because the heart, which is transparent, when the blood it contains is emptied, is naturally more pale than when dilated and full of blood.

But as the quantity of the blood usually increases in an organ acting with more power, and as this increase of itself renders the action more energetic, we ought to presume that a muscle contains more blood when in a state of contraction, that when it is at rest. Many physiologists are also of this opinion.(6) Prochaska likewise believes that when the muscle contracts, fluids flow in greater abundance between its fasciculi and its fibres, and that this greater afflux causes con-

(1) Hamberger, *Phys. med.*, Jena, p. 581.

(2) This is the opinion also of Prevost and Dumas. By putting into the glass larger muscular masses in order to increase the effect of a change in volume, whether real or supposed, there was no manifest alteration of the level of the small tube, whence they concluded, with Blane and Barzellotti, that if the muscle changed in the least, it was to a slight degree only. F. T.

(3) Borelli, *De motu animal*, vol. ii. prop. 18.

(4) Sprengel, *Instit. physiol.*; vol. ii. p. 149.

(5) Gilbert, *Annalen für die Physik*, vol. x. 1812, p. 1.

(6) Particularly Cowper, Stuart, and Baglivi. See Haller, *El. phys*. vol. iv. p. 544.

traction, and obliges the fibres to assume a more tortuous direction. The volume of the muscle then really increases a little on contraction, but as its vessels are full previously, this increase is so slight, that its change is not appreciable.

The arguments adduced by Haller against this theory, viz. that the motion of the heart is involuntary, that we know not why blood should flow in a greater quantity to one muscle than to another, that the muscle is very irritable, and that the artery is not,(1) these arguments are of no weight, for irritation of the muscle would cause a more abundant flow of blood to it, independently of the energy of the vascular system, and the relations of the muscle with the will. Besides, it is certain from experiments made with this view, that the contractions of the muscles are not at least necessarily attended with a greater afflux of blood, and that they do not result from this afflux, since on examining the section of a muscle with a microscope there is no liquid exuding from the wound, neither during nor after the contractions.(2) Contractions take place even when the blood is coagulated in the vessels. The quantity of this fluid has no influence upon them in any manner, and although entirely destitute of blood, they contract with as much vivacity as when the muscle contains its usual quantity.(3)

Paralysis from the ligature of the arteries has been considered as a powerful argument, that muscular contraction depends on the afflux of blood. But this paralysis does not supervene immediately, and even when it occurs soon after the ligature of the arteries, it serves to prove only that the blood is necessary to preserve the normal state of the muscle, and to maintain its fitness for contraction. We have no right to deduce from it any conclusion in respect to the cause of contraction.

§ 325. II. The conditions for the activity of the phenomena of muscular irritability are :(4)

1st. The muscle must be living. At death it loses the power of changing its form by contraction, although its elasticity continues longer, and ceases only when putrefaction commences. The life of the muscle depends upon its uninterrupted communication with the nervous and vascular systems. When this communication has been interrupted, the muscle still preserves its irritability for sometime, even

(1) Haller, *loc. cit.*, p. 545.

(2) *Ibid.* exp. 1–4.

(3) Barzellotti, *loc. cit.*, exp. 10–12.

(4) Nasse has concluded from some experiments that the irritability of the muscles is diminished and even destroyed by water, and has also pointed out the influence of this opinion on the theory of various physiological and pathological phenomena. (*Deutsches Archiv. für die Physiologie*, vol. ii. p. 78.) This fact had been noticed previously by Humboldt, (*Ueber die gereizte Muskel-und Nervenfaser*, vol. ii. p. 221, 222,) Carlisle (*Philos. trans.* 1805, p. 23,) and Pierson (in Bradley, *Med. and phys. journal*, 1807, vol. xvii. p. 93.) It was also demonstrated by Edwards, (*Sur l'asphyxie des batraciens*, in the *Annales de chimie et de physique*, vol. v. p. 356–380,) and again brought forward in his important treatise, *De l'influence des agens physiques sur la vie*, Paris, 1224.) F. T.

when removed from the body, because it contains nerves and vessels; this power however is soon lost.

Probably then the part taken by the nerves and their power as exerted in the contraction of muscles is merely secondary, and the relations between the nervous and the muscular systems are the same as those between the systems of the muscles and vessels, viz. the simple relations of formation and of nutrition. The contractility of the muscles is situated undoubtedly in their peculiar substance, but to call this power into action, a more active life is necessary. This is derived from the nerves and vessels with which the muscles are so liberally provided, probably for this very purpose. This view of the influence of the nerves is confirmed by the circumstance, that in many muscles, it seems to be supplied in some measure by the blood. Thus the nerves of the heart are proportionally smaller than those of the other muscles, while its blood-vessels are much larger; and farther, the extensive surface presented by the reticulated structure of its internal face is wet with blood which is constantly rushing to it. Hence too the reason that the derangements of the nervous system do not affect all the muscles in an equal degree, and that the paralysis, and even the lesion of this system by poisons, the removal of considerable portions of it, as of the brain, the spinal marrow, &c., do not derange the motions of the heart, at least so quickly and to such a degree, as the actions of the voluntary muscles, whose nerves are proportionally larger.(1) But these lesions of the nervous system are not without their effect upon the irritability of the heart, and the total destruction of the central parts of this system soon arrest its motion entirely,(2) hence these and similar phenomena cannot be considered as proving that this muscle is entirely independent of the nervous system.

But we have no right to assert with Legallois, that this difference between the heart and the voluntary muscles depends on this, that the heart receives the vivifying principle necessary to manifest its activity from the whole spinal marrow, by the sympathetic nerve.(§ 182.) But we ought certainly to explain it as we have, from the differences relative to the age at which these observations on the influence exercised by the destruction of the spinal marrow are made, for the older the animal, the more of this cord may be destroyed without a suspension of the activity of the heart.(3)

Muscular irritability has then no relation with the activity of the nerves, except by reason of the formative acts necessary for its continuance in general, and for its more energetic manifestation.

But the influence of the nervous system and the power it possesses upon the irritability of the muscles is very inferior to that of the blood. This seems to be demonstrated by the facts in the experiments made to enlighten us on this obscure point. The force and duration of the con-

(1) Wilson, *Account of some experimens relating to some experiments of Bichat*; in the *Edinb. med. and chir. journ.* vol. v. no. 9. xiii. p. 301.

(2) Legallois, *Expér. sur le principe de la vie*, 1812, p. 83–105.

(3) Legallois, *loc. cit.*, p. 89, 90, 95, 97, 98, 101, 102.

tractions is always considerably diminished in the muscles the arteries of which have been tied, while a division of their nerves does not produce the same results.(1) But these experiments perhaps only prove that the influence of the nerve on the continuance of the irritability in the muscles does not depend upon its communication with the centre of the nervous system, but it possesses a sufficient power independently of this same centre, and that consequently it can exercise sufficient influence on the blood of the part submitted to the experiment.

The importance of the blood to the exercise of muscular action is demonstrated by the deleterious influence of an anomaly in sanguification, particularly upon the irritability. This power suffers generally before all the others in the morbid states of the circulatory and the respiratory systems which renders the change of venous into arterial blood imperfect. In the same manner it is extinguished so suddenly in the bodies of those persons who die by respiring gases which are unfit for the normal formation of the arterial blood, such as the carbonic acid gas, and usually after asphyxia.

In fact we cannot demonstrate that the nervous system is not affected simultaneously in these cases, and that irritability is not extinguished by paralysis: an opinion, the less improbable, inasmuch as the nervous power itself then appears to be more or less enfeebled.

2d. The living muscle must be in its normal state, not only as respects form, but its chemical composition, and its power of receiving impressions. It will not contract if it has remained inactive too long, been too much distended, if compressed or changed into fat, or if exhausted by too frequent or too violent contractions.

3d. A stimulus must act upon the muscle which must be proportional with its power of receiving impressions.(2)

§ 326. The phenomena of irritability are not the same in all muscles. They vary in regard, 1, to their duration; 2, to their extent; 3, to their rapidity of motion; 4, to the nature of the stimulus which calls them into action. Usually the same muscles present the same phe-

(1) Fowler, *Experiments and observations relative to the influence of the fluid lately discovered by Galvani*, London, 1793.

(2) As the extremities of the nerves meet the muscular fibres at right angles, Prevost and Dumas conclude that the galvanic current excited in passing over these nervous filaments causes them to approximate, and that these filaments bring with them the fasciculi of the muscles to which they are attached, which produces the folding of these fibres. Thus, according to their theory, the nerves are the only organs of contraction, and the muscular fibres are inert parts, designed only to obey the nervous filaments. Dutrochet, on the contrary, maintains, that the contraction or curve of the muscular fibre depends on the development of an elastic force which is itself caused by certain molecular phenomena, so that the muscles act as springs. He considers the muscular fibres as solids, which, from the influence of certain external or internal causes, assume either in their mass or intimate parts a curved position, attended with an elastic force which tends to cause this position to be retained. From his view of the subject, it follows that muscular contraction is a real phenomenon of elasticity, but of an elasticity which appears and disappears successively with the curve which attends it, so that as elasticity is, in final analysis, a phenomenon of molecular action, contraction also is found in final analysis, to depend on a certain mode of action in the molecules or the corpuscles which compose the organized solids. One may see that this theory is directly opposite to that of Prevost and Dumas. F. T.

nomena in all individuals, and the action of the whole muscular system is brought into play in the same manner by the same circumstances, so that the exceptions we sometimes find are much less proper to overturn general laws, since the exact knowledge of the causes which produce them will demonstrate that they depend precisely on these laws.

§ 327. 1st. There is not a single muscle which does not possess the power of contracting some time after the intellectual phenomena, and consequently voluntary motion have ceased, even when it has been separated from the body. The circumstances are rare where irritability is extinct in the whole muscular system of a man before one hour is elapsed: but this faculty is lost in some muscles much sooner than in others.

It is generally admitted that it remains longer in the involuntary than in the voluntary muscles. The following has been established as the scale of its duration in the different organs, viz. the *heart*, the *intestinal canal*, the *stomach*, the *diaphragm*, and the voluntary muscles; it remaining longest in the first.(1)

But this rule is often subject to exceptions. Haller himself, to whom we owe the scale just mentioned, has frequently known irritability remain in the intestinal canal longer than in the heart.(2) Zimmermann has found it remain longer in the diaphragm, and Œder in the other voluntary muscles. Froriep and Nysten assert that irritability disappears soonest in the bladder, the intestinal canal, the stomach, and the esophagus, and continues longer in the muscles of animal life.(3)

Some experiments might induce us to suspect that the difference in the duration of irritability depends on that of the stimulus employed: for several naturalists have found, that although the heart contracts longer than any other organ under the influence of mechanical agents, it becomes insensible to galvanism sooner than the voluntary muscles.(4) These phenomena are very remarkable, as they imply that irritability is modified by the nature and the mode of action of the natural exciting causes, in this respect, that during life the natural stimulus of the heart is also a mechanical impulse, while the muscles are excited to contract by an agent very similar to the galvanic principle, if not identical with it. This hypothesis seems more probable, as in other experiments, the voluntary muscles when they were covered by the skin, preserved in fact their power of contraction longer than the heart, even under the influence of galvanism, but still they became insensible to the action of this stimulus much sooner than this organ when they were exposed like it, and when their temperature was reduced to the same level,(5) because the presence of a fluid capable of being vaporized, contributes to produce the phenomena of galvanism.

(1) Haller, *Mém. sur les parties sensibles et irritables*, vol. ii., p. 257.
(2) *Ibid.*, p. 340.
(3) Voigt's *Magazin*, vol. vi., p. 336.
(4) Giulio in Voigt's *Magazin*, vol. v., p. 161.
(5) In Voigt's *Magazin*, vol. vi., p. 337.

But more recent experiments made with the utmost care on man and animals seem to demonstrate that the difference in the duration of irritability does not depend on the nature of the stimulus.(1) The scale established by them is not the same as that mentioned by Haller.

According to these experiments, irritability is lost, 1st, in the left ventricle of the heart; 2d, in the large intestines; 3d, in the small intestines; 4th, in the stomach; 5th, in the bladder; 6th, in the right ventricle, the esophagus, and the iris; 7th, in the voluntary muscles; 1st, in the muscles of the trunk; 2nd in those of the lower and those of the upper extremities, and finally in the two auricles, the right auricle preserving its irritability the longest.

That irritability remains longer in the voluntary muscles, is also demonstrated by the circumstance, that water distilled from the laurel or from bitter almonds, and placed in contact with the stomach and the brain, renders the heart insensible to the most powerful stimulants in ten minutes, while the voluntary muscles move several hours after.(2)

2d. The extent of motion is not the same in all irritable parts. In general, we may admit that the irides, the lymphatic vessels, and the intestinal canal, experience the most considerable changes in their volume, for they are susceptible of dilatation and of contraction to an almost incredible extent.

3d. These parts too are extended and contracted with the greatest rapidity.

4th. The nature of the stimulus to motion is not the same for all the muscles. Thus light is the specific stimulus of the iris; the heart contracts with more power from a mechanical irritation, and its motions continue much longer and with greater energy when the irritant acts on its internal face, than when in relation with its external face. In general, the stimuli are internal or external. The first arise from the nervous system, the others are applied directly to the muscles. The former may be termed immaterial, the latter material. All the muscles are susceptible of receiving impressions from these two orders of stimulants, but there are several immaterial agents which have no action upon certain muscles; such as particularly the stimulus of the will, whence arises the division into the *voluntary* and the *involuntary muscles* (§ 312). Still the changes in the activity of the brain produce analogous phenomena in all muscles, even in the involuntary. The passions modify the action of all the muscles in the same manner: anger quickens the motions of the heart and of the intestinal canal, even without the aid of the will; it heightens the activity and increases the power of the voluntary muscles. The opposite effects of fright and fear are experienced also in all the muscular system.

§ 328. The degree of muscular activity is modified in many ways by different circumstances. Generally its power is in direct ratio with

(1) Nysten, *Rech. de phys. et de chimie pathol.*, 1811, p. 321.
(2) Himly, *Commentatio de morte*, Gottingen, 1794, p. 57.

the perfection of the organization of the muscles. In fact the power of the contractions may be increased even in those muscles which are less perfectly organized and not so well nourished; but, other things being equal, the muscle which receives more nutrition always contracts with more power than that which is less developed. We have before spoken of the influence of the blood and the nerves upon irritability (§ 327).

The duration of the irritability after death, or the cessation of the intellectual phenomena, depends much upon the kind of death, the state of health during life, and the circumstances in which the muscle is placed after death.

Usually irritability continues a longer time in proportion to the good health of the subject, and to the rapidity of death. In a robust man, the right auricle contracted nine hours after the head was severed from the trunk,(1) while, when the disease has lingered a long time, it is entirely extinct at the end of the first hour.(2) It disappears very soon in the bodies of those individuals who have died from chronic diseases, where the process of nutrition was affected. The diseases which pass through their periods rapidly, have no influence on the duration of irritability; so that it remains even a whole day in those patients who have died from inflammation of the lungs, aneurism of the heart, apoplexy, and even nervous fevers.

But there are certain circumstances where irritability disappears immediately, even in those who have enjoyed the best health; as in death caused by lightning, by certain poisons, by violent blows on the abdomen, by great efforts, &c. Different external agents acting on the body, also cause it to disappear promptly after death: thus hydrogen gas, carbonic acid gas, and more especially sulphureted hydrogen gas, paralyze the muscles with which they are in contact.

§ 329. Besides the vital faculty of entering into action from the power of stimulants, the muscle possesses still another, which is not necessarily connected with life, and which may be termed with Bichat *extensibility*, *contractility of tissue*, or with Haller, *dead force*. It is by this property that the muscle distends itself when mechanical forces act upon it. Thus the muscles of the abdomen are distended during pregnancy, in ascites, and the muscles generally by the effect of tumors which are developed in the subjacent tissues, the heart by the accumulation of blood, the bladder by that of urine, the muscular tunic of the intestine by the unnatural retention or by the abnormal development of foreign substances, as air or fœces, within it, and finally all the muscles by the action of their antagonists.

As soon as this extending power ceases to act, the muscle returns to the volume which it possesses naturally in a state of repose, and it is not distended by a strange power. When a dead muscle is divided, if it be distended, the cut portions contract and separate. The shortening of the muscles of the stump after amputations depends on this

(1) Nysten, *loc. cit.*, p. 318.
(2) Nysten, *loc. cit.*, p. 367–383.

power of contractility, whence the bones which were at first concealed in the soft parts gradually appear.

These phenomena do not cease till putrefaction commences. But are they not phenomena of life? We have seen them even in muscles which have been soaked for several hours in a strong solution of opium, and in animals killed by electricity, as also in cases where these organs have not been submitted to similar agents. Bichat divided the muscles of a limb, the nerves of which had been cut ten days previous; contractions occurred as forcibly as in those muscles whose nerves had not been divided: and farther, a certain retraction of the muscles is always observed in the amputation of a paralyzed limb. But we do not consider these facts as demonstrating that the phenomena of which we treat are not the results of life; they only prove that they are the results of a vitality much slower than that which exists when the phenomena of irritability are produced; besides, the duration and the force of the phenomena of irritability do not differ when examined comparatively in the healthy and the paralyzed muscles of the same subject.(1) Probably all the changes in the form of the muscle depend upon the same force which only acts with more energy while the life of the nerves is not extinct, but is preserved for some time afterward, although it does not seem to us probable that the stiffness of the cadaver is a vital phenomenon of the muscles, as Nysten thinks.(2)

§ 330. The muscles are not very sensible, although they receive numerous nerves.

§ 331. The principal differences presented by the muscular system at different periods of life are as follows:

During the earliest periods of uterine existence this system is not distinct from the fibrous, with which it forms a whitish mucous mass.

The muscles are at first very soft, have no apparent fibrous structure, and are much paler than they are afterwards. The fibrous structure does not develop itself in them till toward the beginning of the third month, and is not visible then unless they are immersed in alcohol. From our researches it seems that the large divisions of the muscles, the fasciculi, form before the smaller ones, a remarkable phenomenon, because we observe also in the animals of the inferior classes, that the final subdivisions of the muscles in which length predominates are proportionally and even absolutely larger than in the superior animals, and we see only globules or small points in the centre of those large fasciculi into which the muscle is divided. They are also thinner and more feeble. The heart alone is an exception to this rule: for it is proportionally much larger in the early than in the subsequent periods of life.

It follows, from the great difference in the respective proportions of the regions of the body, that the same muscles have not at all times the same proportional volume in regard to each other or to the whole body; those of the upper half of the body, of the head, the neck, and

(1) Nysten, *loc. cit.*, p. 369.
(2) *Loc. cit.*, p. 384–420.

the back, are much more developed than those of the lower extremities. Thus, for instance, some small muscles of the neck are much larger than the glutæus maximus, which finally exceeds all others in volume.

The loose part of the tendons is already proportionally as long and as strong as it is afterwards, but these organs are less apparent and less developed in the interior of the muscles.

According to some writers, the muscles of the fetus are less irritable than those of the adult; and the degree of facility with which they contract, and the duration of contractions is much less, the nearer the fetus is to the period of its formation. But these assertions are contradicted by several facts:

1st. By the greater tenacity of life in the fetus and the newly born animal, and the entirely opposite phenomena that irritability presents in similar animals, as the cold-blooded and the hibernating animals during their period of hibernation.

2d. By the general law, that the power and degree of effort with which muscles are endowed during life, is usually in an inverse ratio to the facility with which irritability is called into action and to its duration, so that the newly born animal resists longer and more easily the action of cold,(1) of the irrespirable gases and anomalies in respiration.(2) Experiments carefully made have convinced us, times without number, that irritability remains after death in the newly born animal longer at least than in the adult. We have further found no trace of it at the end of an hour and thirty minutes in an old hamster, while the muscle of a hamster killed immediately after birth contracted eight hours after death by merely touching it. Irritability was also extinct in an hour and forty-five minutes in an old rabbit, while it remained two hours and thirty minutes in a rabbit three days old. We have almost always found its duration equally long in the newly born animal; often longer, rarely shorter.

The contractions always appeared to us to be made with more energy in the young than in the old animal. In fact, in the latter we even perceived that slight convulsions only took place, while in the other the muscles always shortened sufficiently to produce for a long time a sensible motion in the limb to which they belonged.

Some time after birth the muscles become redder and stronger, but they remain for a long time round, soft, and with more of gelatin than of fibrin. It is only when the growth is finished, that they become thick, angular, have more cohesion, more solidity, that the red color is well marked, and that they act with all their power. They acquire

(1) W. Alexander, in *Physiological and experimental essay on the effect of opium on the living system*, in the *Memoirs of the Manchester Society*, vol. i., London, 1815, p. 85.

(2) Here we refer to a multitude of facts proving that young animals have perished less quickly under water and in the irrespirable gases: that newly born infants who have been immersed for several days, have been taken out alive; and that the absence, the obliteration, or the contraction of the pulmonary artery has been supported without inconvenience, or at least with slight trouble, for weeks, months, and even years.

these qualities more perfectly, as the subject enjoys better health, and they are more exercised. Their redness, as well as their cohesion and force, gradually diminish, while, on the contrary, they become harder. Their motions are less extensive and less certain.

§ 332. The muscles present also differences dependent on the sex. Other things being equal, they are rounder and feebler, less solid and less vigorous in the female than in the male. We cannot, in the actual state of our knowledge, resolve even probably the question if there are differences relative to the races of men. However, it is possible that the anomalies which degrade us to the class of animals are more common in the inferior than in the superior races.

B. OF THE MUSCLES OF ANIMAL LIFE.

§ 333. The muscles of *vegetative* and those of *animal life* differ so essentially in all points, that, notwithstanding the general considerations into which we have entered in regard to the muscular system in general, it is indispensable to study the two series separately. We commence with the muscles of animal life.

§ 334. The muscles of animal life form a great part of the mass of the body, in fact nearly as much as all the other organs united. They are generally inserted around the bones and represent the forces which move these levers. They are particularly numerous and powerful in the extremities. Their formation is more or less confined in all parts where the principal functions of life are developed, that is, in the cranium, the abdomen, and the chest.

§ 335. These muscles form solid masses, the fasciculi of which, having a straight direction, attach themselves by their two extremities to certain parts of the fibrous system, the tendons, by means of which they adhere to the periosteum which unites them to the bones: at least this is their usual arrangement. It is seldom that a muscle is not attached to a bone, or that it is inserted by one extremity only, and that its fasciculi by folding on themselves give origin to rings. Most of the sphincters, the orbicularis palpebrarum, the orbicularis oris, the sphincter ani, and the constrictores pharyngis do not adhere to the solid parts on which they act; they take a point of support from them. The muscles which are attached to the bones by only one extremity, and which are designed to move the soft parts only, are found principally in the face, in the buccal cavity, and in the organs of generation. The annular muscles offer no appearance of tendinous structure, or at least present it only in those narrow points where they unite to the adjacent solid parts, or in those where they arise from the bones, and never in the places where they are continuous with those soft parts which they put in motion.

§ 336. The tendons are always much thinner than the muscular substance. The muscular and tendinous substances never separate suddenly, but we see them alternating together constantly for a greater or less extent. When the tendon is broad but short, it almost always sends upon the two faces of the muscle, and between its fasciculi small bands which gradually grow thinner and thinner: when it is long and narrow, it plunges between the muscular fibres in the form of a pyramid which gradually diminishes in thickness. The relation between the tendon and the muscle varies much. Some very large muscles have small tendons, as the glutæus maximus, while in others, as the palmaris longus, the soleus, &c., the tendon is much larger than the muscle.

§ 337. Generally the tendons are found only at the two extremities of the muscles, and they may be considered as their integral parts. The central fleshy portion of a muscle is called its *belly* (*venter*); we term the upper tendon, or in general the tendon attached to the most fixed point, the *head* (*caput*), and the opposite extremity the *tail* (*cauda*) of the muscle. We term the *fixed point* (*Punctum adhesionis*, *P. fixum*) that to which the head is attached; while the opposite point is termed the *movable point* (*Punctum insertionis*, *P. mobile.*) The muscle usually contracts towards the former. The muscles are almost always fixed by an upper and a lower tendon to two bones, one of which is more movable than the other. In the rarest cases,

1st. They are attached to the bones by one of their extremities only, the other being fixed on the soft parts, either that they may unite by this extremity with other muscles which act in an opposite direction, as is seen in the muscles of the anus and most of those of the genital organs, or, as in many muscles which pass upon the capsules of the joints, that they may be attached to other organs which they are designed to move.

2d. Their two extremities are loose, and when they contract they move only the skin situated upon them, and to which they adhere intimately, as for instance the platysma myoides muscle.

But it sometimes happens that we find tendons in one or several parts of the extent of the muscle which then is divided into several bellies. We usually find only one of these intermediate tendons, termed *tendinous intersections* (*intersectio tendinia.*) The muscles which present this arrangement are called *digastric* (*biventres*, *digastrici.*) Such are seen in the lower jaw, in the neck, and nucha, as the *biventer maxillæ inferioris*, the *biventer cervicis*, the *complexus cervicis*, the *sterno-hyoideus*, and the *omo-hyoideus*.

The recti muscles of the abdomen present several tendinous intersections, which are sometimes four in number. These intersections usually extend the breadth of the muscle, but sometimes, (as the upper one of the rectus muscle) they occupy only a part of it. They are almost always short in proportion to the length of the muscle, while their breadth equals that of the muscle. The dividing tendon of the digastricus is an exception to this rule.

These tendinous intersections, in fact, divide one muscle into several. They furnish several fixed points, towards which the fibres contract, and between which they can extend.

This arrangement then increases the contractile power of the muscle and its force of resistance, no fibre of which has an extent equal to its whole length. Hence why tendinous intersections are found particularly in those muscles which are thin and long in proportion to their other dimensions. Generally they do not change the direction of motion; they however produce this change in the digastricus, the anterior and posterior bellies being united at an obtuse angle, by means of an intermediate tendon which is itself attached to the hyoid bone.

§ 338. Generally, many muscles act in the same direction, and produce the same change in the parts they move, and almost always contract simultaneously: hence they are called *congenitals.* Others act in opposite directions, and are called *antagonists* (*antagonistæ*). The first occupy the same region, are attached to almost the same points, and are placed more or less internally or externally, above or below, at the side of, or over each other. The antagonists are situated in opposite regions. All the motions of the different parts of the body may be referred to two, whether they are removed from or approach each other. One part receding from another approaches a third. These two effects are produced by the same muscles, but the different motions receive other names, according as the synonymous parts placed at the side of or opposite to each other are approximated or separated, or according as the parts of a whole which move in the same direction, but which, although united, are still movable on each other, experience a similar change in their respective situations.

The first is *abduction* and *adduction*, produced by the *abductor* and the *adductor muscles;* the second, *flexion* and *extension*, performed by the *flexor* and the *extensor* muscles. Abduction and extension do not essentially differ, since the result of both is to displace, in the same or nearly the same direction, two parts which at first are situated near or at the side of each other, as are for instance two synonymous limbs, the fingers of the same hand, or the toes of the same foot, and which in the second case, succeed from above downward, as the different divisions of a limb. Adduction and flexion are also the same phenomena at bottom, since both diminish the distance between adjacent parts, and establish a difference in the direction of parts which are united. In both cases, the faces of the part which changes its form preserve the same relative situation, because the same points of its circumference continue to face or to be opposite to each other, although they are moved from or towards each other. But there is a second kind of motion, in which the part turns around its axis, so as to present successively to the adjacent parts different points of its circumference. This is called *rotation*, and comprises two kinds: *rotation inward*, and *rotation outward*, according as parts at the side of each other are approximated or separated; hence a third kind of antagonist muscles, *rotators inward* and *rotators outward.* These motions are rarely executed by a single muscle. The motion of a part in a given direction results almost always from the contraction of several congenital muscles: hence we have, at least in parts of any magnitude, several flexors and extensors, several adductors and abductors, several rotators inward and rotators outward.

§ 339. The antagonist muscles, and using this denomination in its most general sense, the flexors and the extensors, differ not only in the characters which divide the muscles into several sections, but also in other different circumstances, so that we may consider these two classes as the most important.

Their principal distinctive characters are,

1st. The flexors, generally speaking, are stronger than the extensors.(1) Hence the limbs are more or less flexed when the will ceases to act, or when in a state of entire freedom, in paralysis, in sleep, in the softening of the bones, in subjects where the muscular system is debilitated. The flexors are attached to the bones which they move, farther from the centre of motion, than the extensors are: their direction is less parallel to that of the bones, so that their insertion takes place at a more obtuse angle, and is consequently more favorable. This angle enlarges as the muscle acts, on the contrary it decreases when the extensors contract. The nerves of the flexor muscles are larger than those of the extensors.

2d. A difference is said to exist between the extensor and the flexor muscles, in regard to their excitability; that they contract only under the influence of one pole of the galvanic chain, and this pole differs for each class of muscles.(2) Thus it is asserted that the flexors contract only when the silver pole is in contact with the central extremity of the nerve, and the zinc pole with its muscular extremity, while the contrary is the case with the extensors, and that both remain still when the poles are reversed.

Still the experiments adduced in support of this proposition do not seem to establish its truth, and are well explained by the greater power of the flexor muscles, so that Ritter's law does not differ from it. At least it is not correct to say, that the flexor and the extensor muscles contract only in the circumstances which have been mentioned, for even when these circumstances are unfavorable, the greater force of the flexor muscles allows them to contract sensibly, while the extensors do not contract.

§ 340. The external form of the muscles varies much, 1st, in regard to their complexity. Many, and almost all, arise by a single head, and terminate by a single tail fixed to a single point: these are the *simple muscles* (*musculi simplices*): others divide at one of their extremities into several bellies; these are the *compound muscles* (*musculi compositi*). The division exists sometimes at the movable extremity, as in the common flexors and the common extensors of the fingers and of the toes, the muscles of the abdomen, those of the back, &c.; and sometimes at the opposite extremity, as in the biceps flexor cubiti, the

(1) Richerand, in the *Mém. de la soc. méd. d'émulation*, vol. iii., p. 161, 1799.—*Elém. de physiol.*, vol. ii., p. 213.

(2) Ritter, *Beytrage zur nahern Kenntniss des Galvanismus*, Jena, 1805, vol. ii. pt. 3, 4. no. ii. p. 65. 367.

biceps femoris, the extensors of the fore-arm and of the leg, &c. The result of the first arrangement is that a simultaneous motion is impressed upon different parts of the same muscle. In the second kind, 1st, the effect is increased; 2d, when all the different bellies act, the motion produced by them is modified; as, for instance, the leg is at once extended and drawn outward or inward; finally, it follows that when the muscle acts in a direction opposite to what is usual, that is, when its bellies contract towards the most movable point, several parts are put in motion at the same time.

Among the simple muscles are some which in some measure form the transition from the simple to the compound muscles. In fact there are several which, although arising by a single belly, and terminating by a single tail, are still composed of a greater or less number of smaller muscles, the fibres of which are extended in different directions, and are inserted into the common tendon by small tendons: such are the deltoides and the subscapularis muscles.

As to the compound muscles, those which are the least so consist in two layers of fibres, terminating by a more or less acute angle in a common tendon situated between them. These are called the *penniform* muscles (*musculi pennati*). The rectus femoris anticus and the flexor pollicis longus are examples of this arrangement.

Another kind of compound muscles comprehends those of two or more bellies, which we have mentioned before (§ 337).

In the most simple muscles the fasciculi have exactly the same direction. But the direction, and the relation between the length of the fasciculi and the filaments with the length of the muscle, are not the same in all the simple muscles. Sometimes the direction of the fibres agrees with that of the whole muscle and of its tendon. In this case the length of the muscular fibres is the same as that of the whole muscle, and it is straight. This is seen in the sartorius and in the biceps flexor cubiti. This arrangement is rare. The direction of the fasciculi more commonly differs from that of the whole mass, and they descend more or less obliquely from one of the two tendons between which the belly exists to the other. We do not consider here if, as in the semi-penniform muscles (*musculi semipennati*, *pennati simplices*), for instance in the flexors of the hand and of the foot, of the fingers and of the toes, one of the tendons, usually the upper, be attached to the bone all its length and all that of the muscle; or if, fixed by a point only at its upper extremity, and descending along the belly to the fibres to which it gives rise, it be loose in all its extent, as is seen in the semi-membranosus muscle. In both cases most of the muscular mass is placed on both sides between two tendons. In the first case, however, the direction of the fibres of the upper tendon is the same as that of the muscular fibres, while in the second case it is different.

§ **341**. The forms of the muscles, in regard to the proportion of the three dimensions, differ much from each other, giving rise to a division of the muscles into the *long*, the *broad*, and the *short*.

§ 342. The *long muscles* are found principally in the extremities, and are more or less cylindrical. Usually their tendons are large, and often much longer than their fleshy portion. Sometimes, however, the contrary is the case: thus, the tendons of the lumbricales are very short. In their course they often pass over several bones placed after one another. They form several layers, of which the superficial are the longest, and the deep muscles the shortest; usually, these last are not extended except between two adjacent bones. Thus, for instance, the biceps cubiti is longer than the brachialis internus; it extends from the scapula to the fore-arm, while the latter reaches only from the humerus to the fore-arm. It is among these muscles that the division into several bellies and the insertion by several tendons are the most frequent and apparent. They are even, especially at their upper part, so closely united in some regions, particularly the fore-arm, either by the aponeuroses which are extended over them, or because the fibres of one are inserted into the tendon of another, that they cannot be separated except by cutting them. Usually they are more bulging in the centre than at their extremities, because their fibres almost always extend obliquely from the upper to the lower tendon, so that their extremities do not contain all their fasciculi, but only the upper and the lower, while in the centre we find not only all the central but also a part of the upper and of the lower fasciculi.

§ 343. The *broad* muscles are usually thin; they are found around the cavities of which they alone constitute the parietes, at least in great part, or which they cover, and of which they take the form. Among the first are classed the broad muscles of the abdomen, and among the second, several muscles of the cranium, the frontal muscle, the temporal muscle, and most of the sphincters. Generally these muscles preserve a uniform breadth and thickness in all their course. They are usually simple; they never terminate in long tendons, but in *slips* (*dentationes*), which attach them to different parts. In some parts, as the chest and the abdomen, the broad muscles are placed over each other, and are somewhat alike in form and size; sometimes the broad cover the long muscles, as in the back.

There are muscles which very evidently make the transition from the broad to the long muscles, either because they unite the two forms in all their extent, or because they are broad in one point and elongated in another. Among the former are the sterno-hyoideus, the thyro-hyoideus, and the recti muscles of the abdomen; among the second, the pectoralis major muscle and the latissimus dorsi muscle, which are narrower at their extremities, but at the same time increase very much in thickness.

§ 343. The *short* muscles are usually as thick as they are broad and long. They are generally triangular or square, and are undoubtedly the strongest of all, since none contain a greater number of fibres in a given space. They are found principally in the points where great force must be employed, because the general arrangement of the parts is unfavorable to their motions; as in the temporo-maxillary articulation, in the hip-joint, in the vertebral column, and even partially in the hand and the foot. The glutæus maximus muscle and the deltoid muscle make the transition from this to the preceding class, as the muscles of the hand and of the foot lead to the first.

§ 345. In regard to texture, the muscles of animal life appear formed of fasciculi and of fibres, which are situated close to each other, but do not interlace. Their fibres generally extend from one tendon to another; sometimes, however, they disappear sooner, and we are then unable to demonstrate that they are blended with the adjacent parts. Mucous tissue is very abundant in these muscles, and it is often so loose that it makes a compound muscle of a simple one, because it divides it into several heads, which are implanted in a common tendon, and which are united by a large layer of mucous tissue, as is seen in the pectoralis major muscle. The mucous tissue usually exists more abundantly in the broad muscles; hence their fasciculi are less compact than those of the other muscles. Almost all the nerves of these muscles arise from the brain and the spinal marrow only; and even where there are filaments of the great sympathetic nerve, as in the neck, nerves are received also from the nervous system of animal life. The nerves often come from remote parts of the spinal marrow, although the great sympathetic nerve is the nearest source, as is seen in the diaphragm. The muscular system of animal life generally receives more nerves but fewer blood-vessels than that of vegetative life.

§ 346. The muscles are the powers which act upon the bones or analogous organs, to remove weights. The bones are levers, and usually simple levers of the second class, in which the power, viz. the muscle, is placed between the point of rest, one extremity of the bone, and the resistance, the other extremity of the bone with the parts which are attached to it. The arrangement is not the same in all; but generally speaking, it is in a manner more or less unfavorable; so that to produce their effect, the muscles have to employ a force greater than would be required if the relation between the power and the resistance were more favorable. Hence the muscular force is very considerable. This law may be called the law of Borelli, because until the time of this physiologist, the contrary opinion was admitted, and it was maintained that the muscles are arranged to raise the heaviest burdens by employing the least possible force.

The circumstances which demonstrate that in general the arrangement of the muscles is unfavorable are,

1st. *They are inserted near the fixed point.* Almost all the muscles are attached nearer to this point than to the resistance. When then a weight is raised which is farther from the resistance than the insertion of the muscle, power employed by the muscle is greater in proportion to the difference between its distance from the fixed point and the distance between the latter and the weight: it is always greater than the weight of the burden.

2d. *The obliquity of the muscles in regard to the bones, or of the muscular fibres in regard to the tendon.* Few muscles are attached to the bones at right angles, the most favorable of all for the employment of force; most of them are inserted at very acute angles. On the other hand, in almost all the muscles the direction of the fleshy fibres varies more or less from that of the tendinous fibres. In regard to the first circumstance, the loss of force is greater in proportion to the obliquity of the angle of the insertion of the muscle in the bone; as to the second, the loss which results from it is proportioned to the obliquity of the muscular with the tendinous fibres.

3d. *The resistance which the muscle opposes to the bone on which it takes its fixed point.* This bone, in fact, tends to extend it as much as does the weight raised by its effort, because the muscle contracts from its two extremities towards its centre.

4th. *The resistance of the antagonists over which it must prevail.*

5th. *The friction caused by the parts which surround the muscle,* although it is diminished by the looseness of the mucous tissue which envelops it in all parts.

But, notwithstanding all these circumstances usually unfavorable to the muscle in relation to the weight it ought to raise, there are others which diminish the loss of force occasioned by them.

Thus, the angle by which the muscle is attached to the bone is considerably increased,

1st. By the swelling of the extremities of the bone on which the muscle passes.

2d. By the extension of the ridges in which they are inserted.

3d. By the formation of special small bones, which develop themselves in the substance of the tendons, at a little distance from their insertion (§ 306).

4th. By the direction that the parts give to the muscles, or only their tendons, near their termination; they change their direction from oblique to perpendicular. It often happens that the angle of insertion of the muscle enlarges during the motion itself, and that from a very acute it becomes almost a right angle. This is observed both in the muscles which act and in their antagonists. As to the friction, it is diminished by the fat which accumulates between the muscles and between their fasciculi, and by the presence of fibrous organs, the sheaths, which give to the muscles and their tendons a determinate situation and a fixed direction.

The loss of force which necessarily results from the obliquity of the fibres is amply compensated by their great increase in number; for, in equal spaces, the more oblique the direction, the more numerous are the fibres, and, other things being equal, the power of the muscle is in direct ratio with the number of its fibres.

Besides, in contracting, the oblique fibres shorten the muscle much more than the straight fibres. It requires less effort then to bring together two fixed points by oblique muscles than it does by straight muscles, more particularly as often, for instance between the ribs, two oblique muscular layers which intercross, by acting diagonally, take the place of a single straight layer. This arrangement of the force diminishes the lassitude arising from muscular motion.

For the same reason, when the muscular fibres are oblique, motion takes place more quickly than when they are straight.

Finally, when two intercrossing layers of oblique muscular fibres act on the same part, the motions admit of greater variety, since possibly the two layers contract at a time or only one of the two acts, and both employ an equal or different force.

C. OF THE MUSCLES OF VEGETATIVE LIFE.

§ 347. The muscles of vegetative life differ from those of animal life.

1st. *In respect to their mass.* This is less, for they form but a trifling part of the organism even when we refer to them all the parts which have a slightly muscular structure.

2d. *In respect to their external form.* This is much more simple. They always form cavities which are lined by the internal membrane of the organs which they tend to compose. They are found in the vascular system, the digestive apparatus, the uterus, and the bladder, of which they form the muscular coat. Except in the heart, they have no appearance of tendons, because their action does not tend to displace the solid parts of the organism, but to expel fluids contained in the cavities they circumscribe. When tendons are seen, as in the heart, they are attached to parts which change their position by the contraction of the portions of the organ to which the opposite extremities are attached. The annular muscles of animal life also present something analogous, for we can always figure them as the commencement of a canal, or rather as a dilated canal, the fibres of which would pass, not behind, but over each other. But these latter, both by their situation and their functions, make the transition from the muscles of animal to those of vegetative life: for the sphincters of the mouth and anus are placed on the limit of vegetative and of animal life, and the orbicularis palpebrarum muscle is less subject to the will than the other muscles of animal life.

3d. *In regard to their texture, they differ in several ways:*

a. In the general arrangement of their fasciculi, fibres, and filaments. These are not distinct and parallel to each other, as in the muscles of animal life, but interlace continually, and for this reason are much shorter than the fibres of the voluntary muscles.

b. Their fibres are arranged in several superimposed layers not only in those parts where nearly the same direction is followed, but where they proceed in opposite directions.

These layers are most generally transverse or oblique, and form rings around the cavities they circumscribe. These rings are always stronger than the fibres which extend in other directions: they are nearest each other at the orifices of the cavities and form internal layers: they constantly surround the internal cavities, while frequently the other layers are evident only in some parts of their circumference, as for instance in the large intestine, and are deficient in a considerable extent, as in most of the venous system. Sometimes longitudinal fibres are found without annular fibres, as in the large veins. These two directions are the most usual, and also exist together most frequently.

c. There is less of mucous tissue in the muscles of vegetative life.

d. Their texture presents greater differences in different parts. There is more difference in color, cohesion, and situation, between the fibres of the heart, the arteries, the veins, the intestinal canal, and even between the different parts of the intestinal canal, the uterus, and the bladder, than is found in regard to size and external form between those muscles of animal life which differ the most from each other.

The heart is very red, redder than the muscles of animal life, as solid as they are, but more compact, and very thick in proportion to its cavity: its internal face is very unequal and reticulated, and it is composed of several superimposed layers. The fibres of the arteries are hard, brittle, flat, and yellowish, and all follow precisely the same direction. Those of the veins are redder, softer, and directed the contrary way, and are visible only in the large trunks.

The muscular fibres of the intestinal canal are of a pale red, and very soft.

In the esophagus and in most of the alimentary canal, we find only two layers of fibres; in the stomach are three. Their thickness is not proportional to the size of the cavity.

The fibres of the bladder are pale and form a much more complex tissue than in the other organs.

The fibres of the uterus are very indistinct, except during pregnancy, and even then they are pale and hardly visible; and, with the arterial fibres, are, of all we have mentioned, the most unlike the muscles of animal life, to which the fibres of the heart bear the greatest resemblance.

e. Have the fibres of the muscles of vegetative life more power of resistance than those of animal life, as Bichat asserts, because that ruptures of the hollow muscles are rare, however greatly they may be distended, while many examples have occurred of ruptures of the voluntary muscles? Is it a fact that the muscles of vegetative life are rarely ruptured, while this often occurs in those of animal life? We think precisely the contrary. Bichat states that we find many instances on record of ruptures of the diaphragm, while rupture of the stomach, the intestines, and the heart, are not known. If we wish to arrive at an exact result, we must not compare a muscle, which, from its situation, form, and functions, is unable to support a violent shock, with other muscles on which this cause cannot act directly; we should consider the two systems in the same circumstances. But—will a voluntary muscle tear more readily than a muscle of vegetative life, when slowly and gradually distended? We think not. The muscles of animal life frequently become thin membranes from the pressure of large tumors without being ruptured; they resist the powerful efforts of their antagonists, while a mechanical obstacle not unfrequently causes the rupture of the muscles of vegetative life.

4th. *In the arrangement of their nerves and vessels.* They receive fewer nerves but more vessels than the muscles of animal life. Their nerves except those of the esophagus, the stomach, and the bladder, are derived for the most part from the great sympathetic nerve.

5th. *The muscles of vegetative life have no antagonists.* Their function is to contract and shorten the canals and cavities they surround. Hence the substances within these cavities are usually considered as their antagonists. The different layers of which they are composed are not opposed in action, but on the contrary by acting in concert, they execute their function better, viz. that of diminishing the size of their cavities. The action of some layers does not interfere with and prevent that of others: a kind of opposition is, however, more or less evident between the different regions of the muscular layer of the same organ of vegetative life. Thus the fibres of the ventricles of the heart always contract alternately with those of the auricles, as those of the arteries alternate with those of the ventricles: the greatest activity of the fibres of the auricles is attended with the greatest degree of inaction in the ventricles, exactly as is seen between the antagonist muscles of animal life. There are regions in the intestinal canal where the antagonism is but temporary, between which are no distinct limits, and which are not marked by differences of structure, for they are adjacent portions which alternately dilate and contract to expel the substances contained in this tube.

6th. *The muscles of vegetative life act, at least part of them, sooner than those of animal life.* This is true, especially in regard to the heart and the alimentary canal. As certain parts, at least of the heart, preserve their irritability longer than all the other muscles, after the extinction of the mind, (§ 327,) we may say, in general, that irritability continues longest in the muscles of vegetative life, although there are some of the muscles of animal life which remain irritable longer than some of the involuntary muscles.

7th. *The muscles of vegetative* differ from those of animal life in the relation between them and the stimulus which causes them to act. This relation is of two kinds:

a. The muscles of which it treats are more or less influenced by the modifications of the spiritual principle. The will has rarely any influence upon many of them, as the heart,(1) and perhaps never has any if we except some cases which may be otherwise explained. Its influence on others, as the bladder and the rectum, is very feeble, and their actions as caused by the will are very slow. On the contrary, the changes which take place involuntarily in these muscles cannot be arrested by the will. Hence why their motions are not changed, or but in a slight degree, in states which are marked by a total inaction

(1) This, however is the case in an Englishman, mentioned by Cheyne, and that of Bayle, as reported by Ribes, who could at pleasure relax or suspend the motions of the heart (?) F. T.

of the intellectual principle, and during which the muscles of animal life are at rest.

b. The stimuli which act on them are always separated from the muscles by an intermediate substance, as in the intestinal canal and the bladder by the mucous membrane, in the vascular system by the internal membrane of the vessels, &c. But this difference is not entirely absolute, for we find an arrangement very analogous to it in the voluntary muscles, inasmuch as their nerves which are the conductors of the different changes supervening in the central parts of the nervous system, in virtue of which the muscles contract, are also separated from the proper muscular substance by the mucous tissue which envelops them.

ARTICLE SECOND.

OF THE MUSCULAR SYSTEM IN THE ABNORMAL STATE.

§ 348. The muscular substance when once destroyed is never reproduced, and wounds of the muscles, where there is no loss of substance, heal in the same manner as those where the substance is destroyed. These two states are very similar, from the separation which the contractions of the two portions of the muscle cause between the edges of the wound. In both cases the opening is always a deep point, around which the edges of the wound in the muscle are sometimes swelled. It fills at first with a vascular, reddish, soft, and gelatinous mass, which afterwards loses its vessels and becomes yellowish white, harder, and horny, and always insensible to the action of stimulants, whatever they may be. We sometimes, but not often, find in this mass, several months after the wound, traces of irregular fibres, but slightly analogous to muscular substance, and when the muscle has been entirely divided, its portions are so completely separated that the irritation of one part causes no contraction in the other.(1) Still, however, notwithstanding this insulation, both continue to be nourished, and they do not waste, as happens to a nerve which has been cut; doubtless because the muscles, unlike the nerves, do not form an uninterrupted organized system. A muscle which has been transversely divided and has cicatrized, is in fact changed into a double-bellied muscle, and resembles those which have tendinous intersections.

§ 349. The muscles present anomalies in form, chemical composition, and in action. We shall here examine only the first two.

(1) Kleemann, *Diss. sistens quædam circa productionem partium corporis humani*, Halle, 1786, exp. ii.—Murray, *Commentatio de redintegratione partium corporis humani nexu suo solutarum vel amissarum*, Gottingen, 1787, exp. i-x.—Huhn, *De regeneratione partium*, Gottingen, 1787.—Schnell, *De naturâ reunionis musculorum vulneratorum*, Tubingen, 1804.

§ 350. Among the deviations of formation,(1) which are usually primitive, we class:

1st. Anomaly in number. This is almost always congenital. Sometimes all the muscles of the whole body or of a whole limb are deficient, although the other parts are formed; but this occurs only when the whole body is incompletely developed, and particularly when its upper part is not formed and there exists in its place a gelatinous mass. In many cases of this kind some mistake may have arisen in regard to the muscles, because they are then usually very white, and an enormous quantity of liquid is found accumulated under the skin. It is more frequent that some muscles are either wholly or partially deficient, so that for instance they are not attached to the solid parts as extensively as usual. The muscles most frequently absent are those of small size, the functions of which are trivial and may be supplied more or less by others, as the palmaris brevis, the plantaris, the pyramidalis, and the zygomaticus minor muscle, and some fasciculi or heads of the flexors of the fingers or toes.

Supernumerary muscles are rarely found.(2) The enlargement and the multiplication of slips of insertion gradually leads to this anomaly, which exists in some muscles rather than in others: thus we see it often in the recti muscles of the abdomen, the small muscles of the head, the biceps femoris, and less frequently in the biceps flexor cubiti. It is not uncommon in the latissimus dorsi, the pectoral muscles, the indicator muscles, and the extensor proprius minimi digiti. Among the supernumary muscles thus developed, we distinguish the sternalis muscle, a proper extensor of the third toe, &c. We must here remark, that one limb resembles another in this respect, that the anterior portion of the body is regulated by the posterior, and that these anomalies almost always are analogous with the structure of some animal.(3)

2d. An unusual largeness or smallness in the size of the muscles is seldom congenital; they commonly develop themselves accidentally. When muscles are abnormally small, it results from the want of exercise. Compression even destroys some muscles entirely. An unusual degree of power in these organs, often but not always, results from their being used. It becomes morbid only when a muscle, for instance the heart, performs its functions so powerfully as to injure the general health.

(1) Heymann, *Varietates præc. corp. hum. muscul.*, Utrecht, 1784.—Brugnone *Observations myologiques*, in the *Mém. de Turin*, vol. vii. p. 157–191.—Rosenmuller, *De nonnullis musc. corp. hum. varietat.*, Léipsic, 1804.—Gantzer, *Diss. anat. muscul. variet. sistens*, Berlin, 1813.

(2) Tiedemann having found the pectoralis, major and minor, the glutæi and the trapezii muscles double in the same subject, concludes, that great power in man is not always the result of exercise, but sometimes depends on the congenital redundancy of several large muscles. (*Deutsches Archiv für die Physiologie.*) The author of this treatise was led to form the same opinion from another example of the same kind, and he concludes from sufficient facts, that contrary to the opinion of Tiedemann, this anomaly of the muscular system happens usually on both sides at once, as Bichat has said.

(3) J. F. Meckel, *De duplicitate monstrosa*, Halle, 1715, § 42.

3d. The muscles sometimes present primitive anomalies in their attachments. Not reaching then their accustomed points, they remain powerless, or act contrary to what they ought naturally.

4th. Anomalies in connection are usually accidental. They are either confined to the muscle or extend to its relations with the adjacent parts. We have already described (§348) the phenomena which attend wounds of the muscles. We not unfrequently find a rupture of whole muscles or more commonly of some muscular fasciculi, an effusion of blood around the rent, and this although there is no external injury. These ruptures(1) probably depend on the spasmodic contractions which supervene in the late moments of life. But sometimes the loss of substance is consecutive to the effusion of blood. Continual pressure may also destroy some part of a muscle, and in this manner interrupt the connection which exists between it and the others.(2)

The displacements of the muscles in regard to the adjacent parts, usually result from adhesions which the organs contract after violent inflammation. This inflammation may also cause the adhesion of the muscular fasciculi to each other, which is accompanied with a greater or less degree of rigidity. The *luxation* of the muscles may also be referred to this cause.(3)

§ 351. Among the alterations in the texture of the muscles we must place first the anomalies they offer in their degree of cohesion; they are sometimes extremely flabby and brittle, and again on the contrary more elastic and firmer than usual. The former state is observed in feeble men and in asthenic diseases; the second is independent of every other morbid state, and occurs most frequently in the hollow muscles, as the bladder, and especially the heart. The color of the muscles sometimes varies from its natural shade, although their texture in other respects is not sensibly altered. Thus in certain cases the muscles are unusually pale. This state most frequently attends paralysis, brittleness, and flaccidity of the muscles. The same anomaly of color is observed also in dropsy, where the interstices of their fasciculi are filled with serum and not with fat. Under these circumstances the substance of the muscle *wastes* considerably.

So likewise in *rheumatism*, which generally attacks the sheaths of the muscles, we almost always find a gelatinous fluid effused between these sheaths and the surface of the muscle.

The paleness and softness of the muscles form the transition to an altered texture of these organs which is unfrequent, and which sometimes constitutes a primitive deviation of formation in supernumerary limbs, and sometimes supervenes to inaction of the muscles: we mean their change into fat, either preserving their texture or losing it entirely,

(1) J. Sédillot, *Mémoire sur la rupture musculaire;* in the *Mém. et Prix dé la soc. méd. de Paris*, 1817.

(2) Lieutaud, *Hist. anat. méd.*, Paris, 1767, vol. ii., p. 329.

(3) J. Hausbrand, *Diss. luxationis sic dictæ muscularis refutationem sistens*, Berlin, 1814. This dislocation admitted by Pouteau, Portal, and others, can take place only when the enveloping aponeuroses are divided; but Hausbrand has gone too far in saying it was absolutely impossible. F. T.

and finding in them cellular tissue filled with fat.(1) All the parts of the muscles then generally become smaller than they are in the normal state.(2)

The steatomatous tumors are developed between the fasciculi of the muscles less frequently.

The accidental formation of bone(3) and the tuberculous, schirrous, or fungous formations in the muscles are still more rare.

The appearance of hydatids in the mucous tissue which separates the fasciculi of the muscles is a phenomenon a little less rare. We have found it in the voluntary and involuntary muscles, and among the last principally in the heart.

§ 352. It rarely or never happens that the muscular substance is accidentally developed. In fact, sarcoma has been placed in parallel with the muscle,(4) it has been pretended that the serous membranes,(5) and even the bones(6) have been changed into muscular substance, and finally, that this substance has been found in the ovaries.(7) But, undoubtedly in pointing out alterations of texture, the distinctive characters have been neglected to attend only to their analogies.

SECTION IX.

OF THE SEROUS SYSTEM.

GENERAL REMARKS ON THE SEROUS SYSTEM.

A. ITS NORMAL STATE.

§ 353. The *serous system* is very well marked both in form and texture, although in more than one respect it seems to be but a slight modification of the cellular tissue. It is not a connected system, but it exists in all parts of the frame and assists in uniting different organs. We may refer to it the *synovial membranes*, or the *articular capsules*, which in structure and functions do not differ from it, and hence divide it into the *proper serous system* and the *synovial system*.

(1) Béclard does not admit this change into fat, and thinks that the error arises from simple appearances, and that the muscular fibres are only discolored. This opinion is contradicted by well established facts. F. T.

(2) Gay Lussac in the *Annales de chimie et de physique*, vol. iv., p. 71.

(3) Tiedemann relates a case of accidental bony concretions which were very abundant in several muscles of a man affected with gout, (*Deutsches Archiv für die Physiologie*, vol. v., p. 355.) These concretions were attended with the ossification of several arteries. They were composed of the phosphate and a small portion of the carbonate of lime, and of one fifth of animal matter, without any appearance of proper organization. F. T.

(4) Fleischmann, *Leichenoeffnungen*, 1815, p. 112.

(5) Dumas, in Sédillot, *Recueil periodique*, vol. xxv., p. 74.

(6) Colomb, *Œuvres chirurg.*, p. 72.

(7) Dumas, *Méd. éclair.*, vol. ii.

(8) Bichat, *Traité des membranes*, Paris, an viii., p. 78-111 and 202-292.

§ 354. This system always assumes the membranous form. It is composed of a certain number of round sacs, which are entirely distinct from each other, and are usually perfectly closed.

The form of these sacs is not every where the same. They may be divided, in this respect, into two large sections. The first comprehends the simple sacs, which present in all parts a rounded surface. The serous membranes, which in part compose this section belong to the synovial system; they are always placed between the tendons and the bones, and are badly termed the *bursæ mucosæ*. These bursæ cover only one part of the tendon under which they are found. The serous membranes of the second division are more complex in their forms, and seem composed of two sacs, one of which is found within the other. It appears like a simple sac, folded on itself in a portion of its circumference, or strengthened in part in its proper cavity by the action of a foreign body; if this body be removed, or, what may be done in some places, if the turned portion of the serous membrane be detached and the latter be thus insulated, we obtain a single round sac. In the normal state, the external and the internal sacs do not communicate nor touch, except where the sac seems to be reflected on itself. Further, the external sac always forms a much larger cavity than the internal, although, in several serous membranes, the latter is more capacious than the former, because the membrane has so many folds. The following are all the proper serous membranes, which are found in the normal state, viz. the *tunica arachnoidea*, the *pericardium*, the *pleura*, the *peritoneum*, the *tunica vaginalis testis*, the *synovial membranes*, and several *bursæ mucosæ*. All these membranes form perfectly closed sacs; the part turned in always incloses an organ to which it adheres intimately; in the serous membranes this organ is generally a viscus; the synovial capsules generally inclose the extremities of two adjacent bones which move upon each other; and finally, the bursæ mucosæ which belong to this section contain a part of a tendon. The adhesion, which is slight where the membrane is reflected upon itself, becomes more and more intimate, and often increases so much that, as in the testicles, the spleen, the lungs, and all the articular extremities of the bones, it is impossible to separate the serous coat from the parts below, except to a slight extent; while in all the other parts the inner sac is in fact blended with them.

This adhesion is not equally intimate in every part. Thus, for instance, the peritoneum adheres but feebly to those parts of the bladder, of the duodenum and of the pancreas which are covered by it, rather more to the viscera of the digestive apparatus, and very firmly to the internal organs of generation in the female. Generally the harder the parts to which the serous membrane is connected, the more firm is its union. This proposition applies to the external portion of the serous membrane as well as to its reflected portion. The glands and muscles are separated from it with facility, but the fibrous organs and the cartilages with great difficulty.

§ 355. The serous membranes are reflected directly upon themselves, so that the internal sac is closely applied upon the organ it covers; and between it and this organ there is a depression of variable length formed by two folds, between which the vessels and the nerves proceed to the organs contained in the sac. We may mention, as instances of the former arrangement, several portions of the large intestine, particularly the ascending and the descending colon, a part of the liver and the heart; all the small intestine, and the spleen are examples of the second. In the former case a portion of the organ is most usually uncovered by the serous sac; this is the case in the ascending and the descending colon, the upper and posterior portions of the liver. In the latter, but a small portion of the organ, the point where its vessels enter, is destitute of the serous membrane. These two arrangements are generally found in the same organ, as is the case with the peritoneum, where it covers the liver.

Besides these folds which exist between the external and the internal sac, and the organs covered by the latter, the serous membranes form others of a different character. They always extend beyond the organ covered by the internal sac; but then sometimes they hang loosely and are again reflected on themselves; sometimes they pass from one of the parts contained in the common external sac to another. The former arrangement is seen in the epiploon, the second in the external envelop of the round ligament in the ilio-femoral articulation, in the similar bands contained in the knee-joint, and in the second class of the tendinous bursæ. However, when closely examined, all these processes are essentially the same, that is, they are all produced by the transition of the internal serous sac from one organ to another. In fact, the omenta differ from the tendinous bursæ only in being more extensive, so that they are obliged to fold upon themselves, when passing from one organ to another.

We however find in some places folds which are perfectly loose, and which arise from the surfaces of the organs lined by the internal sac; such are the appendices epiploicæ of the large intestine, and the prolongations which in many capsules of the joints, for instance, those of the knee- and hip-joints, cover the glands of Havers.

§ 356. The folds and prolongations of the serous membranes are usually connected with the respective situation of these membranes, and of the organs which they cover. In fact, in certain circumstances they cover organs, which they do not cover when these circumstances vary. Thus, the intestines, when filled and distended, are imbedded in the mesentery, the stomach in the omentum, and the impregnated uterus in the broad ligaments.

The serous membranes differ, in fact, from the structure of the organs they cover, and they must be considered only as drawing a more exact line of distinction between these other organs, in respect either to situation alone, or to their mode of existence. Thus they envelop the most important organs: the brain, the spinal marrow, the lungs, the heart, the intestinal canal, and the principal parts of the genital apparatus.

Hence why their diseases have less effect upon the organs covered by them than those of other membranes. In dropsies, in thickening, and ossifications of the serous membranes, the subjacent organs are perfectly healthy, even when they adhere intimately, as in the testicle. Still, whenever the union is such that the membrane and the organ are one, as in the capsules of the joints, the diseases of the former soon affect the latter. For the same reason, a part of the the peritoneum not only abandons certain organs in the circumstances above mentioned, but leaves without inconvenience the parietes of the abdomen either abnormally, as in hernia, or naturally, as in the descent of the testicles into the scrotum. We must not forget however that, in the cases above examined, there is an alternate separation and reunion of the organs with the serous membranes, but also a distension and contraction of the same organs.

§ 357. The serous membranes, even those which have a complex form, are perfectly closed, although at first view they seem to be perforated, yet they only fold upon themselves and are perfectly closed. There is but one exception to this rule, viz. the abdominal orifice of the fallopian tubes, which open into the peritoneal cavity on each side. This too is the only instance where a serous membrane is continuous with a membrane of a different class, which, in this case, is a mucous membrane; for we cannot mention as such the communications which exist between the different parts of a serous membrane, as the external arachnoid membrane and that which lines the cerebral ventricles, between the great cavity of the peritoneum and that of the omenta, &c. This complete closure of the serous membranes explains why the congestions of serum never extend beyond the limits of their cavities in dropsy of the pericardium, of the pleura, of the peritoneum, and of the tunica vaginalis testis.

§ 358. The internal face of these sacs in the normal state is always smooth, the external is rough, and united to the adjacent parts by mucous tissue, at least most generally, although there are several exceptions; for instance, both faces of the lower portion of the arachnoid membrane are loose. In fact, in the serous membranes of the second class, the external face of the internal sac which looks toward the inner face of the external sac is smooth and loose, while the internal face is uneven and attached; but this arrangement does not contradict the law we have established, since the internal sac is only a reflected portion of the external. The smoothness of all the organs which exist in serous membranes comes only from the internal sac; when detached, they seem rough and covered with mucous tissue, and their surfaces are never smooth in those parts where, in the normal state, the serous membranes do not cover them: such is the liver in several places, the posterior face of the ascending and descending colon, most of the posterior part of the rectum, a large portion of the uterus, of the bladder, &c.

These sacs are always thin in proportion to their other dimensions, but there is never a direct and constant relation between their thickness and their capacity. They are always more or less transparent, white, and shining, but less so than the fibrous organs with which they are intimately connected. Thus the arachnoid membrane lines the internal face of the cerebral and of the spinal dura mater; the pericardium is covered by a fibrous membrane, and when this is deficient it is supplied by the tendinous part of the diaphragm: the pleura is situated under the periosteum of the ribs and the tendons of the intercostal muscles; the tunica vaginalis testis is placed under the tendon of the cremaster muscle; the synovial membranes under the fibrous ligaments and upon the periosteum of the bones.

§ 359. The whole serous system appears to be but a slight modification of mucous tissue, but of a mucous tissue more dense than usual, and coagulated in larger layers. This is seen from the following considerations:

1st. From its external appearance. Both have the same color. If the mucous tissue be inflated with air, cells are produced which cannot be distinguished from the serous tissue, especially from its thin portion, as the peritoneal coat of the intestines, the epiploon, the arachnoid membrane, &c. So too the fibrous membranes may be converted into mucous tissue by maceration, and by inflating air into the subjacent cellular tissue.

2d. It is not unfrequent to find simply mucous tissue filled with synovial fluid in the place of certain parts of the synovial system.

3d. The serous membranes, like the mucous tissue, present a homogeneous mass: we see no trace of fibres.

4th. Like the mucous tissue, they receive few blood-vessels, so that they are composed almost entirely of absorbent and exhalent vessels.(1) Mascagni thinks them formed only of absorbents, because mercury injected into the lymphatic system converts them into a tissue of these vessels; but when the blood-vessels are injected, or when inflammation, attacking the serous membranes, fills the capillaries with blood, the serous system becomes a tissue of blood-vessels. In fact we find numerous and considerable blood-vessels on the external surface of these membranes, but they do not enter into their composition. The arachnoid membrane is entirely destitute of vessels. The serous membranes when exposed in a living animal are colorless, and blood does not issue from them when they are divided after death.

5th. Like the mucous tissue they are destitute of nerves.

6th. The functions of the mucous tissue and of the serous membranes are the same, viz. exhalation and absorption.(2) Like the mucous tissue, the serous membranes form around the parts they envelop a perfect limit, and which is more marked in them on account of the great

(1) This is not the opinion of Rudolphi. He says that the serous membranes have no vessels, and that they may be easily detached from the organs which they cover, especially when there is a dropsical state. If we then examine them with a microscope there are no traces of vessels. They are formed only of cellular tissue, of which they constitute the bounds to free surfaces. Ribes has ascertained the same fact by numerous dissections. F. T.

(2) According to Rudolphi they do not secrete, but only allow the perspiration furnished by the cellular tissue to pass through them, fulfilling in respect to it the same duty performed by the epidermis in regard to the perspiration of the skin. Nor does he admit that they are porous. F. T.

importance of these organs. As all the organs are imbedded in mucous tissue, which is the common organ of nutrition and formation, so the envelops of the fetus in structure and functions resemble serous membranes exactly. We may then call them the *formative membranes*, as the mucous tissue has received the term of *formative or generative tissue*.*

§ 360. The serous membranes possess a great degree of extensibility and of contractility: hence they remain uninjured even when greatly distended by dropsies or tumors. We must however remark, that, in such cases, they are not only distended, but their folds are partially developed, and are a little displaced from the looseness of the mucous tissue which unites them to the adjacent parts, and that they really increase in mass. Hence why, in dropsies for instance, instead of being thinner in proportion to the enlargement they have acquired, they are thicker. That the changes they experience result in great part from a forced extension is proved by the rapid and great diminution of their cavities, when the substances which distend it (for instance, the serum in dropsies) are removed; and this diminution takes place without wrinkles or folds.

The serous membranes, properly so called, possess these properties in a greater degree than the synovial capsules. The latter are torn when a great force acts upon them, as in dislocations; the former are distended, as in hernia. We must not forget, however, that this difference is mostly owing to the difference in the mode of connection with the subjacent parts.

In the healthy state the serous membranes are insensible, or sensible only in a slight degree; but they become highly so in diseases, and when they are inflamed the pain is very acute.

§ 361. The functions of the serous membranes are, to insulate the organs they envelop, and to facilitate their motions, by rendering their surfaces smooth, and by exhaling a lubricating fluid, which, perhaps, in the normal state of the proper serous membranes, has the form of vapor, but is liquid in the synovial system. Both resemble strongly, in their essential properties, the serum of the blood: that of the proper serous membranes differs but little from it: that of the articular membranes, called synovia, is very analogous to it, but differs from it as we shall mention hereafter. Both contain a large proportion of water, a little albumen, a gelatinous substance, and several salts.(1)

§ 362. The serous membranes themselves differ in respect to their external form and their texture, but more in regard to the former than the latter.

* Another point of resemblance between these tissues is the similarity of the diseases which affect them. On this point Prof. Horner remarks, (*Treatise on Gen. and Spec. Anat.*, vol. ii. p. 7,) "My own experience goes to prove that dropsy seldom manifests itself to any extent in the cellular tissue without also going to the serous texture and the reverse."

(1) Hewson, *On the properties of the lymph contained in the different cavities of the body*, in *Exper. inq.*, ii. ch. vii.—Bostock, in Nicholson, *Journal*, vol. xiv. p. 147.

Have they originally the form of closed sacs? This is probably not the case with all. We have every reason to think that the pericardium and the peritoneum are at first open, for, in the early periods of existence, the heart and the viscera of the abdomen are uncovered, although it afterwards happens that the latter, exposed as before, are still covered by a prolongation of the peritoneum which accompanies them.

The form of the serous membranes varies at different periods of life; they disappear in some parts, and are developed in others; these differences depend on the changes which supervene in the situation of the organs within their cavities. Thus the fold of the peritoneum which at first traverses the umbilical ring disappears in time, while another forms and engages itself in the inguinal ring, when the testicle begins to descend from the abdomen into the scrotum. Even the number of the serous membranes, considered as so many distinct sacs, varies at different periods of life. Thus the tunica vaginalis testis is at first a continuation of the peritoneum, but sometime after birth the upper part is obliterated, and two separate cavities are formed, the peritoneal and the vaginal.

The tissue of the serous membranes is more uniform; except that, like all the organs, they are at first more loosely attached to the adjacent parts, whence they are more easily insulated in the early periods of life. This arrangement is not always applicable, except to their external fold: it does not extend, at least in all cases, to their internal and reflected layer. Thus we cannot detach the serous membranes from the tunica albuginea and from the articular capsules with greater facility in the fetus than in the adult.

The characters of the fluid they exhale probably vary as do those of all others in the course of life, that is, it is thinner and more watery in youth than in advanced age. This conclusion is drawn from comparing the results of analyses made by Bostock and Hewson. The latter states the fluid to be albuminous and gelatinous, the former that it resembles fibrin.

B. OF THE SEROUS SYSTEM IN THE ABNORMAL STATE.

§ 363. The serous membranes present remarkable anomalies in form and in texture. The primitive deviations of formation are somewhat rare. They consist usually in the suspension of development—such as, 1st, the absence of a portion of these membranes, especially the pericardium, the pleura, and the peritoneum, when the heart, the viscera of the thorax and abdomen are exposed; 2d, the abnormal communication between different serous membranes, the cavities of which are not properly united, except during the earliest periods of life. To this we refer particularly the communication existing between the tunica vaginalis and the peritoneum, when the canal between them is not effaced, and which is occasionally the cause of congenital inguinal hernia.

But other primitive deviations of formation also occur. As, for instance, the existence of a serous sac within the proper sac, communicating with it by a more or less narrow opening, and inclosing a portion of viscus which is generally at liberty and which separates it from the rest. This phenomenon has been observed only in the peritoneum, and it is curious, as being essentially the abnormal repetition of a normal formation.

The serous membranes are liable to accidental deviations of formation, as they take part in hernia. Here a portion of serous membrane generally detaches itself from the parietes of the cavity to which it adheres, passes across a separation which is naturally broad, or is enlarged by the action of an external cause, and thus forms a sac called the *hernial* sac, (*saccus herniæ*,) into which penetrate some of the viscera lodged in its cavity and covered by its membrane. This latter is rarely torn, and the viscera seldom protrude unless preceded by it, and it is unfrequent for the hernia to have no sac; this case happens only after great violence, and even then the hernia occurs only in certain places, for instance in the upper wall of the peritoneum. The hernial sac also is rarely ruptured or opened by the effects of previous disease, so as to permit the viscera inclosed by it to be in immediate contact with the common integuments. The peritoneum only is subject to these different accidents, because, of all the serous membranes, it adheres the least to the parietes of its cavity, and also because the parietes of the abdomen are less protected by the bones than those of the other two splanchnic cavities, and cannot resist the efforts of external agents so powerfully.

The serous membranes are not unfrequently distended extremely by the fluid they exhale. This fluid often accumulates in very great quantity, and constitutes the different kinds of *dropsy* (*hydrops.*) Here, the animal substance is thin, and generally less abundant, so that the fluid of dropsy may be regarded as the serum of the blood, which has lost from two thirds to four fifths of its albumen; however, the proportion of this substance is sometimes very much increased, doubtless, on account of the absorption of the watery portion.(1)

§ 364. The other changes in the forms of the serous membranes are, the results of morbid affections, and especially of inflammation, which often affects them.(2) Inflammation of the serous membranes tends to terminate by effusion into their substance which results in a thickening, or by effusion on their surfaces, which causes a mutual adhesion of the corresponding faces of the external and internal sacs, al-

(1) Schreger, *Fluidorum corporis animalis chemicæ nosologicæ specimen*, Erlangen, 1800, p. 16-24.—Marcet, *A chemical account of various dropsical fluids; in the Edinb. med. and surg. trans.*—Berzelius, *On animal fluids; Med. chir. trans.*, vol. ii., p. 251-253.—Bostock, *On the nature and analysis of animal fluids*, ibid., vol. iv., p. 52.

(2) Rudolphi maintains that inflammation is not situated in these membranes, but in the organs they cover; that they cannot inflame any more than the epidermis; and that pleuritis, pericarditis, and peritonitis are inflammations of the surface of the lungs, heart, and abdominal viscera, &c. Chaussier and Ribes entertain similar opinions. If serous inflammations be, in fact, only inflammation of the subvisceral mucous tissue, we can conceive of the rapidity, the intensity, and the danger of these inflammations, and the abundant products they furnish. F. T.

though the membrane is not destroyed by suppuration. These adhesions vary much in extent, solidity, structure, and number. Sometimes they cover the whole surface of the serous membrane and the parts it envelops, so that it becomes almost impossible to distinguish the latter from each other, and one is induced to believe there is no external sac; sometimes they are confined to one or a few points of the external and internal sacs, whence only the organs situated in those places adhere. They may, too, become very intimate, even to a degree that where the united parts seem to make only one, or very loose and easily broken. Finally, the adhesions are sometimes very short, and sometimes long; in the latter case they form cords, ligaments, and membranes, termed generally *false membranes* (*pseudo-membranæ*), which in nature more or less resemble that of the serous membranes, and which are often attended with fatal results, particularly when they are developed in very movable points or parts which may glide into the rings they produce, as in the intestines.(1)

Farther, these adhesions probably take place only after inflammation, and are never primitive, although Bichat admits the contrary in regard to some perfectly organized ligaments, often found between the external and the internal sac of the pleura, and which are evidently composed of two folds fitted to each other, and although Tioch(2) maintains this opinion, in regard to some analogous ligaments situated between the heart and the pericardium, because they resemble those presented by the hearts of several reptiles in their normal state. It is certain, at least, that the most perfect organization of these appendages is not sufficient to justify this opinion, because, parts which have a more perfect organization, as bones, teeth, and even whole serous membranes, are often developed by a vital act, which does not differ essentially from inflammation.

We do not observe the same form in all the alterations in texture of the serous membranes which result from inflammation, and are characterized by the thickening of their substance. Thus, in the internal sac of the pericardium, broad smooth layers appear, which are termed *maculæ cordis*, and in the peritoneum numerous small, hard, round elevations very analogous with the miliary eruption.

§ 365. The serous system tends much to ossify, and in this relation presents the same differences as in that of adhesion. Sometimes, in fact, the substance of the membrane ossifies; sometimes smooth and usually round bodies, varying in number and size, form on its surface, these are more or less loose, and are often entirely detached from the membrane and float freely in its cavity. These phenomena are common to all the serous membranes, although found in some more frequently than in others. Thus, that portion of the peritoneum which covers the spleen, is, of all others, the most disposed to ossify; next comes the internal sac of the tunica vaginalis testis; the others, except

(1) Villermé, *Vraité des fausses membranes*. Paris, 1814.
(2) *Mém. de Montpellier*, vol. ii, p. 351.

the tunica arachnoidea which rarely ossifies, differ little from each other in this respect.

These accidental ossifications almost always have the form of broad layers, and often become, especially in the spleen, very large, so that even the proper substance is frequently entirely concealed. The synovial membranes ossify less frequently; still, however, as their internal sac identifies itself with the articular cartilages, we may say that they become cartilaginous even in their normal state, and that ossification of the proper serous membrane is only an abnormal repetition of the normal state of the synovial membrane.

It is not uncommon to see developed in the substance of the synovial membranes different osseous concretions, which are often found in considerable number in these organs, and more frequently in the bursæ mucosæ. These concretions do not, however, belong to them exclusively, for they occur also in the proper serous membranes, particularly in the tunica vaginalis testis, and sometimes, although less frequently, in the peritoneum, in the pleura, and in those parts of the arachnoid membrane, which are blended with the dura mater.

Most usually, and even almost always, these loose osseous concretions arise as we have stated. Sometimes they may be loose primitively, and be developed in the blood, or in another fluid effused into the articulation by some external injury, but even then, we have reason to think that a connection between the effused blood and the synovial membrane was established before the bone was developed. The formation of these concretions in the serous membranes, which are not in relation with the bones, proves, at least, that the adjacent extremities of the latter have no influence, as Hunter thought, on the change of the effused fluid into osseous substance.

Besides these anomalies, which are somewhat frequent, there are others more rare; such as the development of loose, soft processes, several lines long on the internal face of the synovial capsule of the knee-joint, of which we have a specimen before us; perhaps, however, it is only the first stage leading to the formation of the osseous concretions which we have already mentioned.

§ 366. The serous tissue is one of those which has the greatest tendency to abnormal repetition in the body. The accidental serous membranes are often the foundations of other abnormal formations, since they are developed before them, and give rise to them. They have been called *cysts* (*cystic*), and *encysted tumors* (*tumores cystici*), and have all the essential characters of serous membranes. They constantly form perfectly closed sacs, smooth internally and rough externally. They are produced by mucous tissue, have but few blood-vessels, and fulfill the same functions as the proper serous membranes, although the substances within them are not always of the same nature as the serous fluid, and are not always liquid.

Probably these cysts are not developed, as is generally thought, mechanically, by an effusion compressing the cellular tissue returning again on itself, and thus changing into membrane. Bichat has already contested this theory, by stating that the cysts are most analogous to the serous membranes: that the secretion continues to take place within them, while compression would probably make them impervious: that the cellular tissue does not diminish around them, and that we must suppose from the hypothesis admitted, that the secreted fluid exists before the secretory organ. He thinks these organs are formed, like all others, in the mucous tissue, and that exhalation does not commence within them until their structure is completely developed. However, it cannot be denied, that the formation of the cyst has not been preceded by the effusion of a fluid into the mucous tissue; the cyst, however, does not develop itself, because this fluid compresses the surrounding mucous tissue, but it is formed at its own expense; because it has the power of organizing itself. This theory appears very probable on account of the analogy of structure and formation existing between the mucous tissue and the serous membranes, and because of the pathological phenomena by which the cysts are developed. In fact, we not unusually find either in the cavities of the normal serous membranes, or in the accidental cysts, an immense number of small loose cysts which have no trace of former adhesion, and which are filled with a serous fluid, which is generally limpid. These small cysts called *hydatids*(1) (*hydatides*), are usually surrounded with an analogous liquid. They are evidently formed only at the expense of the fluid effused in the cavity of the serous membrane, by its separation into a solid and a fluid portion. According as this fluid is effused into the mucous tissue, or into a serous membrane, the cysts which arise from it, unite to the adjacent parts by the surrounding cellular tissue, and receive blood-vessels or remain loose and without any adhesion. The serous membranes tend more than any other organ to produce these different kinds of cysts, and even when they seem to be developed in the substance of the viscera, as, for instance in the liver, which is sometimes entirely destroyed, their development probably commences by the portion of peritoneum which covers them, for we always find them on its surface, and on some part of their circumference.

(1) These cysts have been termed *acéphalocysts* by Laennec, who considers them as animals, an opinion which Cuvier and Rudolphi do not adopt. These naturalists and their followers assert, that the acéphalocysts exhibit no appearance of vitality; but even when it is granted that they do not enjoy an existence independent of that of the living bodies in which they occur, they are not the less irritable, like all living parts, and we cannot conceive them otherwise. Besides we have no doubt but these vesicular productions are produced by inflammation. Veit long ago proposed this theory, (*Einige Anmerkungen über die Entstehung der Hydaiden*, in Reil, *Archiv für die Physiologie*, vol. ii., 1797, p. 436,) which G. Jager has since developed. (*Beobachtungen über Hültenwürmer im Menschen und einigen Säugthieren*; in Meckel, *Deutsches Archiv für die Physiologie*, vol. vi., p. 495.) He has thus given an experimental base of the doctrine of the spontaneous generation of intestinal worms, which Rudolphi and Bremser, assuming reasoning and analogy as guides, have adopted as the only one which harmonizes with the present state of our knowledge of animal physiology and general physics. In fact, the acéphalocysts lead insensibly to the proper entozaries by the echinococci, which naturalists no longer recognize as intestinal worms, notwithstanding the special organs with which they are provided, and which differ but slightly from the cœnurus, which all herminthologists object to place in their catalogue. F. T.

ARTICLE SECOND.

SPECIAL REMARKS ON THE SYNOVIAL MEMBRANES.

A. OF THE SYNOVIAL MEMBRANES IN THE NORMAL STATE.

§ 367. The *synovial capsules* and *the bursæ mucosæ*(1) present all the essential characters of the proper serous membranes in regard to form and functions, as Munro, Gerlach, and Bichat had already remarked. But they differ in certain respects so much as to deserve to be studied separately ; and they are so similar to each other, that we had better embrace them all in a general description. They may be termed, collectively, the *synovial membranes*. The principal characters which belong to them all, and in which they differ from the serous membranes, are as follows :

1st. *Their relations with the adjacent parts.* They are, at least generally, united to bone in a part of their circumference, and this bone is cartilaginous where they adhere. They are more closely connected with the cartilage than the serous membranes are with the parts which they cover.

2d. *Their texture.* It is very common to see a particular kind of corpuscles which project within their cavity. In fact these corpuscles do not exist in all the synovial membranes, nor in all the bursæ mucosæ, but they are found constantly in several. They are very vascular masses, and of course very red, especially at the end which is unattached, slightly hard, of different forms, and they are inclosed in the special folds of the membrane, while their loose extremity is almost always fringed. Those met with in the articular capsules are usually protected from all external pressure, being situated in the depressions of the bones. These latter however always press slightly upon them when they move. In some joints, as the hip-joint, there is only one, while several are found in others, as in the knee- and the elbow-joints.

These corpuscles are termed *Haver's glands* (*glandulæ mucilaginosæ*), because Havers first called the attention of anatomists to them,(2) although Cowper had already mentioned some of them. He considered their structure to be glandular, and their function to secrete synovia. Beside these bodies which project into the cavities of the

(1) Jancke, *De capsulis tendinum articularibus*, Leipsic, 1753.—Fourcroy, *Six Mémoires pour servir à l'hist. anat. des tendons, dans lesquels on s'occupe spécialement de leurs capsules muqueuses*, in *Mém. de Paris*, 1785-1788.—A. Monro, *Description of all the bursæ mucosæ of the human body*, Edinburgh, 1788.—Koch and Eysold, *De bursis tendinum mucosis*, Wittenberg, 1789.—Nurnberger and Gerlach, *De bursis tendinum mucosis in capite et collo reperiundis*, Wittenberg, 1793.—Koch, *De morbis bursarum tendinum mucosarum*, Leipsic, 1790.—Rosenmuller, *Icones et descript. bursarum mucosarum corporis humani*, Leipsic, 1799.—Brodie, *Pathological researches respecting the diseases of the joints*, in the *Lond. med. chir. trans.*, vol. iv. and v., 1813, 1814.

(1) *Osteologia nova*, London, 1691:

articular capsules, we find others on their external face in the surrounding mucous tissue.

It is not probable that the glands of Havers are only masses of fat, and that they secrete synovia, although Portal(1) still maintains this opinion. The great number of vessels they receive, their situation, and the mucous fluid which exudes from them when they are compressed, do not authorize us to admit it, as there are several strong reasons against it. In fact:

a. Secretion takes place in the serous membranes, although they have no apparatus like that in the glands of Havers.

b. These bodies exist only in a few synovial membranes: they are very rarely found in the tendinous bursæ. *Synovia* however is secreted every where.

c. Their structure does not differ from that of ordinary mucous tissue filled with fat. They are not glandular, and although they have a considerable volume, we see no appearance of an excretory duct.

d. We find in some parts in the serous membranes analogous prolongations which are only masses of mucous tissue filled with fat or serum; such are the epiploic appendices of the colon and those of the upper extremity of the testicle.

3d. We cannot question the analogy between the articular capsules and the bursæ mucosæ, although these organs sometimes open into each other. This appears not unfrequently in the shoulder-, the hip-, and the knee-joint, and almost always occurs in the last two articulations. The adjacent bursæ mucosæ also frequently open into each other, and the masses of fat of the articular capsules often project into the adjacent bursæ mucosæ. It is asserted that this arrangement occurs more frequently in old subjects, so that this communication is attributed to the destruction of the parts which would otherwise serve as a barrier between the two cavities, but this theory is not correct. In all cases this communication proves that there is a resemblance between the organs, without being attended with inconvenience. Certain articular capsules perform at the same time the duties of bursæ mucosæ, as they adhere to tendons in a part of their circumference, as do for instance those of the knee and of the shoulder with the tendons of the triceps femoris and the biceps flexor cubiti.

4th. The nature of the fluid contained in these membranes is always the same, even when they communicate together. This fluid is slightly viscous, and its physical properties resemble the white of an egg. In man it has not yet been analyzed: but the analyses of that of the ox made by Margueron(2) and Davy(3) do not agree at all in the proportions of their constituent elements, but both state that there is a great proportion of water, a large quantity of albumen, gelatin, of the hydrochlorates, of the phosphates, and of soda.

5th. The same resemblance exists in regard to their diseases, viz. the dropsy, the thickening, and the solidifying of the substance they con-

(1) *Anat. Medicale*, vol. i. p. 62.
(2) *Annales de Chimie*, vol. xiv.
(3) Monro, *Outlines of anatomy*, Edinburgh, 1813, vol. i. p. 79-81.

tain. There is one, especially the formation of cartilage, and of bone within them, which establishes a greater similarity between these organs than between the serous membranes; for in regard to the frequency of this anomaly, the bursæ mucosæ are more allied to the articular capsules than are the serous membranes.

§ 368. We have already stated the principal modifications in the form of the synovial membranes (§ 354). Most of the articular capsules form simple sacs. However there are some where the sacs are double, because an intermediate cartilage is found between the corresponding extremities of two bones: this is seen in the temporo-maxillary, the sterno-clavicular, and the femoro-tibial joints, &c. We usually find only one synovial membrane between two bones. In some parts, as for instance in the wrist, they unite a whole series of bones blended, if we may so speak, in a single articular surface by ligaments stretched from one to another.

§ 369. The bursæ mucosæ, with a more complex form (§ 334), may be called *mucous sheaths* (*bursæ mucosæ vaginales*), and those of a simple form, *vesicular bursæ* (*bursæ mucosæ vesiculares*). A general remark in regard to both is, that they adhere in a part of their circumference to a tendon, and by the opposite face to a bone, which in this part has no cartilage, to another tendon, or finally to a fibrous ligament. On both sides they are intimately united to the organs below them, and the rest of their circumference is surrounded by a loose and abundant cellular tissue.

The mucous sheaths are cylindrical, and completely envelop that portion of the tendon which they touch, and are, properly speaking, formed like the serous membranes of two sacs; the internal sac which is smaller surrounds the tendon, while the external sac which is larger covers the adjacent parts and blends, opposite the tendon, with that portion of bone not covered by cartilage on which the tendon glides.

They are generally found in the course of long thin tendons, consequently in the extensors and flexors, especially of the fingers and toes. They surround the circumference of the tendon, but they extend a greater or less distance along these parts, like the vesicular bursæ. The tendons of several muscles are frequently enveloped, especially in the joints of the hand and foot, in a common sheath, which often presents as many folds and divisions as there are tendons, so that the general sheath is more or less completely divided into a number of special sheaths, from whence several prolongations are afterwards detached to accompany each tendon. We also find in particular sheaths small prolongations which proceed from that part of their circumference which is adjusted to the bone, to the tendon, and are called *mucous ligaments* (*ligamenta tendinum mucosa*). These processes serve only to increase that of the exhaling surface. There are no fatty masses fringed upon their free extremity which float in the cavity of the mucous sheaths, although fat is often collected in their surrounding cellular tissue.

The mucous sheaths are much thinner and more delicate than the vesicular bursæ, but they are always surrounded with dense and solid fibrous ligaments, called tendinous sheaths, which are protected by osseous canals, while the vesicular bursæ are exposed, and only strengthened in a few instances by a fibrous substance extended on their surface.

§ 370. The vesicular bursæ are round. They never surround a tendon completely, but only cover that face of it which is turned toward the bone, and consequently form simple sacs which are more easily detached without laceration from all the parts to which they are connected. These characters apply particularly to those which are placed between two tendons. These bursæ are most generally placed between the tendons and the bones, where the former are applied directly to the latter, consequently almost always near their insertion. But they are sometimes observed on the external face of the tendon; as happens for instance to the tendons of the supraspinatus and of the infraspinatus muscles.

These vesicular bursæ are not only fixed to the bones and the tendons, but they are found also between two bones which move on one another, between a synovial capsule and an apophysis of bone, between two portions of muscles, and even in the substance of the tendons: the last case is perhaps only an anomaly. The third is sometimes presented between the two layers of the masseter muscle. The vesicular bursæ placed between the coracoid process of the scapula, and the clavicle is an example of the first. These bursæ are properly speaking only articular capsules: they present a peremptory argument in favor of their identity with the synovial capsules, since they demonstrate that the most simple form of the synovial membranes appears also in the articular capsules.

These bursæ are mostly simple: sometimes however a small one exists within the cavity of a large one, as is the case between the tendon of the semi-membranosus and the inner head of the triceps suræ. So the tendon of a muscle has usually only one vesicular bursa; but in certain cases, as in the masseter muscle, the subscapularis muscle, &c., we observe several.

The vesicular bursæ are found more particularly around the large articulations surrounded with short and broad tendons, especially in the shoulder-joint, the hip-joint, the knee-joint, and the elbow-joint. We not only find within many, as the mucous sheaths, ligamentous processes which often form a reticular tissue on their internal face; but also we often see, as occurs in the capsules of the joints, masses of fat which float loosely and are more or less fringed on their edge.

§ 371. The synovial membranes are proportionally more extensive in the early than in the later periods of life. In age they become more dry, firm, and hard, and secrete less synovial fluid. The cellular tissue which surrounds them, as occurs in all other parts, is looser in infancy and youth, so that at this period they are more easily detached from the adjacent parts. The articular capsules and the bursæ mucosæ are not similar in regard to their number at different periods of life: for the number of the former remains always the same, if we except the accidental disappearance of some small capsules, while that of the bursæ mucosæ is always greater in young than in old persons. The communication existing between several of the synovial membranes also differs at different periods of life; for, in the latter periods of life, the bursæ mucosæ seem to communicate, either with each other or with the synovial capsules, more frequently than in young subjects, because continued friction destroys them, directly or indirectly, in a portion of their extent.

B. OF THE SYNOVIAL MEMBRANES IN THE ABNORMAL STATE.

§ 372. The anomalies of the synovial membranes are, 1st, their absence, which is rare, and of which only the bursæ mucosæ present instances.

These bursæ are sometimes deficient in those parts where we are accustomed to find them in the normal state, and are then replaced by mucous tissue.

As to the consecutive and accidental deviations of formation, these are the lacerations which occur in dislocations.

Sometimes we find these organs flabby and distended, either primitively or from too great an accumulation of synovia. This latter state constitutes what is termed *hydrops articuli*, which is never, unless accidentally, complicated with the dropsy of the serous membranes.

The synovial membranes of the joints often inflame;(1) but inflammation in them is much more rare and its progress is generally slower than in the serous membranes Its effect is to increase and to change the secretion, and to thicken the membrane so that it sometimes acquires a cartilaginous hardness which extends to the surrounding mucous tissue, and is attended with the adhesion of its parietes, while its cavity is obliterated, although this latter consequence almost always results from suppuration only. When an ulcer is formed, the synovial membrane is early or late protruded.

We may, in accordance with Brodie, consider the change of the synovial membrane into a pultaceous mass of a bright brown streaked with white, as a disease peculiar to them, which attacks neither the tendinous sheaths nor the serous membranes. This is often half an inch thick, and gradually extends to all parts of the joint, and becomes a destructive suppuration.

Chronic inflammation with suppuration, and the change which we have mentioned, are doubtless the most common of what are termed *white swellings*. In the suppurations and morbid changes described under this term, cysts are not unfrequently developed containing fluids of different kinds, a remarkable phenomenon, as it is a repetition of the tissue in which the disease is situated.

(1) Koch, *De morbis bursarum tendinum mucosarum*, Leipsic, 1790.

(2) *Loc. cit.*, *On cases where the synovial membrane has undergone a morbid change of structure.*

We have already mentioned the cartilaginous and osseous concretions accidentally formed in the serous membranes (§254 and § 270).(1) The knee-joint is that in which all the changes which have been made the subject of inquiry occur most frequently.

The synovial system is almost the exclusive seat of *gouty concretions.* These are hard, uneven, whitish substances, which are effused in the form of a fluid during or between fits of the gout. They gradually harden, and sometimes become large. They have not always the same situation, for they are frequently found within the articular capsules and the bursæ mucosæ; they appear not unfrequently in the surrounding mucous tissue, or even between the dermis and the epidermis. They are usually composed of urate of soda.(2) It would be well to examine if the white earthy layer which sometimes forms in the place of cartilage destroyed by the gout, be not also urate of soda.(3)

§ 373. Synovial membranes are sometimes developed accidentally: this phenomenon is observed in the articular capsules, particularly,

1st. After unreduced dislocations. In this case, as a new articular cavity is formed, even when the old capsule is not torn, which almost always happens, a new capsule is developed, which is smooth within, exhales synovia, and extends from one bone to another, and is only a little thicker, less pellucid, and less brilliant, than usual.

2d. After fractures. Here the formation of a new capsule is not a rare phenomenon. It takes place particularly when the fractured part has been moved. Hence it is observed so often after the fracture of the ribs; then the fragments of bone do not reunite; they become round and smooth, like the articular surfaces; and a perfectly close capsule is developed around them, which exhales a fluid very analogous to synovia. Sometimes Havers' glands are formed in these accidental capsules. However, a new capsule is not constantly developed, and then the synovia comes from the remnant of the old membrane which has been torn.(4) Sometimes also accidental tendinous sheaths are formed; these are more common than the abnormal articular capsules. They are real cysts, which do not differ from the others except in containing a fluid analogous to synovia and often thicker than it. They are called *ganglions.*(5) They are generally considered as abnormal congestions of the synovia altered in the bursæ mucosæ which existed

(1) See our *Pathological Anatomy*, vol. ii.

(2) Wollaston, in Horkel, *Archiv für die thierische Chemie*, part i. p. 147.—Fourcroy, *Connais. chim.*, vol. x. p. 267.—Moore, *Of gouty concretions or chalk-stones*, in the *Med. chir. trans.*, vol. i. p. 112. Lambert has also found some urate of lime.

(3) Brodie, in the *Med. chir. trans.*, vol. iv. p. 276.

(4) Thomson, *Lectures on inflammation*, Edinburgh, 1813.

(5) J. Cloquet says (*Note sur les ganglions*, in the *Archiv. génér. de méd.*, vol. iv. p. 232) that the walls of these tumors are usually very thin, semi-transparent, and possess capillary blood-vessels; that the liquid they contain is usually diaphanous, sometimes very limpid, and sometimes like a reddish, thick jelly, which runs with difficulty; finally, that we not unfrequently find in this liquid a greater or less number of foreign bodies, which float loosely, and appear to be real fibro-cartilaginous concretions. These bodies are white, elastic, and variable in figure; some adhere by a very narrow membranous peduncle, and others are unattached. F. T.

primitively; but they are found so often in those parts where bursæ mucosæ do not normally exist, that they must be regarded, in many cases at least, as real accidental formations.

SECTION X.

OF THE CUTANEOUS SYSTEM.

ARTICLE FIRST.

OF THE CUTANEOUS SYSTEM IN GENERAL.

A. NORMAL STATE.

§ 374. The cutaneous system (*systema cutaneum*)(1) forms a sac which constitutes a general envelop to all the other organs. It may be divided into two large sections, the *external* and the *internal cutaneous system.* The former is usually termed the *skin* (*cutis*) or the *common integuments* (*tegumenta communia*). The second is the *system of the mucous membranes* (*membranæ mucosæ*). Although they differ much, they are only modifications of one and the same type, as they are uninterruptedly continous with each other and in fact are similar in form, in composition, in qualities, and in functions.

§ 375. The external form of this system is that of a sac turned on itself, andconsequently double. From this arrangement openings are formed both in the upper and in the lower half of the body, by which the external and the internal cutaneous systems communicate and are continuous with each other.(2) These openings generally lead into the chief portion of the mucous membranes. The latter form a tube which extends the whole length of the head and the trunk, and is called the alimentary canal. This canal, which has appendages in several parts which give rise to most of the viscera, presents above the openings of the mouth and nose, and below that of the anus. This part of the internal cutaneous system extends above the diaphragm into the cavity of the nose and that of the mouth, and also to their appendages, the salivary glands, and continues by the nasal canal, with a small process in form of cul-de-sac, comprising the tunica conjunctiva and the lachrymal ducts. The mucous membranes of the nose and mouth reunite in the pharynx, forming one, which divides lower down into two branches, the anterior for the trachea and the lungs, the posterior for the alimentary canal. The internal membrane of the respiratory system is the largest cul-de-sac presented by the internal cutaneous system at its upper part. The posterior branch gives off another to the internal ear. Below the diaphragm it furnishes

(1) Willbrand, *Das Hautsystem in allen seinen Verzweigungen*, Giessen, 1813.—Hébréard, *Mémoire sur l'analogie qui existe entre les systèmes muqueux et dermoïde*, in the *Mém. de la soc. méd. d'émulation*, vol. viii. p. 153.

(2) A. Bonn, *De continuationibus membranarum*, 1763.

new culs-de-sac, which ramify, and extend to the liver and pancreas. Forming then the most internal layer of the alimentary canal, it terminates in the anus, where it is continuous with the external cutaneous system.

Besides this general internal cutaneous system, we find others also, both in the upper and the lower parts of the body, which only represent branches of the culs-de-sac: these are, 1st, the internal membrane of the meatus auditorius externus; 2d, that which covers the internal face of the eyelids, the anterior face of the eye, and the lachrymal ducts; 3d, the mammary glands; 4th, the mucous membranes of the genital and urinary systems, which commence by a common opening.

It is impossible to overlook the gradation which exists from the absolute insulation of some parts of the internal cutaneous system, to its perfect union in a single organ. The general system of the mucous membranes of the upper and lower parts of the body, of which we can in imagination place the origin in the mouth and intestinal canal, forms an uninterrupted cavity. That of the eye communicates with it only by a narrow channel, but is not insulated from it, unless after leaving the class of reptiles. That of the mouth and of the meatus auditorius externus are connected with each other in the membrane of the tympanum, but they do not form one cavity. The membrane between the orifice of the genital organs and the anus so much resembles a mucous membrane in its softness and its abundant secretion that we are almost authorized to say it unites the two openings, and really blends them in one. Finally, the mucous membrane of the mammary glands is the only one which is wholly distinct from the general internal cutaneous system.

§ 376. The whole cutaneous system is then formed of two large canals, one narrow and provided with appendages in form of culs-de-sac, the intestinal canal; the other broader, the common integuments, which also possesses some processes in cul-de-sac, which proceed internally. It every where presents two surfaces, one of which is loose, the other adherent. In the common integuments, the loose surface is external, and the other internal: the contrary is the case in the mucous membranes. Thence it follows that we may consider the two sections of the system as two canals, one of which would be folded on itself.

The internal face of the cutaneous system is attached directly or indirectly to the muscles by a short cellular tissue. With the external system this union is generally direct; for the aponeuroses are almost always interposed between the muscles and its internal face, so that the functions of the muscles it covers are rarely in relation with its own. With the internal system, on the contrary, it is direct; for the mucous membrane is separated from the muscular membrane only by cellular tissue, which is the same as itself in regard to structure and functions. The external cutaneous system envelops the voluntary muscles; the internal circumscribes most of the involuntary or hollow muscles.

The loose surface of the cutaneous system everywhere forms folds, projections, and depressions of different kinds, which increase its extent more or less permanently.

§ 377. In considering the cutaneous system as a sac folded several times on itself, we do not propose to give a history of the origin of the different parts of the skin, nor to pretend that the different excavations are hollowed from without inward, in the midst of a mass which is at first solid and homogeneous, so that the upper and lower cavities of the intestinal canal meet half-way, while the others not extending so far would still preserve their appearance of cul-de-sac. There are some facts which seem to favor this hypothesis. Thus the openings do not at first exist, until about the sixteenth week of uterine existence, and the upper and lower portions of the intestinal canal which are separated from each other not unfrequently form a cul-de-sac, each on its side. But these phenomena do not prove that the internal portions of the cutaneous system arise from the prolongation of the external inward. We can also explain satisfactorily the non-existence of openings in the commencement without having recourse to this hypothesis, and by admitting that the skin gradually tears in the place where they exist by the progress of the formation of the cavities proceeding from within outward. This manner of viewing the subject appears more accurate than the other, since in regard to the second argument favorable to the latter: 1st. The place where the separation exists between the upper and the lower extremities of the intestinal canal is not always the same; being often situated in a very distant part; it is usually connected with one extremity only, most frequently the lower, and consequently in this case it would follow that the internal portion of the skin is not developed except from a single opening. 2d. The upper and the lower extremities not unfrequently do not exist, and we find several perforations along the passage of the internal portion of the skin. 3d. The same arrangement is observed in other processes of the skin, terminating also in cul-de-sac, as in the urinary apparatus and the genital system, where, if we except the closed extremity, the extent of which is frequently considerable, it not unfrequently happens that the internal and the external parts are perfectly developed, while, according to the above mentioned hypothesis, their formation should have been arrested where the intermediate partition exists. It is more correct then to admit that the internal part of the skin is formed from within outward; that it probably takes its departure from several different points; that these join as they are developed and then unite to the common integuments, making with them an entire whole.

§ 378. The cutaneous system is essentially composed of several layers which may be considered as so many separate systems or only as the different parts of the same system. It seems more convenient to follow this latter method, because by it we arrive at a better knowledge of the whole system. These different layers are, 1st, the *derma* (*derma*, *corium*); 2d, the *papillary tissue* (*textus papillaris*); 3d, the *rete mucosum* (*rete Malpighii*); and 4th, the *epidermis* (*cuticula*.)

Bichat has separated the epidermis from the skin, and has considered as separate systems several parts described by us (§ 16) as appendages to the epidermoid system; but they are so intimately connected with each other, so identified in different parts, that it does not seem proper to insulate them. We may then consider all these layers generally in the whole cutaneous system, and then particularly in each of its two sections.

§ 379. The *derma* is the strongest, the firmest part, and the base of the whole cutaneous system. Always united to the adjacent systems, it adheres to the muscles, in the external skin by its internal face, and in the internal skin by its external face. It is white, soft, of variable thickness, having but few vessels and nerves, elastic, capable of contracting and extending to a considerable extent; it does not possess a high degree of vitality and when destroyed is not reproduced. Its consistence and thickness in different parts of the body vary very much: generally speaking they are greater in the external than in the internal cutaneous system.

§ 380. The *papillary tissue* (*textus papillaris*) which is applied to the loose surface of the dermis is in reality only a greater development of it, being composed of mucous tissue, of vessels, and of nerves: it has the form of small, regularly arranged tubercles which vary extremely in the different parts of the cutaneous system in volume and form. These tubercles increase the extent of the system still more than the folds (§ 377) which support them. The extreme sensibility of the cutaneous tissue depends upon them.

§ 381. The *rete mucosum* (*rete Malpighii*) is a mucous and semi-fluid substance having an immense number of capillary blood-vessels. It is more readily distinguished from the papillary tissue and the epidermis in the external than in the internal cutaneous tissue. In this tissue and in the preceding the processes of nutrition take place most actively.

§ 382. The *epidermis* (*epidermis, cuticula*) is whitish, solid, brittle, without vessels or nerves, and entirely insensible. It receives a perfect impression of all the irregularities of the layers which it covers. We cannot always insulate these latter in the internal cutaneous system. It becomes much thicker by friction, and is reproduced entirely after being destroyed.

§ 383. We also find in several parts of the cutaneous system simple glands, a species of round bursæ, which vary in size and are called in the internal cutaneous system, the *mucous glands* or *crypts* (*glandulæ* s. *cryptæ mucosæ*), and in the skin are termed the *sebaceous glands* (*glandulæ sebaceæ*).

§ 384. In those parts where the external and the internal cutaneous systems are continuous with each other, the former becomes thinner, smoother, finer, and sometimes redder than usual, as in the lips. The general characters marking the commencement of the latter are, that the epidermis is more easily detached from the subjacent layers than in the rest of its extent.

§ 385. The cutaneous system envelops all the other organs and forms an entire whole; but at the same time it connects the organism directly, with external objects, for it continually absorbs materials from without and expels them within; it establishes a limit, a sort of bridge between the individual organism and the rest of nature. It is in fact the most important part of all the organs of the nutritive life. Hence the frequent diseases in this system and its great influence on the general health, and the part it takes in all the changes which supervene in the organization; hence, also, the close sympathy between all its parts, both in the healthy and the diseased states.

§ 386. The cutaneous system differs in the sexes: it is much thicker, firmer, harder, and less sensible in the male than in the female. It varies at different periods of life, as follows:

1st. It is less extensive in the early periods of existence, not only from the deficiency of some parts, as the extremities, but the intestinal canal is shorter and narrower, and the folds appear late.

2d. It varies in form. At first both the intestinal tube and the anterior part of the body is open; there are not two canals opening into each other, but only two semi-canals.

3d. There are at first more vessels and nerves, whence the process of nutrition is then carried on more actively.

4th. It is much thinner in the early periods of life;

5th. It is then more loosely united to the subjacent parts; and,

6th. There is more analogy between the internal and the external portion.

B. OF THE CUTANEOUS SYSTEM IN THE ABNORMAL STATE.

§ 387. The cutaneous system reproduces itself after having been destroyed, but not perfectly: hence we can always distinguish cicatrices from the true skin. We shall enter into more details upon this subject when treating particularly of the external and the internal cutaneous systems.

§ 388. The congenital deviations of formation in this system are either its total deficiency or that of some of its layers, and its superabundance, as seen in the formation of abnormal appendages. The accidental anomalies of formation, if we except mechanical injuries, almost always result from alterations in texture, to which the cutaneous system is very subject, because of the circumstances mentioned above (§ 385). Beside those diseases in which it participates with other parts, it is often the seat of acute or chronic inflammation. Accidental tissues are frequently developed either in its proper substance or in the subjacent mucous tissue. Other alterations in its texture, for instance ossification, are rare.

ARTICLE SECOND.

SPECIAL REMARKS ON THE EXTERNAL CUTANEOUS SYSTEM.

A. OF THE EXTERNAL CUTANEOUS SYSTEM IN THE NORMAL STATE.

I. OF THE EXTERNAL CUTANEOUS SYSTEM IN GENERAL.

§ 389. The *external cutaneous system*(1) or the proper *skin* (*cutis*) envelops the external surface of the whole body and forms a close sac which possesses its exact form, and is continuous with the internal cutaneous system in those parts previously mentioned (§ 375). The skin differs from the internal cutaneous system generally, in being thicker, firmer, dryer, and less vascular. As we have already remarked generally on its form and composition, we have only to describe its component layers.

§ 390. The *derma* (*corium, derma*) is a white, solid, and dense tissue, which differs in several respects.

Generally considered, it is composed in great part of layers which are very distinctly seen on its internal face and after maceration. These layers are produced by a substance very analogous to fibrous tissue;(2) their direction is oblique from within outward: they are also narrower on their external than on their internal face, and the vessels, the nerves, and the hairs pass through the former. This laminar tissue is continuous in many places, for instance, in the nucha, the back, the abdomen, the sole of the foot, the articulation of the hand, and in that of the foot, with the subjacent fibrous tissue which it resembles almost entirely, in the palm of the hand and in the sole of the foot, by its shining and evidently fibrous texture. But in most of the cutaneous tissue, especially the trunk, and in all parts of the limbs, its fibrous structure is less apparent and its connections with the subjacent tissue less intimate. We find no trace of fibres in the derma of

(1) In addition to the works which have been quoted, we refer to Malpighi, *De externo tactus organo*, in *Epist.*, London, 1686, p. 21–23.—Hoffmann, *De cuticulâ et cute*, Leipsic, 1687.—Limmer, *De cute simulque insensibili transpiratione*, Zerbst, 1691.—A. Kaaw, *Perp. Hipp. sic dicta*, Leyden, 1738.—F. D. Riet, *De organo tactus*, Leyden, 1743.—J. Fantoni, *De corp. integumentis*, in *Diss. anat. VII. renov.*, Turin, 1745, n. i.—Lecat, *Traité des sens*, Amsterdam, 1744.—Cruikshank, *Experiments on the insensible perspiration of the human body showing its affinity to respiration*, London, 1795.—C. F. Wolff, *De cute*, in *N. C. Petrop.*, vol. viii.—G. A. Gaultier, *Recherches sur l'organis. de la peau de l'homme, et sur les causes de sa coloration*, Paris, 1809.—Id., *Rech. sur l'org. cutané*, Paris, 1811.—J. F. Schroeter, *Das menschliche Gefühl oder organ des Getastes nach den Abbildungen mehrerer berümhten Anatomen dargestellt*, Leipsic, 1814.—Dutrochet, *Observations sur la structure et la régénération des plumes, avec des considérations sur la composition de la peau des animaux vertébrés*, in *Journal de physique*, May, 1819.—Id., *Observations sur la structure de la peau*, in *Journal complémentaire*, vol. v.

(2) Osiander, from observations on the skin of the abdomen of women who died in child-bed, asserts that the fibre which forms the dermis is distinctly muscular on the internal face of the skin. F. T.

the back of the hand, of the sole of the foot, of the forehead, of the scrotum, of the labia pudenda, and of the penis, when the substance is perfectly homogeneous.

The dermis varies much in thickness. It is undoubtedly thickest on the back of the hand and in the sole of the foot, and thinnest on the eye-lids, in the mammæ of the female, in the scrotum, the labia pudenda, and the penis. It is thinner in the upper than in the lower extremities, and is thicker and firmer on the skull than on the face.

The dermis under the nails presents a peculiar arrangement, which we shall mention when speaking of these last, because all the layers of the skin are jointly modified in them.

§ 391. The skin is often wrinkled or folded, which depends on the different states of extension or contraction of the skin and subjacent parts, or on other causes.

The folds of the first kind are produced by the action of the muscles or by the diminution of fat below the skin in aged persons, and because of its slight degree of elasticity. In fact they result from the circumstance that certain muscles directly beneath the skin, or at least their tendons, act frequently while the skin is not sufficiently elastic to contract and to dilate in the same proportion, or because this membrane becoming still less elastic in advanced age does not contract, while the fat which distended it is absorbed, and it is therefore folded or wrinkled.

Other folds depend on the papillary tissue of the skin. They are very regular, small, compact, and curved. They are very manifest in the palm of the hand and in the sole of the foot. Each of these folds is composed ultimately of two others, for normally their upper face is slightly depressed, and the adjacent folds are separated from each other by deeper furrows.

§ 392. Below the dermis, in the *panniculus adiposus* which it covers, wind a great many *subcutaneous vessels* (*vasa subcutanea*): of these the veins are very considerable, and are always broader than the deep-seated veins. From these cutaneous vessels arise those which are expanded in the substance and on the surface of the dermis, most of which only pass through it to be expanded in the latter, so that the tissue of the skin is not very vascular. The same is true of the nerves.

§ 393. In some places, for instance at the commencement of the meatus auditorius externus, at the end of the nose, at the edges of the eyelids, around the anus, the vulva, and the nipple, are considerable openings from whence comes an oleaginous fluid which hardens quickly. These openings lead into small culs-de-sac called the *sebaceous glands* (*glandulæ sebaceæ*). As the whole skin exhales an analogous substance, we might be led to think that these glands exist every where; but it is impossible to demonstrate this. Probably the bulbs of the hairs should be considered as organs corresponding to them in structure and in functions (§ 410), or rather we must regard these glands as enlarged bulbs of the hairs which are more developed, since no hairs come from them, and they are found exactly on the common borders of the external and of the internal cutaneous system. It would seem also to result from this, that the development of mucous crypts in the internal cutaneous system corresponds to that of the hairs and the epidermis in the external cutaneous system.

§ 394. The *papillary tissue* (*textus papillaris*)(1) of the skin is composed of small processes situated on the external surface of the dermis, particularly on the elevations of the second kind which this latter presents: these processes are called *papillæ of touch* (*papillæ tactus*). Each elevation presents two ranges of these papillæ, which however are so connected with each other that they may be considered as forming but one. Like the eminences on the surfaces of which they are seen, they are very manifest in the palms of the hands, in the soles of the feet, in the hips, in the glans penis,(2) and in the mammæ.(3) Their surface is villous. In all other parts they are less distinct, even when the epidermis is removed. Even in the preceding regions we find none between the elevations in which the papillæ of touch are situated.

The latter are composed of nerves and of fine branches of the cutaneous vessels. According to Gaultier, they principally give the color to the skin. But this anatomist seems to have confounded them with the vascular tissue which covers them.

§ 395. The external face of the dermis and of the papillary tissue is covered with a fine vascular network, composed of numerous central points united by many anastomosing vessels which are very apparent and regularly arranged.

§ 396. Proceeding from within outward, we find next to the dermis the *rete mucosum*, or the *rete Malpighii*, a mucous homogeneous substance which may be divided into two or three separate layers.(4) It has no openings which allow the papillæ of touch to communicate with the epidermis, but only depressions which correspond to them, and within which they are imbedded as in so many sheaths. This layer is the principal seat of the color of the skin, since in the negro the dermis is as white as in the European,(5) while the rete mucosum always presents the peculiar color of each race. Usually it is considered single, but we have reason to think it compound. Gaultier assigns to it three layers, the first two of which he calls the *internal* and the *external tunica albuginea* (*tunica albuginea interna et externa*), because of their color, while he calls the third the *brown substance*, in the negro, where it is very apparent. Of these three layers the inter-

(1) Hintze, *De papillis cutis tactui inservientibus*, Leyden, 1747.
(2) B. S. Albinus, *De integumentis glandis penis; loc. cit.*, lib. iii. c. ix.
(3) B. S. Albinus, *De papillis mammæ et papillæ muliebris; loc. cit.*, c. xii.
(4) B. S. Albinus, *Quædam de modis quibus cuticula cum corpore reticulari de cuti abscedit*, in *Annot. acad.*, Leyden, 1754, l. i., c. i. *De cognatione et distinctione cuticulæ et reticuli*, ibid. c. ii.—*De reticuli foveolis vaginisque quibus papillæ continentur*, ibid. c. iii.—*Nonnulla de usu et ratione reticuli et cuticulæ*, ibid. c. v.
(5) B. S. Albinus, *De sede et causâ coloris Æthiopum et ceterorum hominum*, Leyden, 1737.

nal is the thickest and the external is thinnest: both are white; the middle is colored, but less so than the vascular tissue, so that it cannot be regarded as the principal seat of color except in the negro. Cruikshank has found between the dermis and the epidermis of a negro, who died from small pox, four layers besides the papillary tissue; the internal very thin, a second in which the variolous pustules were developed, a third which was thicker, the proper seat of color, finally a fourth which was whitish, and which he considered the external layer of the third. This description agrees pretty well with the preceding.

The layers, situated between the papillary tissue and the epidermis, which form this membrane, usually remain united to the epidermis when the latter is separated by putrefaction or boiling; but they sometimes adhere to the dermis.

§ 397. The *epidermis*, or *cuticle* (*epidermis, cuticula*),(1) is a membranous, homogeneous, thin, semi-transparent expansion, whitish in the European, light gray in the negro, forming the most external layer of the skin, covering the internal layers in every part, and adhering to them intimately. It thus presents the same folds and the same inequalities as the latter, and we see on its internal face round depressions which correspond to the papillæ of touch. Its external face is smooth, while the internal is very uneven: it is firmly united to the subjacent layers; but in certain cases this union is entirely destroyed either during life or after death: it seems to take place by numerous small filaments(2) which are perceived very distinctly in the palms of the hands and in the soles of the feet, if the skin be immersed into boiling water, and the epidermis be detached from the dermis. It is however difficult to determine the nature of these filaments. Bichat considers them as the extremities of the absorbent and exhalent vessels;(3) but we have never been able to fill them, even when the cutaneous vessels had been perfectly injected; and Hunter has succeeded no better than ourselves. Might they not have been produced from the mucous tissue by the process of boiling? And if this be false, are they really hollow?

The same uncertainty exists whether the epidermis be filled with holes called *pores*, or whether it be only thinner in those places where these pores seem to exist. Many observers, as Leuwenhoeck(4) and Bichat, particularly the former, admit that the epidermis is porous, and Bichat asserts that the oblique direction of these pores alone prevents

(1) C.G. Ludwig, *De cuticulâ*, Leipsic, 1735.—Fabricus ab Aquapendente, *De totius animalis integumentis, ac primo de cuticulâ et iis quæ supra cuticulâ sunt*, in *Opp. omn.*, Leipsic, 1687, p. 438–452.—J. F. Meckel, *De la nature de l'épiderme et du réseau qu'on appelle malpighien*, in *Mém de Berlin*, 1753, p. 79–97—Id., *Nouv. obs. sur l'épiderme et le cerveau des negres*, ibid. 1757, p. 61–71.—B. S. Albinus, *De incisuris cuticulæ et cutis; loc. cit.*, c. iv.—A. Monro, *De cuticulâ humanâ*, in *Works*, Edinburgh, 1781, p. 54.—J. T. Klinkosch, *De verâ naturâ cuticulæ et ejus regeneratione*, Prague, 1771.—Hermant, *De verâ naturâ cuticulæ ejusque règeneratione*, Prague, 1775.—Mojon, *Sull' epidermide*, Genoa, 1815.

(2) Hunter, *Med. obs. and inq.*, vol. ii. p. 52, 53, tab. 1, fig. 1, 2.

(3) *Gen. Anat.* vol. iii. p. 351.

(4) *Arcan. nat. ep. phys.*, 43.

them from being seen. Others, on the contrary, as Meckel(1) and Humboldt,(2) deny the existence of these pores. We have never been satisfied of the presence of these openings, and their existence is not necessary, since the exhaled fluids can escape very well through the thinner parts of the epidermis.

The thickness of the epidermis is nearly uniform, except in the palms of the hands, and particularly in the soles of the feet, where it is thicker. In fact, friction increases its thickness, and renders it callous in those two parts;(3) but that this difference has not entirely a mechanical origin, is proved by the greater thickness of the epidermis of the palm of the hand and sole of the foot even in the fetus(4). This is the reason that it is more difficult to detach it from the subjacent layers in these two parts of the body.

The epidermis is usually formed of one layer only; but we observe several which are very distinct in those parts where it is thickest. We have observed this several times in the palm of the hand and in the sole of the foot.

§ 398. The epidermis is essentially only the rete mucosum coagulated and hardened. It belongs then properly to the mucous tissue. It is entirely destitute of nerves and vessels, and is consequently dry and insensible. It is completely regenerated by the drying of the rete mucosum. The appearance of the vascular structure presented by it depends either on some extravasation or on the adhesion of a portion of vascular tissue. It has no power of contraction, and but a slight degree of extensibility

The epidermis moderates in part the impressions made on the papillæ of touch in the skin, and in part opposes evaporation. Hence a blister not unfrequently causes all the serum of the mucous tissue in dropsy to escape in a short time. Hence too the skin not only dries rapidly in those parts where the epidermis has been removed either before or after death, but it also adheres intimately to the subjacent organs, while that of the adjacent parts which has preserved its epidermis always remains moist.

That the epidermis arises from the hardening of the rete mucosum is proved by the fact that it is partly the seat of color in the skin, for it always presents the same tint as the rete mucosum, but it is less distinct.

§ 399. The epidermis appears early; it is already seen distinctly in the fetus of two months; it is then even proportionally thicker. Besides, the considerable growth of hairs and the formation of the caseous substance (*vernix caseosa*) with which the skin of the fetus is covered, prove the great activity of the epidermoid system at this period.

We may state, as *sexual differences*, that it is softer and thinner in the female than in the male.

(1) *Mém. de Berlin*, 1763, p. 63.
(2) *Ueber die gereizte Muskel- und Nervenfaser*, vol. i. p. 156.
(3) Nurnberger, *De cuticulae frictione comprimente callosâ*, Wittenberg, 1789.
(4) B. S. Albinus, *De sede col. cutis*, p. 9.

The races of the human species also present some differences. Although several anatomists, among others Malpighi(1) and Littre,(2) affirm it is white in the negro, we now know that it has a grayish, brownish tint. We agree with the opinion of Santorini,(3) Ruysch,(4) Albinus, (5)Meckel,(6) and Sœmmerring.(7)

It is a little coarser in the negro than in the European.

II. OF THE MODIFICATIONS OF THE EXTERNAL CUTANEOUS SYSTEM, OR OF THE APPENDAGES OF THE SKIN, THE HAIR, AND THE NAILS.

§ 400. The hairs and the nails are generally considered only as appendages of the epidermis. But in our opinion this is incorrect; for the nails and the hairs are in fact modifications of the whole cutaneous system, although the epidermoid system and that of the rete mucosum predominate in the most of their length. In fact the dermis below the nails is peculiarly modified, and corresponding variations are observed in the other layers of the skin. We must then consider as belonging to the nail not only the epidermis which is particularly modified, but also the whole cutaneous texture. The same is the case with the hair, for their bulbs are evidently analogous to the dermis.

1st. *Of the nails.*

§ 401. The *epidermoid portions of the nails*, or the proper *nails* (*ungues*),(8) are broad, hard, slightly convex, and oblong layers formed at the ends of the backs of all the fingers and toes, and which cover the anterior part of the third phalanx, projecting forward and on the two sides.

We distinguish in the nails three portions, the posterior or the *root*, the central or *the body*, and *the anterior* or *the free extremity*.

The *root* (*radix unguis*) is concealed under the skin, and is softer and thinner than the other two parts. It gradually becomes thinner, and terminates in a rounded edge. It is one fifth or one sixth of the whole length of the nail. *The central part, the body*, is much larger than the other two parts, and its internal face adheres intimately to the skin, while the external face is unattached. Its posterior part varies proportionally in extent according to the subjects, and almost always diminishes from the thumb to the fifth finger: it is white, convex forward, and concave backward, and is termed the *crescent* (*lunula*).

(1) *Exerc. de externo tactus organo.*
(2) *Hist. de l'ac. des sc. de Paris*, 1702, no. 13, p. 40.
(3) *Observ. anat. Venet.* 1724, l. i. p. 1.
(4) *Curæ renovatæ*, no. 59, 87.
(5) *Loc. cit.*, p. 6.
(6) *Mém. de Berlin*, 1753, p. 93.
(7) *Ueber die korperlichen Verschied. des Negers vom Europræ*, 1785, p. 45.
(8) Frankenau, *De unguibus*, Jena, 1696.—Ludwig, *De ortu et structurâ unguium*, Leipsic, 1748.—B. S. Albinus, *De ungue humano ejusque reticulo, itemque de cutis loco, qui ungue tactus ac de loci istius papillis*, in *Annot. acad.* vol. ii.-xiv.—*De naturâ unguis*, ibid. c. xv.—Bose, *De unguibus humanis*, Leipsic, 1773.—Haase, *De nutritione unguium*, Leipsic, 1774.—Nurnberger, *Meletemata super digitorum unguibus*, Wittenberg, 1786.

The anterior is much greater, and appears reddish. The *free extremity* projects beyond the skin, so that its two faces are entirely free. It is the thickest part of the nail, which consequently diminishes gradually in thickness from behind forward. The length of this extremity is not fixed, and depends on the greater or less degree of attention with which it is cut. Left to itself, it becomes very long, thick, and pointed.

§ 402. The nails are connected only with the epidermis, and adhere to it so intimately in all their circumference that they are retained firmly in place. The nail is slightly covered behind and on the sides by the epidermis which is reflected forward from below. Behind, this membrane projects on the concave and thin edge of the skin which covers the posterior part of the nail, forms a small groove often separated from the skin by a kind of channel, and which is intimately connected before with the anterior edge of the crescent. Thence the epidermis goes backward, insinuates itself below the portion of the skin which slightly projects above the nail, is reflected on the inferior face of the nail, and is continuous with it forward. On the sides, the epidermis projects as it does behind, but it is not extended foward, and is also continuous with the edge of the nail. The epidermis having covered the anterior extremity of the finger leaves the skin, and attaches itself to the anterior convex edge of its central and adherent part, and blends itself with its substance.

Thus, the nail (in the common sense of the word) is only a thickened portion of the epidermis, which detaches itself, like this latter, from the subjacent layers of the skin.

§ 403. But these subjacent layers present of themselves some modifications. The dermis is thicker, softer, has no layers, and is not attached to the nail by any prolongation. Under the body of the nail, it is very red and more vascular than in the other parts. Under the root and the crescent, on the contrary, (if we except the nails of the toes, which usually have no crescent,) it is white, so that the whiteness of this semilunar spot does not depend on the nail, but on the skin. Its upper face has very distinct longitudinal fibres, especially in its reddish anterior portion, which is the most extensive. These fibres may be compared to the papillœ of touch, and the internal and inferior face of the nail, which is soft and also provided with very distinct longitudinal fibres, may be compared to the rete mucosum intimately connected with them. In the small nails of the toes, which are imperfectly developed because they are compressed, we discover neither the fibrous structure of the skin nor the rete mucosum, but the projections and excavations which correspond to them are irregular and more similar to papillœ.

§ 404. The epidermoid portion of the nail is composed of superimposed layers, the external of which extends the whole length, while the internal gradually diminish from behind forward, so that the most anterior are the shortest; these, too, are also the softest, and become, at least apparently, more fibrous. The structure of the nails is homogeneous, like that of the epidermis; they have neither vessels nor nerves.

§ 405. The epidermoid portion of the nails presents no trace of sensibility or contractility. The vital phenomena which take place in them are very slow, except the acts of growth, which proceed rapidly, as is proved by their continual increase.

§ 406. The nails begin to appear in the fifth month of fetal existence, and are very imperfect at the ninth.

2d. *Of the Hairs.*

§ 407. The hairs (*pili*, *crines*)(1) are filaments of various lengths, always thin in proportion to their length, about $\frac{1}{600}$ of an inch in diameter, more or less cylindrical and usually smooth. We rarely perceive at intervals these swellings, which are apparently produced by some disease. Their attached extremity, called the *bulb* (*bulbus*,) is a little thicker and always soft, the other is slightly pointed. In the normal state, they are seen only on the external cutaneous system, or the skin properly so called, covering all its parts, except the palms of the hands and the soles of the feet, where it is very remarkable that that the epidermis is considerably thick. We must remark in general,

1st. That principally around these points where the external cutaneous is continuous with the internal cutaneous system, we find numerous hairs, which assume a peculiar arrangement, as on the edges of the eyelids, in the nostrils, at the entrance of the ears, around the mouth, the anus, the vulva, and the mammæ.

2d. That the law of polarity exists between the parts on which they grow in abundance; as in the head and the pubis, on the chin and the anus, on the back and the belly.

§ 408. The hairs are composed of two substances, an *external* and an *internal*.

The *external*, which surrounds the other like a sheath, has all the properties of the epidermis. It is always transparent, white, and very difficult to destroy; it is continually reproduced, and in the bulb or follicle is more or less evidently composed of several layers.

Under this sheath we find a colored substance formed of about ten filaments, probably vessels. The form of this substance resembles that of the hairs, but it is much thinner than the internal envelop. It is imbedded into the centre of a fluid, which being partially lodged in

(1) P. Chirac, *Lettre écrite à M. Regis sur la structure des cheveux*, Montpellier, 1668.—Malpighi, *De pilis observationes;* in *Opp. posth.*, London, 1697, p. 93–96.—M. J. J. Bajerus, *De capillis diss.*, Jena, 1700.—O. Zaunslifer, *Diss. exhibens historiam pilorum in homine*, Leyden, 1738.—Meibomius, *De pilis eorumque morbis*, Helmstadt, 1740.—G. A. Langguth, *De pilo parte corp. hum. non ignobili*, Wittenberg, 1749.—F. Grutzmacher, *De humore cutem inungente*, Leipsic, 1748.—e. P. L. Withof, *Anatome pili humani*, Duisburg, 1750, in 4to.—J. H. Kniphof, *De pilorum usu*, Erford, 1754.—J. P. Pfaff, *De varietatibus pilorum naturalibus et præter naturalibus*, Halle, 1799.—Rudolphi, *De pilorum structurâ*, Gripswald, 1806.—Grellier, *Dissertation sur les cheveux*, Paris, 1806.—Rudolphi. *Aufsatz über Hornbildung;* in *Abhandlungen der Wissenschaften von Berlin*, 1818, p. 180.—Rowland, *An historical, philosophical, and practical essay on the human hair*, London, 1818·—Buck, *Diss. de pilis eorumque morbis*, Halle, 1819.—Aegidi, *Dissertatio de pilorum anatomiâ*, Berlin, 1819.—Heusinger, *Remarques sur la formation des poils*, in *Journal complémentaire du Dict. des sc. méd.*, vol. xiv., p. 229.—Id., *Sur la régénération des poils*, same journal, vol. xiv., p. 339.

the canal formed by the filaments partly scattered between them and the external envelop, unites them together, and constitutes, with them, the marrow of the hairs.

This internal substance corresponds undoubtedly to the rete mucosum of the skin, and is the coloring matter of the hairs, which whiten when it disappears.

§ 409. The hairs do not seem to receive blood-vessels, at most we can perceive but a few, and these very seldom, in the inferior swelled portion of the bulbs, which is provided with one or more openings. Through these come the blood-vessels, and probably the fine nervous filaments. In fact we cannot plainly distinguish the nerves, but the analogy derived from the coarse hairs of animals and the pain occasioned by their removal, authorize us to suspect their existence. It is, however, certain that the nerves do not extend beyond the bulb.(1)

§ 410. The hairs are situated under the skin in the mucous tissue, which is almost always filled with fat. The largest are found there, (although this arrangement is not so apparent in regard to the smaller ones,) in the small, closed, thin, whitish and very vascular envelops which loosely surround them, pass through the openings in the dermis (§ 390), thus arrive at the epidermis, continue with it, remain fixed to its internal surface as small hollow prolongations, when it is detached from the dermis. There is no adhesion between the hairs and the envelops except at the extremity of the bulb, so that in this place the hairs appear more or less villous on their surface. A thin fluid exists between them and the surrounding sac, which in the dense hairs of animals is real blood.

§ 411. From the want of nerves, the hairs are insensible. They have no contractile power; but the formative power is much developed. They grow constantly, and lengthen even after death, or when detached from the body.(2) Thus they are reproduced after having been lost from accident, but not when vitality is absolutely extinct. They possess great strength, and are with difficulty destroyed, undoubtedly because of their external envelop.

§ 412. According to the latest researches of Vauquelin,(3) the hairs are composed,

1st. Of an animal substance which constitutes their base, and is very similar to dried mucus, and certainly comes from the external envelop.

2d and 3d. Of two oils, one white and concrete, the other blackish, on which their color depends, at least in part, and which undoubtedly belong to their internal substance, since they vary according to the color of the hairs, and are not colored in those which are white.

4th. Of iron.

5th. Of a little of the oxide of manganese.

(1) Rudolphi has followed the nerves into the bulbs of the mustaches of the seal—as has also Andral, jun. See his note: *Sur les nerfs qui se rendent aux mustaches du phoque;* in the *Journal de physiologie expérimentale.* vol. i., 1821, p. 73. F. T.

(2) Krafft, in *Nov. com. Petrop.*, vol. ii., p. 24.

(3) *Annales de chimie*, 1806, vol. lviii.

6th. Of the phosphate } of lime.
7th. Of the carbonate }
8th. Of silex.
9th. Of a considerable quantity of sulphur.

§ 413. The hairs differ from each other very much in the different regions of the body. The *hairs of the head* (*coma* s. *capilli* s. *cæsaries*) are the longest, the strongest, the most numerous, and the closest of all.

Next come those of the beard, the hairs of which are distinguished from those of the head in being more distant from each other.

Next come those of the pubis, of the axilla, of the anterior face of the thorax, and of the abdomen, the eyebrows, the eyelashes, the hairs found in the nose, the anus, and those on the limbs, which become shorter and thinner as we descend to the lower part of the limb, and finally, those of the cheeks and the forehead.

The hardest and coarsest are those in the nose, and those on the face are, if we except the beard, the softest. The hairs of the pubis are the thickest; next come those of the axilla, then the hairs of the head, next the eyebrows and the eyelashes.

The color of the hairs is usually the same in all parts of the body, but to this rule there are many exceptions. It sometimes happens, but it is rate, that a part of the hairs of the head are unlike the rest in color, more often, even usually, only some hairs are discolored, while the rest preserve their primitive color.

All the hairs of the same subject do not appear at the same time. The hairs of the head exist at birth, while the beard and the hairs on the pubis and the axilla do not appear till puberty.

§ 414. The hairs are subject to very considerable periodical changes.

The skin is entirely smooth till towards the middle of fetal existence. At this time, however, it is covered with numerous short fine hairs, a kind of *down* (*lanugo*). At first these hairs have no color, but assume one as the period of birth approaches. On certain parts of the body, for instance, on the face, they are much longer than the permanent hairs which afterwards appear in these same parts. Their length is at first almost equal in every part, but at birth however, those of the head are much longer and stronger than the rest.

These downy hairs of the fetus fall some before, but most of them after, birth. They are found in the waters of the membranes and in the meconium. Those which replace them on the body do not begin to appear till puberty, when the beard and the hairs of the pubis, of the axilla, and of the trunk are developed. The hairs of the head, on the contrary, remain the same and grow much more rapidly after birth than before.

The color of the hairs generally becomes deeper in age: this rule is, however, subject to exceptions, although they are few.

Sooner or later, usually about the age of thirty, the hair begins to whiten, by the disappearance of the internal substance. A little later when the external envelop has continued for some time to grow regularly, the attachments existing between it and the follicle in which it is contained are destroyed, and the hair begins to fall off.

The white hairs contain a colorless oil and some phosphate of magnesia, which is not found in the colored hair.

Both of these changes take place first in the longest and thickest hairs, that is, those of the head, and particularly those found on the top of the head. The hairs of the extremities change the last.

The hairs which have fallen off are rarely replaced, and those which have lost their color seldom resume it; some examples of this phenomenon, however, have been seen.

The part which forms first is the sac which surrounds the bulb, a complete ovum, which, either in the primitive hairs or in those afterwards developed, is already perfectly formed before the bulb, and is pierced by the hair which lengthens outwardly, as the capsule of the tooth is by the tooth, or the membranes of the ovum by the fetus. Probably its decay causes the death of the hairs; for in old men whose hairs have fallen, we find no traces of these sacs under the skin, while, when we see them as in the natural state, after those diseases where the hair has fallen off, a new growth arises from them.

§ 415. We may mention as *sexual differences*, that in the female the hairs are finer; those of the head are longer, but those in other parts of the body are shorter. They are not entirely deficient in any of those parts where they exist in the male; and in those places where they are largely developed in the male, they are also rather longer and more numerous in the female, especially when the functions and the differences dependent upon sex are not perfectly developed.

§ 416. Besides these differences arising from age and sex, the hairs present others also. In fact they vary according to the individuals, and in this relation they present, in the different human races, peculiarities, some of which are accidental, while others are very constant:

1st. The color of the hair differs surprisingly in different individuals of the same race and of the same family. It varies from a very bright yellowish (white) to the deepest black, between which two extremes we find every imaginable shade of auburn, red, and brown. Other colors, as green for instance, cannot be considered as primitive: they depend on external influences, such as copper.

2d. As much may be said in regard to the thickness, number, and length of the hairs. Generally we may admit that the blackest are the thickest, and that the lighter are finer. Withof found in one fourth of a square inch of skin one hundred and forty-seven black hairs, one hundred and sixty-two chestnut, and one hundred and eighty-two light hairs. This rule, however, is subject to exceptions, and the more as the hairs are not at equal distances in all individuals.

3d. The direction of the hairs is various. Usually they are even and straight; often, however, they are more or less curled or frizzled.

The differences met with in the same nation may be considered as the differences of races. The most important ones have already been mentioned (§ 33); we shall only remark that these occur in all races: thus, there are negroes who have straight, long hair.

B. OF THE EXTERNAL CUTANEOUS SYSTEM IN THE ABNORMAL STATE.

417. The external cutaneous system possesses in a great degree the power of reproducing itself.(1) All its layers are reproduced, by whatsoever cause they may have been destroyed. But they do not reappear with characters perfectly similar to those which they have in the normal state.

The dermis is less elastic, and adheres more closely to the subjacent mucous tissue, than the natural dermis; it is in fact blended with this tissue, and cannot be separated from it. Like all other regenerated parts, it is less hard and has less spontaneous activity than the natural dermis. This explains the ease with which even old cicatrices are torn, and with which the new integuments of cutaneous ulcers are sometimes entirely destroyed.

The new dermis is at first exceedingly thin, delicate, and soft, more vascular, and of course redder, than the natural dermis; it gradually becomes less vascular, whiter, firmer, and harder than the latter, and acquires almost all the qualities of a ligament. At the same time its aspect is smooth and shining, which depends undoubtedly on the absence of the papillæ of touch and on that of the hairs, as well as on the tension of the new integument and its more intimate adhesion to the subjacent mucous tissue.

Its sensibility is less than that of the primitive dermis, doubtless because of the absence of the nervous papillæ. Perhaps also it receives fewer nerves than the latter.

These different phenomena are not however seen except when the dermis has been entirely destroyed; for when the injury is only superficial, all marks of difference disappear with greater or less promptitude.

The new dermis is covered with a rete mucosum and an epidermis; but these latter are reproduced only gradually, as the first formed layers always fall off.

The color of the rete mucosum is developed the last, and this is sometimes entirely deficient. Bichat pretends that its color is not reproduced when it has been removed, and that cicatrices are white in all people; but this assertion is not perfectly correct, for in the negro the cicatrices of small pox are black,(2) and those which are developed after all injuries of the common integuments, are as black and sometimes blacker than the rest of the skin.(3)

(1) Moore, *On the process of nature in the filling up of cavities, healing of wounds, and restoring parts which have been destroyed in the human body*, London, 1782, sect. ii. p. 46.
(2) Meckel, in *Mém. de Berlin*, 1753, p. 81.
(3) Moore, *loc. cit.*, p. 52.—Hunter, *On the blood.*

The nails and the hairs also possess the restorative power to a considerable extent.

The nails are reproduced not only in their natural places, but we have also seen them developed at the end of the second phalanx of the fingers when the third has been destroyed.

The hairs are not regenerated when the dermis has been destroyed entirely; but they grow again more or less perfectly when they have fallen off from disease.

§ 418. The diseases of the skin extend to all the layers, or are confined to some only, which remark applies also to the anomalies of its form or to the alterations of texture.

§ 419. The principal deviations of formation are,

1st. Its *absence*. The whole skin or some of its layers only may be deficient in one point or another. The first occurs when the cavities of the viscera are not entirely closed. But sometimes the epidermis is primitively deficient without any division or fissure of the body. The same is true of the nails and the hairs.

2d. Its *excess*, which is manifested, when the whole skin participates in it, by the existence of a greater or less number of rounded oblong excrescences in different parts of the body, almost always attended with a want of development in other parts.

As to the different parts of the cutaneous system, the most striking example of their excess is the extraordinary length of the hairs in places where they are usually very short. This deviation of formation is almost always attended with a greater development of fat and a darker tint of the skin.

The same deviations of formation may also be secondary or accidental.

The epidermis, the hair, and the nails, die after diseases of the skin, or in other morbid states consisting essentially in extreme weakness of the vital powers; they are then detached from the body. The epidermis is constantly reproduced; but this is not the case with the hairs and the nails. The *albinism* of the hairs also results from an imperfect nutrition, for it depends upon the slow or rapid death of their internal substance.(1)

The skin and its different parts can also acquire an increase of development. The dermis thickens, the papillæ of touch become longer. Warts arise from an unusual increase of some parts of the dermis, corns and callus from the thickening of the epidermis; a considerable development and a horny hardening of the epidermis, forms also the essence of *icthyosis*. There is much affinity between these different states and the excessive growth of the hairs of the head in *plica polonica*, which makes the transition from deviations of formation to alterations of texture.

§ 420. Alterations of texture are very frequent in the cutaneous tissue. Among the first we place a want of color in the rete mucosum,

(1) Wedemeyer, *Histor. pathol. pilorum*, Göttingen, 1812.

the *leucethiopia*, or *leucosis*, which is usually congenital, but which sometimes develops itself during life.(1)

Besides the inflammations, to which we give different names, according as they attack the different layers of the skin or the subjacent cellular tissue, the cutaneous system is subject to a great many affections which are peculiar to it and known by the term *exanthemata*, the history of which belongs to pathology. Generally in the exanthematous diseases, the skin becomes like the mucous membranes, for its vessels receive more blood, it softens, furnishes liquid secretions, and the epidermis is almost always detached from it. As to the eruptions themselves, they are usually rounded, giving origin to a local increase of the peculiar life of the tissue which from a central point extends a greater or less distance, and assumes the characters of an inflammation which almost always results in the formation of a peculiar fluid. They may be considered as very imperfect organisms, or even as more or less successful attempts to produce ova, which they resemble in their round form, and from this circumstance, that they never become otherwise than fluid. Besides, the phenomena they present in their progress are in fact the same which are observed in entire organisms from their origin till their death. The chronic exanthemata are situated principally in the thickness of the dermis, while those which are acute in their progress appear at the external face of this membrane and in the vascular tissue.

§ 421. Abnormal formations of another species are developed, at least primitively, in the subcutaneous cellular tissue: such are fatty tumors, schirrus, cancer, and fungus hematodes, which extend sooner or later to the skin itself.

§ 422. Formations of the skin sometimes appear in abnormal places; but this is less common in regard to the dermis than to the epidermoid portions, particularly the hairs.(2)

The most remarkable peculiarities presented by the accidental formation of the hair are,

1st. They are developed in the same circumstances as the regular hairs, that is, at the same time as the fat, and in the parts resembling the skin, either those newly formed, as the cysts, or those already existing, as the mucous membranes.

2d. They perfectly resemble the normal hairs, both in their structure, their situation, and their changes. Like them they have roots, and almost always are implanted at first very firmly; like them also they usually fall off after a certain lapse of time, and then appear mixed with fat. It is possible, however, that sometimes their roots are implanted in the fat only.

(1) G. T. L. Sachs, *Historia naturalis duorum leucæthiopum auctoris ipsius et sororis ejus*, Salzbach, 1812.—Mansfeldt, *Réflexions sur la leucopathie considérée comme le résultat d'un retardement de développement*, in the *Journ. compl. des sc. méd.*, vol. xv. p. 250.

(1) Meckel, *Mémoire sur les poils et les dents qui se développent accidentellement dans le corps*, in the *Journ. compl. du Dict. des sc. méd.*, vol. iv. pp. 122 and 217.—Bricheteau, *Observation de kystes dermoïdes et pileux, suivie de quelques remarques sur ces productions organiques*, in the *Journ. compl. des sc. méd.*, vol. xv. p. 298.

3d. The places in which they occur most frequently are those where the activity of formation is the greatest, as in the ovaries. They are rarely seen in the testicles, although they have been found in these organs also.

The nails, or horny productions,(1) are developed more rarely in places differing from those which have been mentioned as their usual situations. The most general conditions of their formation are as follows: 1st, as far as our knowledge extends, they form only in the skin; 2d, they develop themselves in cysts filled with fluid, which they pierce from within outward; 3d, when destroyed, they are reproduced like the natural parts; 4th, we generally find several at the same time in the same subject; 5th, they are more common than in any other part in the loose portion of the skin, and especially in the integuments of the head, although they are sometimes found in places where this membrane is reflected on itself, for instance in the glans.

ARTICLE THIRD.

OF THE INTERNAL CUTANEOUS SYSTEM.

A. OF THE INTERNAL CUTANEOUS SYSTEM IN THE NORMAL STATE.

§ 423. We have already mentioned the division of the *internal cutaneous system*, or the *system of the mucous membranes* (§ 375). From the description we have given of it, it follows that this system represents a large canal extending from the mouth to the anus, presenting in its passage several prolongations and several simple or complex culs-de-sac, which communicate directly with the external cutaneous system. We observe besides, in all portions of the system of the mucous membranes, enlargements and contractions, which depend on the figure of the parts which it contributes to form, and the internal face of which it always lines.

The internal is much narrower than the external cutaneous system, but it is much longer and more distributed in the body.

§ 424. The external face of the mucous membranes is attached to the neighboring organs, which are almost always muscles—seldom, as in the gums, to bones—and sometimes to cartilages and fibrous tissue, as in the trachea—by a dense and solid layer of cellular tissue, in which are the large vascular trunks which go to these membranes. This layer of cellular tissue is called the *nervous coat;* and, according to Bichat, the form of the organ depends on its inner layer of mucous membrane.

(1) Caldani, in the *Mem. della societa italiana*, vol. xvi. p. 126.—Meckel, *Sur les cornes accidentelles, et en particulier sur celles qui viennent au gland, chez l'homme*, in the *Journ. compl. des sc. méd.*, vol. iv. p. 91.—Bertrand, *Note sur une production cornée*, in the *Archives gén. de méd.*, vol. v. p. 534.

This assertion, however, is not well founded; for the form of these organs is determined principally by the muscular tunic: this is proved particularly in those places where this latter tunic is very thick, as in the uterus, the mouth, the pharynx, the esophagus, and the rectum.

In fact Bichat brings forward an experiment which he believes proves his assertion. If we deprive a portion of intestine of its peritoneal, muscular, and nervous coats, and afterwards inflate the canal, the mucous membrane porjects at the place from which these coats have been removed. If a fold of the intestine be turned, and the mucous membrane and the nervous coat be removed, and it be inflated, the muscular and the peritoneal tunics also pass from the opening. But this experiment has always afforded me different results, which settle beyond a doubt that the form of the organ does not depend on its muscular coat.

In the former case, in fact, when the intestine remains in its proper place, the protrusion occurs when the muscular coat is removed, although it becomes more considerable after the separation of the nervous tunic. If, on the contrary, the intestine be turned, the removal of the nervous and mucous coats is not followed by the protrusion of the muscular membrane, although when the latter is raised, the peritoneal coat rises slightly.

The union between the mucous membrane and the surrounding parts is not every where equally intimate. Usually, as in the whole intestinal canal, the nasal fossæ, the bladder, and the vasa deferentia, the adhesion is feebler than in some other parts, as of the tongue, the alveolar processes, and the uterus, where it is so intimate that the respective limits of the parts can scarcely be distinguished.

§ 425. The internal and loose face of the mucous membranes is not perfectly smooth, like that of the external cutaneous system. It presents inequalities which in some parts are more distinct even than in the latter. Sometimes these inequalities depend on the great development of the nervous papillæ, as in the tongue and the small intestines; so that they are produced by these papillæ and by the epidermis, that is in fact by all the layers of the mucous membrane, but also by it alone. Sometimes they give origin to *folds*, *valves* (*plicæ* s. *valvulæ*), formed either by the nervous coat and the mucous coat alone, or at the same time by the muscular coat. The former is much more common than the latter. Among these folds are arranged the valves of Kerkring in the intestinal canal, the folds of the internal face of the gall-bladder, of the vesiculæ seminales, and of the neck of the uterus, the wrinkles of the stomach and of the vagina. Among the folds of the second kind may be cited the pyloric and ileo-cæcal valves. These latter are found in that part where the function of the organ to which they belong requires a barrier or a line of demarkation between its different sections. The differences of the first kind are either constant or not. Thus, the folds of the intestines are always found, while those of the stomach and of the vagina are inconstant. The first, like those dependent on the development of the nervous papillæ, arise from the extent of surface presented by the development of the mucous membrane; while, on the contrary, those of the stomach appear because the mucous membrane is less contractile than the surrounding muscular tunic. The wrinkles in the vagina are inconstant for the same reason as the folds of the stomach; for as they are more or less completely effaced by repeated distensions of this canal, this peculiarity demonstrates that their existence and their absence depend on the same cause.

§ 426. The internal differs but slightly from the external cutaneous system in its texture; but, in this respect, it varies more than the external in different parts of the body, doubtless because of the greater variety of functions it executes, according to the nature of the organs the internal face of which it lines.

The chief differences are,

1st. The manner in which the mucous membrane is bounded externally, or in which it is continuous with the surrounding parts. We have already examined this question (§ 424).

2d. The relations of the layers to each other. The mucous membranes differ from the external cutaneous system, as we cannot, in all parts, insulate the layers which constitute them.

In fact, these layers are so intimately united in almost every part of the internal cutaneous system, that ordinary means have in vain been employed to demonstrate them. Of this we have proofs in the mucous of membranes of the urinary apparatus, of the genital organs, and of most the intestinal canal, where blisters during life, and maceration after death, will not prove the existence of an epidermis, or more especially of several superimposed layers. On the contrary, the epidermis may be insulated in the mouth and the esophagus; it is also more or less perceptible on the surface of the glans, in the meatus auditorius, in short, as before stated (§ 384), in most of those places where the internal cutaneous system is continuous with the external. It is however softer, more brittle, and detached with greater difficulty in a certain extent, than that of the skin, although in several parts, for instance in the tongue, its thickness exceeds that of the epidermis which covers most of the external regions of the body.

It is very doubtful if the epidermis exists in those places where we cannot by any means insulate it; and although Haller, Bichat, and other physiologists, think its existence is proved by the appearance of membranes having the form of the canals from which they are expelled; still the form of these membranes may be well explained in several other ways. In fact,

a. It is possible that these may be new formations produced by the inflammation of the mucous membranes; which is more probable because they appear when the organs are inflamed, and abnormal membranous expansions are not only developed very often on the surface of inflamed serous membranes, but also an expansion of this kind, the caducal membrane, is normally produced, in the uterus, either by coïtus followed by impregnation or by a morbid state without coïtus.

b. The expelled membrane also may be itself a mucous membrane separated from its connections by gangrene, since we see the skin and other organs detached in their whole thickness from the same cause.

The existence of the epidermis as a distinct layer is not proved by the thickening, the hardening, and the dryness which the mucous membranes experience when they have been often irritated, or exposed for a time to the action of the external air. Finally, it is not demonstrated by the facility with which the mucous membranes support these unusual relations with external objects ; for all we can conclude from this is, that the mucous membranes have on their free surfaces a tissue analogous to the epidermis.

We discover also fewer traces of a distinct rete mucosum, at least unless we consider as such a whitish fluid found between the epidermis of the tongue and its papillæ.

The dermis of the mucous membranes offers as many differences ; and as they are formed in most of their extent of only a single layer, we must refer almost exclusively to this layer the principal variations they present, and which still remain for us to examine.

3d. The thickness. It varies much. The dermis of the urinary organs, of the respiratory organs, and of the genital organs, is usually very thin ; that of the intestinal canal and of the stomach is thicker ; that of the esophagus still thicker, but always less so than that of several parts of the mouth, as the palate and the gums. The dermis of the mucous membrane of the nose has also considerable thickness.

4th. The development of the capillary tissue. We may justly compare, as Bichat has done, the villosities (*villi*) of the mucous membranes to the papillæ of touch (§ 394). Like the latter, they are composed of cellular tissue, in the substance and on the surface of which blood-vessels and lymphatics are certainly distributed, and which probably receives nerves also, although we are not certain that the latter exist every where. The vessels are demonstrated by injections : this cannot be doubted when the injected parts are examined with a microscope. The nerves are seen distinctly in some parts, as in the tongue ; but farther, for instance in the intestinal canal, microscopical observations made with the most scrupulous care demonstrate only a simple granular structure in the villosities. We have not been able to observe openings in them with certainty.

The size and development of the papillæ of the mucous membranes are not everywhere the same. In several parts, as in the tongue and the small intestine, these papillæ are more developed than elsewhere, and are visible without any preparation, for instance without raising the epidermis, as is necessary in the skin. In the lips and penis they are considerable, but in those parts the epidermis covers them. Every where else they are extremely small and even imperceptible.

We particularly remark that the degree of their development is in direct relation with the wants and functions of the organs, for their volume increases in all those parts where a great increase of surface is necessary.

5th. The glands of the mucous membranes are much more developed than those of the common integuments. They always represent culs-de-sac, and are more distinct in some parts, as around the mouth, than in others, especially in most of the extent of the mucous membranes, where they exist as simple depressions. Their special properties will be mentioned when treating of the glands. We shall only observe in this place that their number and volume are inversely as those of the villosities; of this we may be convinced by comparing the membrane of the palate and tongue with that of the small and large intestines.

6th. The continual moisture on the internal and free surface of the mucous membranes depends on the mucous glands, on the peculiar activity of the vessels of the mucous membranes, and on their slight exposure to the drying action of the air. The fluid secreted by these glands and called *mucus*, varies in the different parts, although its essential properties are every where the same:(1) it is insoluble in water but absorbs much of it; it coagulates neither by heat nor cold, and when dried becomes transparent.

7th. The color of the mucous membranes is not every where the same; usually they are light red.

8th. These membranes are considerably softer than the external skin.

9th. They are also more vascular.

But they resemble more or less the common integuments in all these relations when placed in the same circumstances, especially in the inversion and the prolapsus of parts which they cover.

§ 427. Have the mucous membranes appendages similar to the nails and the hairs of the external cutaneous system? We discover in them parts perfectly corresponding to these appendages, only in the abnormal state, and even then only hairs (§ 422): but we may consider the teeth as organs having many relations with them. Bonn(2) pointed out this resemblance, which has since been better developed by Walther(3) and by Lavagna,(4) and many facts might be adduced in its support; but we shall consider this important question in descriptive anatomy when treating of the teeth.

(1) Fourcroy and Vauquelin, in *Annales du Muséum*, vol. xii. p. 61, 67.—Berzelius, *On the mucus of mucous membranes, in, General Views of the properties of animal fluids*, in the *Med. chir. trans.*, vol. iii. p. 245–247.

(2) *De contin. membr.*, § xvi., in Sandifort, *loc. cit.*, p. 276. *An ergo membranula hæc folliculum constituens, cutis oris propago est, per foramenula limbi producta? An testula, quæ dêin crusta vitrea vocatur continuatio ejus epidermidis, et naturæ unguium quodammodo, sed magis induratæ?*

(3) *Physiologie*, vol. i. p. 174, 175.

(4) *Esperienze e rifiessioni sopra la carie de' denti umani coll' aggiunta di un nuovo saggio sulla riproduzzione de' denti negli animati rosicanti*, Genoa, 1812, p. 164–198.

B. OF THE INTERNAL CUTANEOUS SYSTEM IN THE ABNORMAL STATE.

§ 428. We are deficient in observations to enable us to decide, if the mucous membranes grow again after having been destroyed, or if, where they have appeared to be reproduced, there has been only a contraction and reunion of the sound parts.(1)

§ 429. The mucous membranes present many anomalies. Their deviations of formation, especially the primitive, coincide almost always with analogous states of the whole organ, the internal face of which they line: such are, fissures, prolongations in form of sacs, contractions, inversions, &c. In these different cases all the layers vary in the same manner from the normal state.

In fact in other circumstances the upper layers also present simultaneous anomalies: but these are of a different nature. Thus when the mucous membranes are considerably distended by their passage as hernias through the muscular coat, and which are known, particularly in the intestinal canal and the bladder, by the term *diverticulum spurium*, the fibres of the muscular tunic are separated from each other.

We however observe abnormal processes which belong only to the mucous membranes, independently of the other layers.

§ 430. These last anomalies form the transition from deviations of formation to changes of texture, since they are sometimes simple prolongations, such as the valves in the intestinal canal, but much more frequently excrescences, new formations, the texture of which differs more or less from that of the normal mucous membranes. We may remark, generally, that they are seen rather more frequently at the extremities of the internal cutaneous system, near its union with the external, in the nasal fossæ, the buccal cavity, the pharynx, the rectum, the uterus, and the vagina. They are not however more common, the nearer they are to the limits of the external cutaneous system; they are, on the contrary, almost always a little distant from these limits, so that for instance the excrescences of the nasal fossæ are developed more frequently in the maxillary sinus, those of the buccal cavity in the back part of the mouth, those of the urinary apparatus in the bladder, those of the female genital system in the uterus or in the vagina, and we are unable to tell to what this peculiarity must be ascribed.

The excrescences spoken of are termed *polypi*. They are attached to the internal face of the mucous membranes by a long or short, broad or narrow peduncle, and are loose in their cavities. Their structure is not always the same. They are generally formed of a very homogeneous substance; sometimes however we see fibres perpendicular to the substance which supports them. They vary also in consistence, being sometimes hard, sometimes soft and mucous. They sometimes receive a great many very irregular vessels which form

(1) Thomson, *Lectures on inflammation*, Edinburgh, 1813, p. 421, 422.

large sinuses and have no proper parietes, but in others, vessels cannot be distinguished. Sometimes they are very inconvenient from their size and from the compression which they exercise. Sometimes they injure the health by frequent hemorrhages from their surfaces or from their ruptured vessels. Sometimes they inflame and suppurate. The place where they are developed usually shows a great tendency to reproduce them when they have been extirpated.

Schirrus and cancer are also peculiar to the mucous membranes and to the glandular system; they may be considered as resulting from the development of these membranes. These abnormal productions appear in some parts more frequently than in others, and are generally seen in those where polypi are developed. The parts, however, most frequently affected, are the female genital organs and the rectum; they also are often developed in some other points, more particularly where polypi rarely grow, as in the pyloric orifice of the stomach.

This disease is unquestionably situated in the mucous crypts, and arises from the frequent irritation of the parts in which it is developed. It often contracts the cavity of the organ, because of the considerable thickening usually resulting from it.

It is rare that the mucous membranes ossify, or that osseous matter is deposited on their posterior face; but round, fatty tumors are often developed in several places, among others in the esophagus and the small intestine: Monro(1) and Vicq d'Azyr(2) have denied the existence of these bodies, but wrongly: although other tumors, entirely different in character, may possibly have been confounded with them.

The general condition of all these anomalies is the increase of the formative power, *inflammation*, which however often attacks the mucous membranes without giving place to them.(3) One of the most

(1) *Encylc. méth. anat. pathol.*, p. 343.

(2) *Morbid anat. of the human gullet*, Edinburgh, 1815, p. 196.

(3) As the mucous membranes were not considered in a general manner before the time of Pinel and Bichat, we seek in vain in the writings of previous authors for general views of diseases of this system; but if we reflect that, properly speaking, they form the lungs, the stomach, the intestines, and the appendages of these viscera, we have only to study what has been written on the morbid affections of the latter to have a knowledge of their diseases. The works of Bonnet and of Morgagni contain many valuable facts upon the pathological anatomy of the mucous membranes. Pinel arranges among the inflammations of these membranes all the catarrhal affections of the ancients; or rather he has admitted as inflammations of these organs only the catarrhs (*flux sereux, muqueux*, &c.) of his predecessors. No one however had treated particularly of the subject when P. A. Prost published his *Médecine éclairée par l'observation et l'ouverture des corps*, (Paris, 1804, 2 vol. in 8vo.) He there establishes from a great many facts the following propositions: irritation of the mucous membrane of the intestines extends to the animal centre without pain: the excitement, the agitation, the derangement of its functions are relative to the susceptibility of these organs, to the causes which irritate them, to the natural disposition, and to the sensibility of the individual. The alterations of these viscera have more influence on the brain in proportion as their arteries are more developed, the red blood more abundant in their extent, and the means of irritation more active. The pains of the abdomen depend on the state of inflammation of the peritoneum and of the surrounding cellular tissue. Inflammation of the mucous membrane of the intestines, when very active, frequently extends to the peritoneal coat, but the latter may be inflamed, although the mucous coat is healthy. The prostration of the ani-

usual consequents of this inflammation, especially when it has continued a long time, is the thickening of this membrane. Ulcers are not unfrequently developed there; but the mucous membranes can suppurate without ulceration, doubtless on account of the great analogy which exists between their natural secretion and pus. The unattached surface of the inflamed mucous membranes often secretes a greater or less quantity of coagulable substance which gives rise to solid or hollow cylinders. This is seen for instance in croup, (*angina membranacea* s. *polyposa.*) The parietes of the mucous membranes very seldom adhere after exsudations of this matter, but they often unite after ulcers, especially in those places where union is not impeded by motion and the continual passage of foreign substances.

mal centre results from the absence of red blood from the intestinal mucous surface, whether there be alteration and thickening, hardness, fungosity, infiltration, ulceration of this membrane, or even if these affections do not exist. Finally, alterations of the intestines with or without inflammation, are in relation with the last symptoms of the animal functions preceding death. Prost could not but deduce from these general facts a medical theory very different from that taught before his time; but he did not draw from his observations definite conclusions: confined as he was by the despotism of classifications, he made only an indecisive application of them to pathology.

Broussais has gone still farther. After censuring the exaggerations of Prost he concludes by attributing all essential fevers to the inflammation of the mucous membranes, especially those of the stomach. Inflammatory, gastric, bilious, mucous, adynamic, ataxic, and typhoid symptoms result, in his opinion, directly or sympathetically, from this inflammation: no inflammation of any organ whatever can give rise to the symptoms of simple acceleration of the circulation, unless the mucous membranes of the stomach are more or less affected. He ascribes to the acute, chronic, latent, obscure inflammation of these membranes, a host of diseases, as the exanthemata, gout, rheumatism, vesanies. The danger of most acute or chronic diseases arises principally from the inflammation of the mucous membranes which the physician should foresee, prevent, and combat; finally it is the most frequent and gravest disease, that which affects the rest of the organization in the greatest degree, and a profound knowledge of which is the key to pathology. Broussais has also given a fine history of the inflammation of the pulmonary and gastro-intestinal mucous membranes, and important ideas upon the inflammation of the other mucous membranes. He thinks that all the alterations of texture of which they are susceptible depend on acute or chronic inflammation. However exaggerated these ideas of inflammation of the membranes may be, it is no less true that they are erroneous only in being too general, and that Broussais has supplied a great deficiency in pathology, in pathological anatomy. His opinions and their varieties may be found in the *Histoire des phlegmasies, ou inflammations chroniques*, Paris, 1808, 2 vol. in 8vo.; *id.* 1816, 2 vol. in 8vo.; *id.* 1821, 3 vol. in 8vo., in his *Examen des doctrines médicales généralement adoptées*, Paris, 1821, 2 vol. in 8vo., and in his *Annales de la médecine physiologique*, Paris, 1822. Boisseau endeavored in 1817 to prove that gastritis did not constitute all essential fevers, and that inflammations of the mucous system were not the only ones which produced fevers. See his *Réflexions sur la nouvelle doctrine médicale*, in the *Journal universel des sciences médicales*, vol. vii. p. 1, and vol. viii. p. 257; his article, *Fièvre* in the *Dictionnaire abrégé des sciences médicales;* his *Pyrétologie physiologique*, Paris, 1823, in 8vo.; *id.* 1824, in 8vo.—See also Roche, *Réfutation des objections faites à la nouvelle doctrine des fievros*, Paris, 1822, in 8vo.—Bégin, *Physiologie pathologique*, Paris, 1821, in 8vo.—J. Cloquet *Mémoires sur les ulcérations des intestins*, in *Nouveau journal de médecine*, vol. i. p. 107.—Scoutetten, (*De l'anatomie pathologique en général, et de celle de l'appareil digestif en particulier*, Paris, 1822, in 4to.), and Andral, (*Médecine clinique*, Paris, 1823, in 8vo.), have carefully described marks of inflammation of the mucous tissue.—Goupil, *Exposition des principes de la nouvelle doctrine médicale, avec un Précis de thèses soutenues sur ses différentes parties*, Paris, 1824, in 8vo. F. T.

§ 431. Do the mucous membranes assist in forming the exanthemata so common in the external cutaneous system, and which appear under such various forms ?(1)

Perhaps upon no question in pathology are there so many different opinions.

Exanthematous diseases doubtless form in the external portion of the mucous membranes near the places where they are continuous with the external cutaneous system when the latter is itself affected. Besides, these membranes frequently inflame with eruptive diseases of the skin. But do the exanthemata assume there the same form as in the common integuments ? The great difference in the texture of the two parts authorizes us to think, that the cutaneous exanthema differs much from that of the mucous membranes, and experience teaches, that in many exanthematous diseases, for instance in small pox, all the mucous membranes are often acutely inflamed, but no pustules are found in them, although they cover the skin. Some observations however, as those of Wrisberg(2) and Blane,(3) establish incontestably, contrary to the opinions of the most celebrated physicians, that, when the variolous pustules exist in the skin, they sometimes form also in the mucous membranes, especially those of the air-passages and alimentary canal, and differ but little from those on the surface of the common integuments.

§ 432. The mucous membranes are not unfrequently developed abnormally ; usually, however, after inflammation when it has terminated by suppuration. We think that every suppurating surface may be compared to an imperfect mucous membrane.

After inflammation, the cellular tissue, imbibing the coagulable part of the blood which has infiltrated into its texture, changes into a soft and whitish membrane, which soon acquires the power of secreting a peculiar fluid, called *pus ;* so analogous to mucus that we cannot distinguish them by our reagents. This membrane is intimately united to the subjacent cellular tissue and soon receives numerous vessels. Its surface, which is at first smooth becomes uneven, and numerous small tubercles, formed of vessels and cellular tissue, arise ; these are called *granulations :* in this state pus is continually secreted, until the number of its vessels diminishes, the granulations waste, and in their place is developed a substance which resembles more or less the natural membrane which previously existed. The mucous membranes then suppurate more readily than all other parts ; and what is more remarkable, they have the power of forming pus, although there is no previous destruction of their tissue and the formation of a new one—indispensable conditions in other organs. The same perhaps is true of the serous membranes : but they then resemble the mucous membranes very much, as is shown by their thickening, softening, the increased number of vessels in their substance, and their consequent redness.

(1) Scoutetten, *loc. cit.*—Andral, *loc. cit.*

(2) *Sylloge comment.*, p. 52.

(3) *Trans. for impr. of med. and surg. knowl.*, vol. iii., London, 1812, no. 31, p. 425, 427.

The accidental cysts are often similar to the mucous membranes, both in regard to their structure and the nature of the fluid which they contain; and Bichat has gone too far in referring them all to the class of serous membranes. We have found more than once, in the ovaries and in the uterus, large and small cysts which resemble the mucous much more than the serous membranes. We believe also there is an exact relation between their structure and the nature of the fluid contained by them, for we have recognized that the cysts filled with serum resemble much the serous membranes, while others filled with thicker mucilaginous or purulent matter are more similar to the mucous membranes.

The purulent cysts, which are connected with the surrounding cellular tissue less intimately than are ordinary abscesses, naturally lead to the latter.

SECTION XI.

OF THE GLANDULAR SYSTEM.

ARTICLE FIRST.

OF THE GLANDULAR SYSTEM IN THE NORMAL STATE.

§ 433. It is very difficult to give a satisfactory definition of the organs which constitute the glandular system.(1) They are usually too extensive, too narrow, or false. The difficulty arises especially from the great difference between the organs known as *glands*. If we should conform to custom and give to the definition all the extent of which it is susceptible, we should say that the glands are organs which secrete from their immediate materials and from their proper substance a fluid different from the blood, a liquid, which, in its relations with the functions of an organ, has nothing mechanical, and which acts, in a part different from that in which it arose; that their forms are more or less rounded; that a considerable number of blood-vessels and of lymphatics enter into their composition with a peculiar substance and nerves, and finally that they are surrounded with one or more envelops, and are imbedded in a loose mucous tissue.

By this definition we exclude from the glandular system the serous system, which resembles it in the fluid which its tissue also exhales. But

(1) Warton, *Adenographia*, London, 1656.—Malpighi, *De viscerum structurâ*, in *Opp. omnia, et seors. ed.*, Amsterdam, 1669.—Idem, *De structurâ glandularum conglobatarum consimiliumque partium*, in *Opp. posth.*—Lossius, *Disq. de glandulis in genere*, Wittenberg, 1683.—Nuck, *Adenographia curiosa*, Leyden, 1691.—C. Mylius, *De glandulis*, Leyden, 1698.—L. Terraneus, *De glandulis universim et speciatim ad urethram virilem*, Leyden, 1729.—*Opuscula anat. de fabricâ glandularum in corpore humano continens binas epistolas, quarum prior est Boerhaavii super hac re ad Ruyschium, altera Ruyschii ad Boerhaavium qua priori respondetur*, Amsterdam, 1733, in Ruysch, *Opp. omn.*—A. L. de Hugo, *Commentatio de glandulis in genere et speciatim de thymo*, Gottingen, 1746.—Bordeu, *Recherches anat. sur la position des glandes et sur leur action*, Paris, 1751.—G. A. Haase, *De glandularum definitione*, Leipsic, 1806.

the serous system has a membranous form ; the liquid it furnishes has simply a mechanical relation with the organs, and acts only while it is inclosed in the cavity of the serous membranes.

This definition also excludes from the glandular system the stomach and the alimentary canal, for, although they secrete fluids which differ from the blood, these fluids act within the organs which have produced them.

But on the other hand, it admits into the system, organs, which in its strictest sense should be excluded. Thus in adding that the fluids secreted by the glands escape by proper excretory ducts, we are obliged either to imitate Bichat, and to exclude the spleen, the thyroid gland, the thymus gland, the renal capsules and the lymphatic glands, or to adopt the hypothesis of Haase, and to assign to these organs excretory canals which have not been demonstrated and probably do not exist.

Besides, this addition is entirely useless, for it matters little to the function of the gland, whether the fluid formed in it escapes by a proper excretory duct, or is taken up by the lymphatic vessels. The above definition prevents us from considering the glands as appendages of the internal cutaneous system,(1) although they are usually continuous with it by the ramifications which this system sends into their substance. It embraces almost all the parts termed *viscera*, and in fact it is incorrect to apply it only to certain glands, and to exclude others(2) which present all the characters included in the strictest sense of the definition, since there is no essential difference between the glands and most of the viscera, as Malpighi(3) has perfectly shown, contrary to the opinion of Wharton.(4)

§ 434. According to this definition the glandular system comprises,

1st. The *mucous glands.*

2d. The *sebaceous glands.*

3d. The *liver*, the *salivary glands*, the *amygdalæ*, the *testicles*, the *ovaries*, the *prostate gland*, *Cowper's glands*, the *kidneys.*

4th. The *lymphatic glands*, the *thyroid gland*, the *mammary glands*, the *thymus gland*, the *spleen*, and the *renal capsules.*

§ 435. The most essential general characters of the glands are:

1st. The glands have cavities in their substance in which the liquid they secrete is deposited. They are then more or less apparently hollow organs.

2d. Their form is not generally the same in every part: they are usually round, and those which appear smooth and angular in the later periods of life are rounded in the early stages of existence.

(1) According to Wilbrand, *Vom Hautsystem*, p. 36.

(2) As Haase has done: he includes in the glandular system only the lachrymal glands, the salivary glands, the thyroid gland, the thymus gland, Cowper's glands, and the renal capsules.

(3) *De hepate*, c. iv.

(4) *Adenog.*, c. v.

3d. They also differ from each other in several respects in respect to number.

a. Some are single, others are numerous. Among the former are, the liver, the kidneys, the testicles, the ovaries, the prostate gland, the lachrymal glands. On the contrary, the mucous glands are disposed in the whole course of the mucous membranes. The salivary glands make the transition from the first to the second.

b. The insulated glands are sometimes single, as the liver, the thyroid gland, and the prostate gland; sometimes double, as the kidneys, the testicles, the ovaries, and the lachrymal glands. The single glands differ in the greater or less degree of symmetry existing in their construction. The liver is the least symmetrical in situation and form; the prostate gland and the thyroid gland are more symmetrical: they are composed of a right and a left corresponding half, and are situated on the median line of the body. Nor are the double glands perfectly symmetrical. The renal capsules and the kidneys of the two sides do not resemble each other. There is more similarity between the testicles, the ovaries, and the salivary glands of the right and the left side.

4th. The glands have not a constant type of formation. The collections of mucous glands within the intestinal canal vary in almost every individual. The kidneys are sometimes united in various ways in one mass; they are sometimes very unequal in size, or uncommonly long, or situated lower than usual, &c. This difference in the formative type is not however equally great in all glands. The kidneys are doubtless those which vary the most in this respect. Next come the liver, the salivary glands, and the lachrymal glands. The formation is most constant in the glands which belong to the genital organs, at least in the larger glands, which form the essential parts of this apparatus.

5th. The glands receive a great many blood-vessels and lymphatic vessels. The vessels ramify infinitely and form small skeins. Thus the whole gland has more or less an arborescent form.

6th. The origin and the distribution of the vessels frequently vary. These variations depend partly on the situation and form of the glands. A kidney which is more oblong than usual receives a greater number of vessels which are proportionally smaller. When situated lower than usual, these vessels, present the same arrangement. These different circumstances however are frequently independent of each other. Thus when there is no change in the form of the kidneys, of the thyroid gland, and of the liver, the origins of the vessels often vary.

7th. The number of nerves which enter the glands is on the contrary small. They are derived either from the central system or from the great sympathetic nerve, but most frequently from the latter.

8th. The tissue and the peculiar substance differ in all the glands which do not belong exactly to the same class.

9th. The internal tissue of these organs, that in which secretion takes place, escapes all our means of investigation, because of the smallness of the objects. In regard to this subject opinions are divided between two hypotheses, that of Malpighi and that of Ruysch.

According to Malpighi, we find small membranous vesicles in the limit between the vessels which bring the blood and those which carry it, in the parietes of which the final ramifications of the vessels are distributed. According to Ruysch, on the contrary, these vesicles are only the undeveloped ramifications of the vessels, and the final terminations of the vessels are connected uninterruptedly with the roots of the excretory ducts.

But although we cannot deny that good injections and careful maceration demonstrate that the vesicles admitted by Malpighi are fine ramifications of the vessels, still the hypothesis of this anatomist is preferable to that of Ruysch. In fact there are no large vesicles in the place where Malpighi asserts their existence. But the system of excretory ducts very probably commences by a multitude of roots in cul-de-sac, which insinuate themselves between the finest ramifications of the vessels, and form with them the smallest granulations, even as the gland is generally composed of blood-vessels and of excretory vessels. Malpighi has already availed himself with great sagacity of the structure of the liver in the inferior animals and in the fetuses of the superior animals to support his opinion,(1) and we may add that the arrangement of the whole glandular system in these animals favors his theory, since all their glands are composed uniquely of simple or complex, more or less numerous, closed canals which float loosely in the nutritious fluid effused between the organs.

The least complex mucous glands, which are only simple sacs, furnish the original of the glandular formation. Let us suppose this sac to be extended, to ramify, and to spread its branches between those of the vessels, and we shall have a compound gland, without ever arriving at a direct communication of the blood-vessels with the excretory ducts.(2) This applies also to the imperfect glands, as within them we see also more or less apparent excavations which are filled with a secretory fluid. These cavities are however closed in all parts, and probably ramify less than in the perfect glands.

In this manner, the two hypotheses may be reconciled, for the objections of Ruysch apply only to the large vesicles.

10th. According to Luca, there is every where a striking analogy between the color of the secretion, and that of the substance of the gland.(3) If, however, we except the case where the color is derived from the fluid contained in the glands, this assertion is evidently un-

(1) *De viscer. struct.*, c. ii., and *Ep. de gl. conglob.*, p. 6.

(2) It follows from this highly philosophical opinion, which very much simplifies the theory of secretions, that the lungs themselves are real glands, even in the strict sense of the word, since the trachea serves as an excretory duct. Here however the secretion requires one more condition than the other glands, the presence of the external air in the excretory duct. This view, if adopted, will modify the theory of respiration and will overturn the gratuitous hypotheses on which it has hitherto been vainly attempted to place it. F. T.

(3) *Untersuchung der Thymus*, Erfurt, 1811, p. 39, 1812, p. 28.

founded; for we discover not the least analogy between the color of the salivary glands and that of the saliva, between that of the liver and the bile, between that of the kidneys and of the urine, that of the testicles and of the semen.

11th. The glands are always imbedded in a loose and abundant mucous tissue; and most of them are also covered with one, and sometimes with several special membranous capsules.

12th. They accumulate principally towards the internal parts.

13th. They are fragile, and slightly elastic. They experience no transient change in volume, although they often increase and diminish. In the normal state, their sensibility is, generally speaking, very slight; there are, however, some exceptions, as the testicles.

14th. Their functions are always highly important. They form the principal parts of the apparatus with which they are connected, and the uses of the other parts of this apparatus are purely mechanical.

§ 436. The whole glandular system may be divided into the *perfect* and the *imperfect* glands. To the former belong those provided with an excretory canal; the latter comprises those in which the canals are replaced by the lymphatic vessels. The first division includes the mucous, the sebaceous, the salivary, and the lachrymal glands, the liver, the pancreas, the amygdalæ, the testicles, the ovaries, the prostate gland, the glands of Cowper, and the kidneys; the second, the mammary, the lymphatic, the thyroid, and the thymus glands, and the renal capsules.

I. OF THE PERFECT GLANDS.

§ 437. The *perfect glands* are always connected with the skin, or with a mucous membrane, and consequently with the cutaneous system, by the hollow appendages of this system, which penetrate within them. We divide them into three classes.

§ 438. 1st. To the first class belong the *simple glands* or *crypts*. (*Glandulæ simplices, cryptæ.*) They have the form of round, flattened, lenticular, hollow bursæ, or small, closed depressions, which do not open externally by a duct distinct from their substance, but only by an orifice situated upon some portion of their circumference. They are not composed of several lobes, but their texture is homogeneous; they are the smallest of all the glands. They line the posterior face of the mucous membranes, in great numbers. The first modification of their form, the lenticular, is much more common than that of a sac. These two kinds of simple glands, differ from each other in their form and texture; the parietes of the lenticular glands are thicker in proportion to their cavities than those in the form of sacs, the walls of which are very thin. The lenticular glands are found in all parts of the intestinal canal, in the respiratory system, and in most of the genital organs. We find the others only in the urethra. Their volume, number, and situation are not the same in all parts. Those which exist around the mouth, are the largest, and are generally more than a line in diameter.

Those of the small intestine are much smaller, and those of the large intestine a little larger. We find similar glands in the skin, but not in so many places; principally in the nose and also in the ear. The former are called *mucous glands* (*glandulæ mucosæ*); the latter, *sebaceous glands* (*glandulæ sebaceæ*). Here, too, are found the *Meibomian glands* (*glandulæ meibomianæ*), situated in the eyelids, on the borders of the external and the internal cutaneous system.

§ 439. 2d. Next come the *conglobate glands* (*glandulæ agglutinatæ*). They seem formed by the union of several small simple glands, and open externally by several orifices. Here belong the tonsils (*tonsillæ*), and the prostate gland (*prostata*). Their substance seems homogeneous, like that of the crypts. They are round, and have a smooth and uniform surface. Among them and the crypts, we find the glands of Peyer (*glandulæ Peyerianæ, agminatæ*); these are situated in the ileum, and consist of distinct collections of mucous glands, the thickness of which does not increase in proportion to the number of simple organs which unite to form them.

§ 440. 3d. The *conglomerate glands* (*glandulæ conglomeratæ*), are more or less evidently composed of several lobes, and are attached to the expansions of the skin, on the surface of which they open by canals of various lengths called *excretory ducts* (*ductus excretorii*), arising by numerous roots, like veins, and formed of two coats, the internal mucous coat, and an external, which is firmer, and not the same in every part. These glands have the most complex structure, and they seem too the most insulated. Many of them have considerable size, and are classed among the largest organs of the body; such are the liver and the kidneys.

§ 441. These glands differ from each other, in several respects. 1st. In regard to their structure: in this respect they may be divided into two classes. Some, as the salivary glands, the lachrymal glands, and the testicles, are composed of several distinct lobes, which are also divided into smaller lobules, and are connected only by a mucous tissue, which is more or less loose. These may be called the *lobate glands* (*glandulæ lobulosæ*).

Others, on the contrary, do not have this lobate structure, at least at all periods of life, but internally form a connected whole, the outer surface of which is uneven. The liver and kidneys belong particularly to this class. We find in this class what we do not in others, viz. a distinction into an external and an internal substance, which sometimes, as in the kidneys, are arranged in layers, so that the external covers all the surface of the gland; and sometimes, as in the liver, are of such a nature, that the external substance extends into all the gland, whence result numerous small sub-divisions, each formed of the two substances. We must however observe, that this difference does not exist at all periods of life; for the kidneys and the liver, the former longer than the latter, are at first composed of several lobes, which are gradually blended into a single mass.

These are the only glands which have a proper capsule, different from the mucous tissue, surrounding their substance in all parts, giving them a smooth, uniform surface, and separating them entirely from the other organs. We however observe also some differences among the glands which are provided with a capsule. Thus, the testicles and the ovaries have a double envelop, of which the external belongs to the class of serous membranes, while the internal, which is much stronger, is arranged among the fibrous organs. The liver has only a serous capsule, furnished by the peritoneum. The mode in which the kidneys are attached is between that of the testicles and the liver, for they are imbedded in a mass of mucous tissue, very analogous to the serous membranes, and their peculiar capsule allies them to the fibrous organs.

When perfectly developed, these latter glands are undoubtedly the most perfect of all. They seem the best fitted to constitute separate organs. They fulfill special functions, and in many parts of the body as for instance the different salivary glands, do not exist in pairs.

Finally, the texture of those glands which are most similar also varies, and each gland has peculiar characters. Thus, the salivary glands, independent of their volume, have lobes of various sizes, with a firmer or softer tissue. In most glands of this class, we cannot easily recognize at first view, that they are formed of blood vessels and carrying vessels, and we are obliged to destroy a portion of their substance by maceration, and then the structure appears. In the testicles, these canals are entirely naked, and they are observed immediately after the external envelop is raised. In almost all, there are several short and arborescent vessels. These are fewer in the testicle, but they are extremely long, tortuous, and convoluted.

2d. The arrangement of their excretory ducts differs in several respects:

α. In number: Some glands, as the liver, the kidneys, and several of the salivary glands, have only one excretory duct, formed by the union of the excretory ducts from the different lobes. Others, on the contrary, as the lachrymal, the sub-maxillary, and the mammary glands, have several, which open at the side of each other. In both cases, the cavities of the excretory ducts do not communicate together, and the lobes of the glands are entirely separate. This difference is not, however, constant, for sometimes in the place of one duct we see several, which are formed, not by the union of some branches which remained insulated, as in the liver and kidneys, particularly the latter; while in other cases, which are more rare and more difficult to demonstrate, the number of these same canals is diminished. The transition from unity to multiplicity is by gradations. In many glands, as the salivary, the excretory duct comes already formed and single from the glandular substance; in others, as the liver and the kidneys, two or three large trunks emerge, and do not unite in one, except externally; finally, in the testicle, the gland furnishes numerous ducts which do not unite, for some distance, in one canal. To these glands are allied the lachrymal and the mammary glands.

β. In the relation of length. The length has no relation with the volume, but with the situation of the gland, and with the distance which separates it from the place where the secreted fluid is emptied. The testicle, which is so small in volume, has an excretory duct of enormous length; while that of the liver, which is much larger, is very much shorter.

γ. In the relation of breadth. Generally, but not always, their breadth is in direct ratio with the volume of the gland; hence, why we not unfrequently see them enlarged, in proportion as the gland enlarges. The lactiferous vessels, scarcely visible except at the time of lactation, become several lines broad during this period. This arrangement, however, does not occur strictly in every part; thus, the excretory canal of the liver is even positively smaller than that of the kidney. Again, the increase in size of the gland does not necessarily imply an enlargement of the excretory ducts, and hence it must depend on an increase in the secreting power of the organ; thus the liver, the prostate gland, the kidneys, &c., often acquire an enormous size, while there is no enlargement of their excretory canals.

δ. In regard to its degree of complexity. Most of the excretory ducts arise by roots, which gradually unite in a single trunk, and proceed without any remarkable change in their structure and dimensions to the place where they open, following a direction more or less straight, so that they carry the fluid secreted by the gland immediately to its destination. This takes place in the excretory ducts of the mammary, salivary, and lachrymal glands. Those of some other glands, on the contrary, are changed into a large reservoir, within which the secreted fluid remains and is modified before it is expelled. This arrangement is seen in the excretory canals of the liver, of the testicle, and of the kidney. These reservoirs, called bladders or vesicles (*vesicæ*), from their proportional size, are usually found nearer the external than the internal extremity of the excretory ducts, and are connected with it by a more or less narrow portion, which varies in length, and sometimes constitutes a peculiar canal, to which a special name is given, as happens to the gall-bladder, and sometimes presents itself only as a contraction of the bladder, and is called its *neck*. These bladders are designed either to mature the fluid within them, particularly to concentrate it by absolving its aqueous parts, or to keep it in reserve, to prevent its continual dribbling. The biliary and seminal vesicles fulfill the first intention, while the bladder performs the second. The arrangement of the parietes of the reservoirs is not the same in both cases: in the first, the mucous membrane is folded, so as to increase its surface; there are no folds in the second, but, on the contrary, a muscular coat, which we do not find in the first, is developed, to expel the accumulated liquid. The excretory ducts of some glands, particularly those of the kidney, are arranged very differently from what is usually seen; in the kidney, in fact, their branches do not unite gradually in trunks, but open into a common reservoir, the *pelvis*, which afterwards contracts, to give origin to a common excretory duct, the ureter. However, when closely regarded, this difference is since found to be more apparent than real; the excretory ducts which open into the pelvis by distinct orifices arise from the anastomoses of smaller branches, and the pelvis is, in fact, formed by their union. The difference depends only on the size and proportional bigness of the common trunk and its branches, since the smaller twigs dilate suddenly into a large trunk, instead of forming branches, which gradually in volume increase.

ε. In their direction. Most of the excretory ducts proceed in almost straight lines; those of the testicle are, on the contrary, very tortuous, both within and without the gland.

ζ. In regard to the mode in which they open externally. Sometimes the place where they open is not distinguished from the rest of the surface, except in the orifice of the duct; sometimes we observe a depression; finally, sometimes the extremity of the duct projects more or less, like a wart. The first arrangement is seen in the orifices of the ducts of the parotid and of the lachrymal glands; the second in those of the liver and pancreas; and the third in those of the mammary and sub-maxillary glands.

η. In relation to their internal structure. We have already said, that the most essential tunic of the excretory ducts is a mucous membrane. This membrane presents numerous differences, which seemingly depend principally on the nature of the liquid which passes through these canals. In the excretory ducts of the salivary glands it is smooth, and destitute of mucous follicles, which are found in great number in the biliary ducts, the gall bladder, the bladder, and the urethra. To this membrane succeeds one more external, which is more solid; this is not very thick; it is formed of cellular tissue, and is somewhat extensible, while in the vasa deferentia it is extremely thick, hard, solid, and but slightly extensible. In some parts of the body, the excretory ducts also present a peculiar structure, which admits of uses which are also special. Thus there is developed around the mucous membrane of the urethra a very complicated venous network which is surrounded by a fibrous membrane, by means of which, when the blood remains in it, the penis acquires the stiffness necessary to its introduction into the vagina.

θ. In regard to their continuity. The excretory ducts are generally blended with the substance of the gland, the secretion of which they carry. But this is not true in regard to those of the ovaries; the fallopian tubes are, in fact, in the normal state, separated from their glands; they open by a large orifice into the abdominal cavity, and are adjusted to the ovaries only in certain circumstances; but to speak properly, it begins in the ovary, as the vesicle of Graaf. This vesicle is entirely closed in virgins, and consequently terminates in cul-de-sac towards the tube; it does not open until after coition followed by impregnation; the tube then applies its loose extremity upon the ovary, to receive the fluid secreted within it; and the relations between the two organs at this moment are similar to those of all the glands:

to what they are, very probably, during the first periods of fetal existence.

§ 442. The arrangement of the vessels is not the same in all the glands. The differences they offer in this respect, relate,

1st. *To the kind of vessels, and consequently, to the nature of the blood.* All the glands receive blood by the arteries, and it is carried away by the veins; but the liver receives, in addition, a larger quantity of venous blood from the vena-porta, the arterial portion of which is distributed in its substance; the liver is composed, then, of a quadruple, and not of a triple tree, like the other glands. We are still ignorant, and it is difficult to determine, (and besides it does not belong to general anatomy,) whether the blood of the vena-porta serves for the secretion of bile, or if that of the hepatic artery alone furnishes its materials; or, finally, if the two do not equally contribute.

2d. *To the volume and to the number of the vessels.* Some glands do not receive as much blood as others; the liver, the kidneys, the salivary and the mucous glands, receive vessels much larger, in proportion, than those of the testicles, the ovaries, and the prostate gland. This difference depends evidently on the less secreting power possessed by these latter glands. Although the vessels which go to the liver and the kidneys are not proportionally larger, they receive more blood than the salivary and the lachrymal glands; a difference which is probably owing to the same cause, and also, perhaps, depends (especially in the liver) on the peculiar character of the secreted fluid, which does not resemble blood in any respect.

3d. *To the manner in which the vessels go to the gland.* In general they are short, as the arteries of the liver, of the kidneys, and of the salivary glands. Those of the testicles and the ovaries are, on the contrary, long; these vessels generally go in straight lines; they enter some glands by several points of their surface. This arrangement is seen in all those which have no special envelope, distinct from cellular tissue; thus they are found in the lobate glands, the salivary, the lachrymal, and the mammary glands. Others which are enveloped in a proper membrane always admit the vessels by a point of their surfaces, where a small depression or fissure (*hilus*) appears. The vessels divide into a greater or less number of branches before disappearing.

4th. *To the relation between the different kinds of vessels.* The veins are not generally as large and numerous in proportion to the arteries as in those organs which do not secrete.

There is a great similarity between the arrangement of the different kinds of vessels, both within and without the gland. In several of these organs they enter and emerge at the same point. Thus the arteries, the veins, and the excretory ducts are found in the same place in the kidneys, the testicles, and the lungs. In other glands this arrangement applies only to one order of vessels. Thus the blood enters the liver by the same point as that where the bile comes out, and emerges at a point entirely different. In the salivary glands the blood-vessels proceed together, but the direction of the excretory ducts is different. However, the different vessels accompany each other within the gland to which they unite and give rise. The agreement beween them is often expressed also by the similitude of their anomalies; the renal arteries, the renal veins, and the ureters often but not always correspond in this respect. The excretory ducts generally have a type of formation more constant than that of the blood-vessels: the ureter and the hepatic duct seldom present anomalies, while they are frequently seen in the blood-vessels, particularly the arteries.

II. OF THE IMPERFECT GLANDS.

§ 443. The *imperfect glands* (§ 436) have with the lymphatic system a relation similar to that which exists between the perfect glands and the cutaneous system, since they are attached to it by very numerous and large lymphatics. Perhaps also their functions relate to the perfection of the nutritious fluid. There is no doubt of this in regard to the lymphatic glands, and it is highly probable of the others from their position and their large number of lymphatic vessels. Besides all are situated near the thoracic canal, the renal capsules at its lower part, the thyroid gland and the thymus gland at its upper part, so that the fluid prepared by them only pass through a short space to go to be united to that which it contains already. We may then compare the lymphatic glands to the simple glands which exist in all of the internal cutaneous system, as also to the salivary glands, and the others to the proper and perfect glands of the different systems, to the liver, the testicles, the ovaries, the mammary glands, and the kidneys.

§ 444. The most remarkable periodical differences of the glands relate,

1st. *To their size.* The glandular system is generally more developed in the early periods of life. At this time all the glands receive more blood and are proportionally larger. But all do not present a similar proportion in this respect. Some, especially the liver, the thymus gland, and the renal capsules, are proportionally much larger at the early periods of life than at any other epoch.

2d. *To the duration of their existence.* All the glands are not alike in this respect. Most of them remain during life. However, this is not the case with the thymus gland, of which there is normally no trace in the twelfth year. Some lymphatic glands also disappear, while others are developed. We rarely see analogous phenomena in the renal capsulse, the testicles, and the ovaries.

3d. *To their structure.* This is not the same in all periods of life. Those glands which are at a future period to form one mass, as the liver and the kidneys, are at first composed of a large or small number of lobes which gradually unite.

4th. *To their situation.* This also varies, and depends partly on a difference in size. Thus the left lobe of the liver, which is the larger, occupies at first the whole left hypocondrium, where afterward it does not even reach. We however observe also in this respect differences which do not depend on size. Thus the testicles exist at first in the abdominal cavity, which they afterwards leave and come to the surface of the body: the ovaries also in the early periods of life are situated much higher than in the grown female.

ARTICLE SECOND.

OF THE GLANDULAR SYSTEM IN THE ABNORMAL STATE.

§ 445. The glandular substance is never reproduced when destroyed.

§ 446. The glands present many anomalies. Primitive deviations of formation are not unfrequent, because they belong to the class of organs of vegetative life. The nature of these deviations depends on their normal form.

Deviations in *quantity* may be stated as follows:

1st. Their total or partial deficiency. The partial defect is principally seen in the glands, which exist in pairs, as the kidneys and the testicles, when one of these synonymous organs does not exist. In some cases this deviation depends on certain conditions. Thus the renal capsules sometimes do not exist when there is anencephalia. The glands of the sexual organs are those in which defects are most common.

2d. *Their smallness.* This is more rare, but all the glands present instances of it. Some are more particularly subject to it than others. In the same circumstances where the renal capsules are sometimes entirely deficient, it is more common to find them smaller than usual. This abnormal formation appears most frequently in the glands of the genital organs, although they may be formed very regularly in other respects.

3d. Allied to these two states is the lobate structure, observed in several glands, which consists essentially in an imperfect development, since it is one of their normal characters during the early periods of life.

4th. *Increase in number.* This generally is only apparent, and arises from the subdivision of a part, which, in the normal state, is single.

5th. An excess in size. This is rarely congenital; sometimes however the liver and the thyroid gland are much larger than usual at birth. We may also class here the abnormal continuance of this high degree of development from birth. The liver and the thymus gland particularly furnish examples of this in certain cases.

Deviations in respect to *quality* are,

1st. The division of a simple gland into several: as is seen particularly in the spleen, more rarely in the thymus, and in the thyroid gland, the kidneys, and the liver.

2d. The abnormal union. This exists to a small or great extent, and the kidneys furnish examples of it.

3d. *Abnormal position.* Some glands from various causes present, in this respect, more numerous and considerable differences than others. The kidneys, the testicles, and the liver vary more than all the other glands in regard to situation.

The kind of anomaly in situation is not the same in all glands. The kidneys are placed too low, the testicles too high, the liver without the cavity of the abdomen, &c.

The asymmetrical glands are subject to inversion: thus we sometimes find the spleen on the right, and the liver on the left side.

§ 447. The accidental deviations of formation which may supervene at all periods of life occur in the same respects as the congenital.

1st. The glands not unfrequently waste or grow smaller, as happens to the liver, the spleen, the testicles, and the renal capsules. But in this case the texture is more or less evidently changed.

2d. The glands increase much more frequently in volume, either primitively or because other organs become inactive.

In this case also the texture is often but not always modified to a greater or less degree: when slight, it consists in an alteration of color, and an increase, more rarely a diminution, in consistenee. In a still greater degree, the increase depends upon the effusion of the serum and the fibrin of the blood. In a still higher degree new abnormal formations of different kinds are developed. Increase in volume however is sometimes pure and simple. This occurs particularly when a synonymous organ, for instance the kidney, executes the function of its congenital when the latter has been destroyed. The spleen often enlarges after intermittent fevers, although it is not changed in other respects. This phenomenon is rare in other glands.

3d. Accidental displacements are rare, on account of the solidity of their attachments, which are not however very close. Still they are sometimes seen in hernias.

§ 448. Increase and diminution in cohesion make the transition from deviations of formation to alterations in texture. The glands are often too hard, too soft, with too loose a tissue and too easily torn. In many cases they present no other changes. When their tissue is too soft, they are subject to ruptures, of which the spleen and liver furnish instances.

§ 449. Alterations of texture in the glands are still more numerous, doubtless because their function is to produce a substance different from their own. These alterations usually consist, in the formation in the centre of the glands, of a peculiar solid substance which accumulates in their tissue while the secreted fluid is expelled outwardly in the normal state.

The following may be regarded as a series showing the degree of frequency of alterations of texture, and of the deviations from the normal state: the mammary glands, the renal capsules, the spleen, the testicles, the mucous glands, the lymphatic glands, the liver, the thyroid gland, and the ovaries. The last are doubtless those which present the most frequent anomalies and produce the most normal productions, such as serous membranes, mucous membranes, fibro-cartilages, cartilages, hair, bones, teeth, and fat.

Inflammation of the glands rarely terminates in mortification, more frequently in effusion, which is principally the cause why the glandular tissue hardens, and in suppuration, which sometimes completely destroys this tissue. These different peculiarities seem also to be connected with the functions performed by the glands.

§ 450. The glandular tissue is never accidentally developed, which is owing to its complexity and the peculiar characters of its structure.

SECTION XII.

OF THE ACCIDENTAL FORMATIONS.

§ 451. The accidental formations(1) are produced sometimes by a peculiar fluid effused expressly to give rise to them, sometimes by precipitation and crystalization, in accordance with the laws of chemical affinity, in a secreted fluid, the chemical composition of which is somewhat changed. The calculi are developed by the second mode; to the first belong all other formations, whether primitively connected in their organization with parts already formed, or not.

The proximate cause of all alterations of texture is an anomaly in nutrition.(2) However different the productions of this power may

(1) Besides the treatises on pathological anatomy which have been before mentioned, consult Ludwig, *Primæ lineæ anatomiæ pathologicæ*, Leipsic, 1785.—Conradi, *Handbuch der pathologischen Anatomie*, Hanover, 1796.—A. Clarus, *Quæstiones de partibus pseudo-organicis*, Leipsic, 1805.—Pinel, *La médecine clinique rendue plus précise et plus exacte par l'application de l'analyse*, Paris.—Prost, *La médecine éclairée par l'observation et l'ouverture des corps*, Paris.—I. L. Knoblauch, *Dissertatio quæ continet phænomenorum hominis ægroti expositionem*, Leipsic, 1810.—Otto, *Handbuch der pathologischen Anatomie des Menschen und der Thiere*, Breslau, 1814.—J. Cruveilhier, *Essai sur l'anatomie pathologique en général, et sur les transformations et productions organiques en particulier*, Paris, 1816.—Rayer, *Sommaire d'une histoire abrégée de l'anatomie pathologique*, Paris, 1810.—Consbruch, *Taschenbuch der pathologischen Anatomie*, Leipsic, 1820.—See also the *Note sur l'anatomie pathologique*, by Laennec, in the *Journ. de Corvisart*, vol. ix. p. 360, and his article *Anatomie pathologique*, in the *Dictionnaire des sciences médicales*. See likewise the articles *Anatomie pathologique*, in the same collection, and in the *Dictionnaire abrégé des sciences médicales*, the first by Bayle, the second by Boisseau; Martin's work on organic diseases in general, in the *Mémoires de la société médicale d'émulation*, vol. vii. and Gruithuisen's researches on the essence of inflammation, in the *Gazette médico-chirurgicale de Salzbourg* (1816, vol. ii. p. 129), in the preface to his *Organozoonomie*, in his *Beytrage zur Physiognosie und Eautognosie*, and in his *Traité sur le pus et le mucus*.

(2) The nutritive action is doubtless changed in producing every alteration of texture; but this opinion is entirely unimportant, because we are totally unacquainted with the nutritive action, unless it be with the appearance, the form, and the structure, of the parts upon which it acts. To say then that an anomaly in nutrition is the immediate cause of all alterations in texture, is to say, in conventional language, that the altered tissues change in their structure, their form, their appearance, and not to resolve, or in any way to conceal, an insoluble difficulty. Our author on this topic follows his master Reil, to whom also belongs the merit of placing in the organization, in the organic matter, the origin of all the physiolo-

be when it is deranged, they are very similar in regard to their origin;(1) and after a certain time, the differences in several depend either on the nature of the parts within or near which they are developed, or on external and accidental circumstances.

All alterations of texture come from an albuminous substance which very probably is always fluid when it is effused.(2)

Dropsy, that is, the abnormal accumulation of an albuminous fluid, may be regarded as the first step of the organism toward forming new substances.

These fluids are sometimes clear and limpid. They often contain coagulated flakes.

They vary much in regard to their specific gravity, their degree of coagulability, and the respective proportions of their liquid or solid constituent principles, especially in their quantity of albumen. The proportion of the salts on the contrary is nearly the same in all.(3) The serum in ascites, hydropericarditis, hydrothorax, hydrocele, &c., which contains much albumen, is easily coagulated by the acids and by heat. That of hydrorachitis and hydrocephalus is but slightly coagulable, from its small quantity of albumen.

Adhesions sometimes occur between organs normally separated, as those enveloped by a serous membrane, by the coagulation of the effused fluids.

When the coagulation exists only to a certain extent, or when the congestion of the liquid disappears, the parts only adhere.

But when the quantity of the effused liquid is considerable, the organs not only adhere, but are imbedded in a thick layer of coagulated substance; so that we cannot distinguish them from each other, and are led to believe that some of them, although very large, have entirely disappeared.

gical and pathological phenomena of the living economy. See his fine memoir entitled *Veranderte Mischung und Form der thierischen Materie, als Krankheit oder nachste Ursache der Krankheitszufälle betrachtet*, in the *Archiv für die Physiologiie*, vol. iii. 1799, p. 424. F. T.

(1) This proposition is true, inasmuch as inflammation is the occasional cause, if not the direct creator, (if we may be allowed this metaphorical expression,) of every accidental production. F. T.

(2) The ancients attended to accidental formations only to investigate the proximate cause, and to point out their symptoms; some of the moderns have attended particularly to describing them, others to determine the morbid alteration which creates them. Heretofore they have been attributed to alterations of the lymph, the blood, or of both of these at the same time; at present they are considered as the result of a change in the organic texture. Some endeavor to trace their relations of resemblance and of continuity, and their differences from the primitive tissues, while others attempt to place them in one or another order of vessels. Thus Broussais thinks they depend on a change in the organization of the white or of the red vessels, or of both. Meckel goes so far (as we have seen) as to assert that they originate in the exhalation and the coagulation of an abnormal albuminous liquid. The dissections and the preparations of the accidental tissues have not as yet been either numerous enough or sufficiently delicate for us to adopt any of these opinions. The time has not yet come to establish on a solid foundation the connections and the natural relations of these accidental formations. All that we can do is to investigate the composition, the texture, the varieties, and to determine the morbid state which is the first condition of their formation; so that pathological anatomy is yet in its infancy. F. T.

(3) Marcet, in the *Med. chir. trans.*, vol. ii. p. 380, 381.—Bostock, *ibid*, vol. v.

The alteration in nutrition which produces this ultimate union is more serious than that by which the fluids are only accumulated. This state is termed *inflammation* (§ 126).(1)

The connecting substance varies in quality and consistence ; it not unfrequently ossifies. This is the origin of most ossifications, especially those between the corresponding surfaces of the serous membranes, appearing sometimes in the form of layers, and much more rarely as filaments. The organs surrounded by this coagulation are usually healthy, or at least if they are sometimes slightly changed, we must attribute it to compression. Very solid whitish coagulations, in which we can scarcely trace any texture, are generally called *steatoma* or *sarcoma*.

Most probably all tumors originally assume this form. Analysis demonstrates that they are composed almost wholly of albumen.(2)

The abnormal formations generally adhere more or less intimately to the parts near which they are formed. This remark however is not true of all, for some are perfectly loose ; this is particularly the case with the fibrous concretions which appear in the vascular system, or the polypi, and also with several cartilaginous or bony substances found in the cavities of the serous membranes, the calculi, and the intestinal worms. Most of these productions are at first connected with the adjacent parts, or are excrescences of them ; this is not the case with the intestinal worms and calculi, for they certainly are not formed in the midst and at the expense of a fluid.

§ 452. If we carefully examine the relations of situation between the alterations of texture and the organs, it is proved that they result from the change of the normal substance of these organs into another substance more or less different, or that a foreign body forms either within or without the organ, which sometimes, from its mechanical influence, destroys the primitive organ to a greater or less extent, and sometimes causes it to increase more or less in size. This difference, however, is more apparent than real; at least it depends only on the exte-

(1) We have seen before (p. 137) that Meckel considers *inflammation* or an *analogous act* as the principal mode in which all regular or irregular formations, that is, all accidental tissues, whether analogous to those in the organism or not, are produced, and that he considers inflammation as situated in the capillary system. Broussais, in his *Histoire des phlegmasies chroniques* (Paris 1808), considers pain, swelling, redness, heat, gangrene, induration, suppuration, ulceration, tubercles, lardaceous tumors, cancer, marasmus, dropsy, &c. &c. as the effects of inflammation, In the second edition of his *Examen* (Paris, 1821) he asserts that cartilaginous, osseous, aud calcareous formations, melanosis, schirrus, tumors,cancers,encephaloid, and tubercles, are produced by inflammation. But he thinks that, in order to the production of many if not all of these alterations, inflammation of the white vessels must be complicated with that of the red vessels, with inflammation properly so called : he terms the former sub-inflammatiou ; this, he asserts, attends every chronic inflammation, and causes all chronic alterations in texture. This consonance of opinion between the French pathologist and the German anatomist favors their theory.
F. T.

(2) Vauquelin, in the *Journal de médecine*, after the history of a steatoma which filled most of the chest.—*Dissection of an albuminous concretion which was found in the cavity of the thorax*, by Wardrop, in the *Edin. Med. and surg. Journ.* vol. ix. p. 11.

rior, that is, its form.(1) In fact, in the second place, the accidental substance is uniformly blended with the normal substance, or the latter is more or less changed into it; in the former case it forms insulated and distinct depositions: but this state essentially consists in the production of a substance different from the abnormal tissue, either by an alteration, a derangement, or an anomaly of nutrition, also under whatever form this new substance appears, even when it is inclosed in a cyst which separates it from the normal substance, whether this cyst has appeared before it, and has secreted it, or whether its formation was consecutive to its own and purely accidental.

§ 453. All alterations of texture may then be regarded as new formations, which are sometimes repetitions of those already existing in the normal state, and are abnormal only from the place where they appear, and sometimes are substances wholly foreign to the organism. The latter are somewhat analogous to the normal tissues; hence for a long time they were called by the same names as the latter, which some moderns still preserve; but the analogy being very slight, we have no right to consider all the new and morbid formations as repetitions of the normal formations.(2)

We have thought it more convenient to refer the history of the first kind of formations already mentioned (§ 40) to that of the regular tissues of which they are repetitions, since there are but trifling shades between the phenomena of their production and those of the regeneration of the organs, especially of some of them, as the bones. We shall here mention the details of the others, although we have briefly considered them when treating of each of the regular tissues in which they can be developed. Farther, these two kinds of accidental tissues often exist together, so that it is very common to find different abnormal productions existing simultaneously. There seems to be some regularity in this respect, for there are certain accidental productions more frequently associated than others; in this respect the different substances are sometimes perfectly distinct, and placed at the side of each other in masses of various sizes, and they are sometimes divided into such small portions, and so intermixed, that they seem to form a new and special tissue.

§ 454. The classification of the perfectly new tissues is very difficult, both from the uncertain marks by which they are recognized, and

(1) The untility, and the foundation of this distinction between the *change* of a primitive into an accidental tisssue and the production of the latter in a primitive tissue, have already been mentioned. These two kinds of development seem to occur in many cases. The distinction however is not so important as would seem at first view, since it is so difficult to determine it. F. T.

(2) As has been done recently by Fleischmann, (*Leichenoffungen*, 1815, p. 111, 112,) who certainly goes too far when he contrasts sarcoma with muscle, steato-sarcoma with fat and muscle, the pancreatic sarcoma of Abernethy with the pancreas, and his medullary sarcoma with the medullary substance of the brain. Dumas (*Mém. sur les transformations des organes*, in the *Journal de Sédillot*, vols. xxiii. and xxv.) had already considered, in an analogous but more ingenious manner, all morbid alterations of the organs as changes of these same organs into each other. This hypothesis has long been expressed by the names of most tumors and by the theory imagined to explain them (Plenk, *De tumoribus*, Vienna, 1767).

the distinctions between the different species, and also from the modifications which they present acccording to the different organs in which they are developed, and from the frequent instances in which several new formations entirely different from each other co-exist. In regard to some tissues, we cannot positively decide whether they are simple excrescences, or partial enlargements of the substance of the organs, or finally formations entirely new. Such are particularly the polypi of the mucous membranes.

We may, however, admit three kinds of abnormal formations, which are connected with the organs in the same manner as the organs themselves; 1st, the *tuberculous* tissue; 2d, the *schirrous* tissue; 3d, and perhaps the *fungous* tissue.

Beside these three, Abernethy(1) admits, 1st, a pancreatic sarcoma, which seems to be only a modification of accidental fibro-cartilaginous tissue, determined by the nature of the parts in which it is developed; 2d, a mammary sarcoma and a medullary sarcoma, which are very similar to the encephaloid tumor of Laennec. The melanosis of the latter scarcely differs from his encephaloid tumor. The latter may be united to the tuberculous, tissue, and the melanosis to the fungous tissue, which perhaps is only a modification of the schirrous tissue.(2)

§ 455. The tuberculous tissue, the tuberculous or scrofulous formations, and the schirrous, cancerous, or carcinomatous tissue, are similar in certain respects,(3) and different in others.(4) It is on account of their relations with each other and with the other abnormal formations, that the terms *tubercle* and *schirrus* are employed in so general a manner, and often for each other, when we would designate those abnormal productions, which, when they inclose a liquid, do not appear in the form of cysts. It is thus that many pretended cancers of the uterus are nothing but fibrous tumors.

The common characters of these two alterations are:

They vary in hardness and have a grayish color. They become harder by the action of acids and heat. In time they soften and become fluid.

The following are their characteristic marks:

The *tubercles*(5) are homogeneous, pale white, sometimes yellowish, and opaque. They change into a white and friable mass, then

(1) *Surg. observ. on tumors*, London, 1814.

(2) Laennec divides those tissues which are unlike those in the normal state into *tubercles*, *encephaloid tumors*, *schirrous tumors*, *melanosis*, *cirrhosis*, *sclerosis*, and *squamous tissue*. His remarks on these different organic alterations may be found in the *Bulletin de la faculté de médecine*, Corvisart's *Journal de médecine*, his article *Encephaloïde* in the *Dictionnaire des sciences médicales*, and his work on *Auscultation*. F. T.

(3) Bayle, *Sur les indurations blanches des organes*, in the *Journ. de méd.* vol. ix. p. 285.

(4) Stark, in the *Med. communicat.*, London, 1784, vol. i. no. 24.—Bayle, in the *Journ. de méd.*

(5) G. Stark, *Observations clinical and pathological*, London, 1784.—Reid, *Essay on the nature and cure of phthisis pulmonalis*, London, 1782.—Bayle, *Remarques sur les tubercules;* in *Journal de Corvisart*, vol. vi. 1803, p. 3.—Id. *Remarques sur la dégénérescence tuberculeuse non enkystée du tissu des organes*, vol. ix. 1805, p. 427, vol. x. p. 32.—Id. *Recherches sur la phthisie pulmonaire*, Paris, 1801.—J. Baron,

into an unctuous fluid, in which float small, irregular, grayish, cheese-like films. They appear as rounded bodies, sometimes inclosed in a cyst, or as irregular masses which pervade most of the part in which they are developed.

The *schirrous* tumours are formed of two substances, one white, fibrous and opaque, which forms a network, the other semi-transparent, a little brilliant, bluish or greenish, rarely white or red, which is inclosed in the spaces of the network. They change into an ichorous pus which corrodes the skin and gives rise to fungous tumor and ulcers, the edges of which are turned over.

The *tubercles* are situated principally in the lungs and in the lymphatic glands, particularly those of the mesentery, of the mucous membranes, of the intestinal canal, especially in the last stages of tubercular phthisis, more rarely in the liver, the spleen, the testicles, the kidneys, and the muscles.

The schirrous tumors are developed particularly in the glandular organs, especially in the mammary glands, the uterus, the prostate gland, the intestinal canal, and the skin, whence they extend also to the lymphatic glands, and to all the adjacent parts.

The fungus hematodes of Hey, the spongoid inflammation of Burns, the melanosis of Laennec,(1) are in fact one and the same formation, which differs from the preceding onlyin its greater softness and blackish color. It is however so allied to schirrus in structure and progress, that it has been termed soft cancer.(2)

§ 456. The abnormal formations of which we have spoken may be considered as integral parts of the organism, as they are so intimately connected with the other organs. Some however are unconnected with it and are loose, but derive their nourishment from it. These are the intestinal worms, or the *entozoa*, some of which live in separate cysts, and others in direct contact with the substance of the organs.

The lowest formations of this kind are loose vesicles, with thin, semi-transparent, and round parietes, which are perfectly homogeneous, and filled with a serous, thin fluid ; they vary much in size and number, and are developed both in the substance of the organs and in the normal and abnormal cavities. These vesicles probably should be regarded not so much as animals, but as membranes analogous to those of the ovum. They have been termed *hydatids*, and by Laennec, *acephalocystes*.(3)

An inquiry illustrating the nature of tuberculated accretions of serous membranes and the origin of tubercles and tumors in different textures of the body, London, 1819.

(1) Hey, *On fungus hæmatodes*; in *Obs. on surgery*, London, 1814, ch.vi.—Wardrop, *On fungus hæmatodes*, Edinburgh, 1809.—Burns, *Spongoid inflammation ; in Lectures on inflammation*, Glasgow, 1800, vol. i. p. 302.—Laennec, *Sur les mélanoses ;* in *Bullet. de l'éc. de méd.* 1806.—Breschet, *Considérations sur une altération organique, appelée dégénérescence noire*, Paris, 1821.—Id. *Supplément aux considérations sur la mélanose ;* in *Revue médicale*, vol. vii. p. 79.—Heusinger, in his *Recherches sur la production accidentelle de pigment et de carbone dans le corps humain* Eisenach, 1823, considers the melanosis, from the analyses made by Barreul and Lassaigne, as a deposition of the coloring matter and of the fibrin of the blood.

(2) Maunoir, *Mémoire sur les fongus médullaire et hématode*, Paris, 1820.

(3) Ludersen, *De hydatidibus*, Gottingen, 1808.—Laennec, in *Bulletin de la fac. de médecine*, 1812, p. 49.—See also Rodet, *Observations sur les hydatides ;* in *Journal*

They occur principally in the liver, whence they perhaps pass into the abdominal cavity, the ovaries, the kidneys, the brain, the lungs, and the testicles. However they have been found in every organ, although rarely.

After the hydatids come the *vesicular worms*, which are contained in special cysts. Sometimes there are developed in their vesicle several organs, which perhaps should be considered as parts of one whole (*echinococcus*), rather than as separate animals, and to which many cases of acephalocystes are doubtless referred; sometimes the vesicle almost entirely disappears or is seen only at the posterior extremity of the body in the form of a caudal pouch (*cysticercus*), even as in the superior animals, the envelops of the ovum are connected with the lower region of the body. The former of these vesicular worms appears in the same places as the hydatids, and the second principally in the cellular tissue, the muscles, and the brain.

The other intestinal worms have an existence still more independent. They are not inclosed in sacs distinct from their proper substance, and we cannot trace the organs which have formed them. In most of them, especially in the *filaria*, the *hamularia*, the *trichocephali*, the *ascarides*, the *strongyli*, and the *tæniæ*, the greatest dimension is their length. At the same time they are also round, except the tæniæ, which are very thin and flat. Some of them, the *distomata* and the *polystomata*, are short, broad, and flat. They live principally in the intestinal canal; this at least is the case with the ascarides, the trichocephali, the tæniæ, and the distomata. Others are met with in the cellular tissue, under the skin and the muscles (*filaria*), in the bronchial glands (*hamularia*), the ovaries and the Fallopian tubes *polystoma*), in the kidneys and the bladder (*strongylus*).(1)

compl. du Dict. des sc. médic., vol. xvii. p. 123.—G. Jæger, *Beobachtungen über Hulsenwürmur im Menschen und einigen Saugthieren*; in Meckel, *Deutches Archiv für die Physiologie*, vol. vi. p. 495.—J. F. M. De Olfers, *Commentarius de vegetativis et animatis corporibus in corporibus animatis reperiundis*, Berlin, 1816. H. Cloquet, *Faune des médecins*, vol. i. Paris, 1822.—Rendtorff, *De hydatidibus in corpore humano, præsertim in cerebro, repertis*, Berlin, 1822.

(1) Among the *entozoa* peculiar to man, the *tricocephalus dispar*, the *oxyurus vermicularis*, the *ascaris lumbricalis*, the *botryocephalus latus*, and the *tænia solium*, are the only well-determined species hitherto observed, which live in the intestinal canal. Blainville has applied the term *nettorhyncus* to another intestinal worm, which has been long observed, but which has been neglected by zoologists. Cloquet has described another as the *ophiostoma Ponthieri*, which perhaps is only a *gordius aquaticus*. Of the entozoa which do not inhabit the intestinal canal, we find the *filaria medinensis* under the skin, but perhaps it come from without. The *hamularia subcompressa* has been found in a bronchial gland; it is a doubtful genus, although Cloquet states that he has observed a new species of it, which had caused very serious nervous affections. The *strongylus gigas* lives in the kidneys and perhaps also in the adjacent muscles. The *distoma hepaticum* inhabits the gall-bladder and perhaps the liver. The *polystoma pinguicola* has been found only once in the fat around the ovary of a young peasant girl; it is a doubtful animal. The *cysticercus cellulosus* inhabits the cellular tissue of the muscles and of the brain; Rudolphi has remarked that it is very common in man, although Bremser asserts the contrary. The *cysticercus cellulosus*, *fischerianus*, *dicystus*, and *albo-punctatus*, have also been found in man. The *echinococcus hominis* occurs in the cysts of hydatids, as do also the *acephalocysta ovoïdea*, *surculigera*, *granulosa* and *racemosa*. All other intestinal worms mentioned by authors are either larvæ of hexapodous insects, or worms of rain-water or parts of

Of these worms, the *echinocci hominis*, the *tænia solium*, the *tænia lata*, and some other species, as yet but little known, the *polystoma pinguicola*, the *hamularia subcompressa*, the *ascaris vermicularis*, and the *filaria medinensis*, are peculiar to man, the others are met with also in most of the mammalia, but only in animals.

§ 457. The *calculi*(1) are formed in the secreted fluids(2) by a chemical process, by precipitation and crystalization.

plants. Bremser has termed them collectively *pseudo-helminthia*, which is not very convenient, because many of these animals, particularly the *ditrachyceros rudis* of Sulzer, and perhaps some others, all in fact doubtful, resemble at least the entozoa.

The history of the animals developed in the bodies of other animals is as yet not much advanced, and hitherto has not been considered in a truly philosophical point of view. Thus, for example, not to mention the discussion which has continued since Redi, on the cause of their production, that is, on their mode of formation, although we cannot doubt that they are created, if not by a real inflammation, at least by a state very similar to it, we have separated from the considerations in regard to these animals, those which relate to the history of the *entozoa*, that is, from the animated parasites which develop themselves, and live on the surface of living animals. Even the history of the latter, although it is so evidently connected with that of the entozoa, has been neglected. We wish to speak particularly of the pediculi, which exist in such numbers that nosologists have formed a disease called *phthiriasis*. The great multiplication of these parasitic animals, in crusta lactea, tinea, plica, induce us to believe with Bremser, that in certain cases they are formed primitively. This manner of production is even the only one which can be admitted in certain cases, even when the pediculi alone form the contents of certain tumors, of which Rust has observed a remarkable instance cited by Bremser (*Sur les vers intestinaux de l'homme*, p. 97), and to which may be attached an interesting note of Bory of Saint Vincent, on a species of ascarides which lives in the human body (*Journal compl. du dict. des. sc. méd.* vol. xix. p. 182). Another circumstance favorable to this theory is the specific difference which seems to exist between the pediculus of the white man and that of the negro (Fabricius, *Systema antliatorum*, p. 340), and which resembles the difference observed between the kinds of tenias peculiar to the inhabitants of the north of Europe and those observed in the people of the south.

Finally, we must adduce together with these facts the vegetable parasites of the class of mushrooms which have been found in animals, and which arise undoubtedly from the same source; physiologists have never attended to this last phenomenon. We however have two authentic instances of it, observed one, by A. C. Mayer, (*Deutsches Archiv für die Physiologie*, vol. i. p. 310), the other, by G. F. Jæger (*same journal*. vol. ii. p. 354). F. T.

(1) Walter, *Anatomisches Museum*, Berlin, 1796.—Wendelstaedt, *Ueber Steine im menschlichen und thierischen Körper*; in his *Medicinisch-chirurgische Wahrnehmungen*, Osnabruck, 1800, vol. i. p. 156–264.—Fourcroy, *Sur le nombre, la nature et les caractères distinctifs des différens matériaux qui forment les calculs, les bezoards et les diverses concrétions des animaux*; in *Annales du Muséum*, vol. i. p. 93.—Marcet, *On the chemical nature of calculi.*—Consult also, 1st. *On urinary calculi*; Tenon, *Sur la nature des calculs*; in *Mém. de Paris*, 1764. Link, *De analysi urinæ et originâ calculorum*, Gottingen, 1788.—Wollaston, *On gouty and urinary concretions*; in *Phil. trans.*, 1797, p. ii. p. 386.—Pearson, *Experiments and observations, tending to show the composition and properties of urinary concretions*; same journal, 1798, p. i. p. 15.—Brande, *On the differences of calculi dependent on their formation in different parts of the body*, same journal, 1808, p. 223–248.—Prout, *On calculus disorders*, with notes, by S. Colhoun, Philadelphia, 1828.—2d. *On biliary calculi*; Morand, *Sur des pierres de fiel singulières*; in *Mém. de Paris*, 1741, p. 355.—Sœmmerring, *de concrementis bilicariis*, Erfurt, 1795.—Mosovius, *De sede calculorum animalium, eorumque imprimis biliarium, origine et naturâ*, Berlin, 1812.—3d. *On intestinal calculi*; J. F. Meckel, *Ueber die Concretionem im menschlichen Darmkanal*; in *Archiv für die Physiologie*, vol. i. p. 454–467.—4th. *On lacrymal calculi*; Walter, *Sur les dacryolithes ou calculs lacrymaux*; in *Journ. compl. des sc. méd.*, vol. vii. p. 51.—5th. *On venous calculi*; Tiedmann, *Sur les calculs qui se rencontrent dans l'intérieur des veines*; same journal, vol. iii. p. 38.

(2) In regard to the intestinal worms of man see the classical work of Rudolphi, *Entozoorum hist. nat.*, Amsterdam, 1808–1810.—Bremser, *Traité zoologique et physiologique sur les vers intestinaux de l'homme*, trans. by Grundler, with notes by Blainville, Paris, 1824.

Sometimes, but this is very unusual, they are developed accidentally around a foreign body, which has been introduced into the organ and serves as a nucleus. Sometimes, and most commonly, they form in consequence of a change in the chemical composition of the liquid, in the midst of which they are precipitated, probably also in that of the common nutritious fluid, and generally because all the functions are deranged.

They differ so much in form, number, chemical composition, and color, that it is almost impossible to refer their history to any general head. All that we say on the subject is reduced to the following particulars:

1st. They are primitively loose; they rarely adhere to the parts in which they are found.

2d. Each liquid has its calculi more or less peculiar in regard to chemical composition, but which are similar in some of their constituent principles.

3d. Their constituent principles sometimes do not exist in the liquid in which they are found.

4th. In most of the fluids at least we find not only one but several kinds of calculi.

5th. They are sometimes single and sometimes compound, their different constituent principles are sometimes intimately blended in all parts of the calculi, and sometimes form so many different layers.

6th. They are usually developed around a nucleus.

7th. Their number is almost always inversely as their size.

8th. They are generally solid and rarely hollow.

9th. Their structure is radiated or lamellar.

10th. They are sometimes smooth and sometimes rough.

11th. They generally appear at mature age, which is not invariably the case, for they are sometimes found even in the fetus.

12th. Certain liquids, as urine and bile, have a greater tendency to produce them than others, but their formation is favored by external circumstances so, that the same kind of calculus is more common in some parts of the body than in others.(1)

(1) Here should be referred all those abnormal productions termed by pathologists *accidental ossifications*, which, attached to the body by no organic connection, and presenting none of the characters which distinguish the bones, cannot be referred to the latter unless we listen to the insidious suggestions of a purely external analogy.
F. T.

DESCRIPTIVE ANATOMY.

DESCRIPTIVE ANATOMY.

SOURCES.

Before treating of general anatomy, we mentioned the principal sources, which, at the same time, appertain in part to descriptive anatomy: here we notice the principal general works which are connected with descriptive anatomy, and which contain general descriptions of the different organic systems, which are however proportionally shorter.

A. GENERAL WORKS.

I. HISTORY OF ANATOMY.

P. J. Hartmann, *Disquisitiones historicæ de re anatomica veterum*, Kœnigsberg, 1693.
Portal, *Hist de l'anat. et de la chirurgie*, Paris, 1770–1773.
Lauth, *Hist. de l'anat.*, Strasburg, 1815.

II. CATALOGUES OF BOOKS AND DICTIONARIES.

J. Douglas, *Bibliographiæ anatomicæ specimen, s. catalogus omnium pene auctorum qui ab Hippocrate ad Harveum rem anatomicam ex professo vel obiter scriptis illustrarunt*, London, 1718.
Haller, *Bibliotheca anatomica, qua scripta ad anatomen et physiologiam facientia, a rerum initiis recensentur*, Zurich, 1770–1777.
Heister, *Anatomisch-chirurgisches Lexikon*, Berlin, 1753.
Tarin, *Dictionnaire anatomique, suivi d'une bibliothèque anatomique et physiologique*, Paris, 1753.

III. SMALL TREATISES ON DIFFERENT SUBJECTS,

Corvinus, *De dignitate, jucunditate, et usu anatomiæ*, Leipsic, 1611.
Fabricius Hildanus, *Anatomiæ præstantia et utilitas*, Berne, 1624.
B. S. Albinus, *De necessitate studii secandi*, Francfort, 1683.
E. Stahl, *De serie et usu inventionum anatomicarum*, Halle, 1705.
Dern, *De anatomes in praxi usu*, Halle, 1707.
J. J. Rau, *De meth. anatomen docendi et discendi*, Leyden, 1713.
B. S. Albinus, *De vera via quæ ad corp. hum. cognitionem ducat*, Leyden, 1721.

A. Walther, *De usu et præstantia anatomes scientiæ*, Leipsic, 1723.
Coschwitz, *De studii anatomiæ præstantia et utilitate*, Halle, 1727.
Heister, *De anatomes necessitate*, Helmstadt, 1727.
Hebenstreit, *De medici cadavera secantis religione*, Leipsic, 1741.
Munnicks, *De summis quas anatome habet deliciis*, Groningen, 1771.
Bonn, *De simplicitate naturæ anatomicorum admiratione, chirurgorum imitatione digna*, Amsterdam, 1771.
S'Gräuwen, *Oratio de anatomiæ pathologicæ utilitate et necessitate*, Groningen, 1771.
Sandifort, *Oratio de circumspecto cadaverum examine, optimo practicæ medicæ adminiculo*, Leyden, 1772.
M. Girardi, *De re anatomica oratio*, Parma, 1781.
C. Siebold, *Rede von den Vortheilen, welche der Staat durch anatomische Lehranstalten gewinnt*, Nuremberg, 1788.
Rougemont, *Rede ueber die Zergliederungskunst*, Bonn, 1789.
D. G. Silbermann, *De promovendis anatomiæ pathologicæ administrationibus*, Halle, 1790.
Roeschlaub, *Einiges ueber Anatomie*, in the *Magaz. zur Vervollkommung der Medicin*, vol. vi. p. 401, Francfort, 1801.
F. Schelling, *Ueber das Studium der Medicin und der organischen Naturlehre ueberhaupt*, in the *Vorlesungen ueber die Methode des akademischen Studiums*, Tubingen, 1803.
Index rerum musei Ticinensis ; accedit Scarpæ oratio, Padua, 1804.
Froriep, *Einige Worte ueber den Vortrag der Anatomie auf Universitaten*, Weimar, 1812.—Idem, *Ueber die Anatomie in Beziehung auf Chirurgie*, Wiemar, 1813.

IV. TREATISES AND MANUALS.

A. THE NORMAL STATE OR THE NORMAL AND THE ABNORMAL STATE.

Galen, *De anat. administrationibus*, lib. ix., and *De usu partium*, lib. xvii. in *Opp. omn.* vol. ii. Vienna, 1597.
Mundinus, *Anatomia emendata*, Marburg, 1540.
Berengarius, *Carpi, Commentarii cum amplissimis adnotationibus supra anatomiam Mundini*, Bologna, 1521. Idem, *Isagoge in anatomiam corp. hum.*, Bologna, 1522.
Riverius, *De dissectione partium corp. hum.*, lib. iii. Paris, 1545.
Vassaeus, *In anatomen corporis humani tabulæ*, iv. Paris, 1553.
J. Sylvius, *Isagoge in libros Hippocratis et Galeni anatomicos*, Paris, 1558.
Vesalius, *De corp. hum. fabrica*, lib. vii. Basle, 1545.
Gemini, *The anat. of the inward parts*, London, 1559.
Colombo, *De re anatomica*, l. xv., Venice, 1559.
Valverde, *Anat. del corpo umano*, Rome, 1560.
Coiter, *Extern. et intern. princip. hum. corp. partium tabulæ*, Nuremberg, 1573.

F. Plater, *De corp. hum. structura et usu*, lib. iii., Basle, 1583.
Piccolomini, *Anotomicæ prælectiones*, Rome, 1586.
Guidi, *Opp. omn.*, Erfort, 1668.
Varolius, *Anatomia, s. de corp. hum. resolutione*, l. iv., Erfort, 1591.
Bauhin, *De corp. hum. fabrica*, Leyden, 1590. Idem, *Institutiones anatom.*, Francfort, 1592. Idem, *Theatrum anatomicum*, Francfort, 1605.
Riolan, *Anthropographia*, Paris, 1618. Idem, *Enchiridion anatomicum et pathologicum*, Paris, 1648.
Spigelius, *De corp. hum. fabrica*, l. x. Venice, 1627.
T. Bartholinus, *Anatomia reformata*, Leyden, 1641.
Veslingius, *Syntagma anatom.*, Padua, 1641.
Highmore, *Corp. hum. disquisitio anatomica*, Hague, 1651.
Marchettis, *Compendium anatomicum*, Padua, 1652.
Lyser, *Culter anatomicus*, Copenhagen, 1653.
Habicot, *La semaine, ou Pratique anatomique*, Paris, 1660.
Zeidlern, *Somatotomia anthropologica*, Prague, 1686.
Collins, *System of anatomy*, London, 1685.
Diemerbroek, *Opp. omn.*, Utrecht, 1685.
Taury, *Nouv. anat. raisonnée*, Paris,1690.
Verheyen, *Anat. corp. hum.*, Louvain, 1693.
Keil, *Anat. of the hum. body*, London, 1698.
St. Hilaire, *Anat. du corps hum.*, Paris, 1698.
Fantoni, *Brevis manuductio ad hist. anat.*, Turin, 1699.
Bartholinus, *Specimen hist. anat. part. corp. hum.*, Copenhagen, 1701.
Cheselden, *Anat. of the hum. body*, London, 1713.
Dionis, *Anat. de l'homme*, Paris, 1716.
Heister, *Compendium anatomicum*, Altdorf, 1717.
Hellwig, *Nosce te ipsum*, Erfort, 1720.
Kulmus, *Tabulæ anatomicæ*, Amsterdam, 1732.
Winslow, *Expos. anat. de la struct. du corps hum.*, Amsterdam, 1732.
Palfyn, *Anat. chirurg.*, Paris, 1734.
Cassebohm, *Methodus secandi, &c.*, Halle, 1740.
Lieutaud, *Essais anatomiques*, Paris, 1742.
A. Schaarschmidt, *Anatomische Tabellen*, Berlin, 1746–1750.
Verdier, *Abrégé de l'anat. du corps hum.*, Brussels, 1752.
Krapff, *Naturspiegel*, Basle, 1761.
Sabatier, *Traité complet de l'anat.*, Paris, 1772.
Plenk, *Primæ lineæ anatomicæ*, Vienna, 1777.
Leber, *Prælectiones anatomicæ*, Vienna, 1778.
Mayer, *Beschreibung des ganzen menschlichen Koerpers*, Berlin, 1783–1794.
Loder, *Anatom. Handbuch*, vol. i. 1788.
Hildebrandt, *Lehrbuch der Anatomie des Menschen*, Brunswick, 1789–1792.
Soemmerring, *Vom Bau des menschl. Koerpers.*
Caldani, *Institutiones anatomicæ*, Venice, 1791.
Wiedemann, *Handbuch der Anatomie*, Brunswick, 1796.

J. Bell, *The anat. of the hum. body*, Edinburgh, 1797.
Boyer, *Traité complet de l'anat.*, Paris, 1797.
Bichat, *Traité de l'anat. descript.*, Paris, 1801–1803.
Hempel, *Anfangsgründe der Anatomie*, Gottingen, 1802.
Hesselbach, *Anleitung zur Zergliederungskunde des Menschen*, Rudolstadt, 1805.
Fattori, *Guida allo studio dell' anatomia umana*, Pavia, 1807.
Langenbeck, *Anatom. Handbuch*, Gottingen, 1806.
Mayer, *Anatom. Handbuch*, Vienna, 1812.
Monro, *Outlines of the anat. of the hum. body*, Edinburgh, 1812.
Gordon, *A system of human anatomy*, Edinburgh, 1815.
H. Cloquet, *A system of human anatomy*, trans. by R. Knox, Edinburgh, rep. at Boston, 1831.
Marjolin, *Manuel d'anatomie*, Paris, 1814.
Boek, *Handbuch der praklischen Anat. des menschl. Koerpers*, Meissen, 1820.
J. Cloquet, *Anat. de l'homme*, Paris, 1822.
Bayle, *Petit manuel d'anat. descript.*, Paris, 1823.
C. Wistar, *A syst. of anatomy*, 5th edit., Philadelphia, 1830.
W. E. Horner, *A treatise on general and special anatomy*, 2d edit., Philadelphia, 1830.

B. THE ABNORMAL STATE.

Bonetus, *Sepulchretum, s. anat. pract.*, Geneva, 1700.
Morgagni, *De causis et sedibus morborum*, Venice, 1761.
Lieutaud, *Historia anatomica medica*, Paris, 1767.
Ludwig, *Primæ lineæ anat. path.*, Leipsic, 1785.
Baillie, *The morbid anat. of the most imp. parts of the hum. body*, London, 1793.
Conradi, *Handb. der pathol. Anatomie*, Hanover, 1799.
Vetter, *Aphorismen aus der pathol. Anatomie*, Vienna, 1803.
Voigtel, *Handbuch der pathologischen Anatomie*, Halle, 1804–1805.
Meckel, *Hanb. der pathol. Anatomie*, Halle, 1812–1816.
Otto, *Handbuch der pathol. Anatomie*, Breslau, 1813.
W. E. Horner, *A treatise on path. Anatomy*, Philadelphia, 1827.

COPPERPLATE ENGRAVINGS.

I. NORMAL STATE.

a. In respect to the external form of the body.

A. Durer, *Vier Buecher von menschlicher Proportion*, Nuremberg, 1528.
Genga and Lancisi, *Anatomia per uso et intelligenza del disegno ricercata non solo sugl' ossi e muscoli del corpo humano, ma dimostrato ancora su le statue antiche più insigni di Roma*, Rome, 1691.

b. In respect to the structure of the whole body.

B. Eustachius, *Tabulæ anatomicæ*, Rome, 1714.
C. H. Ryff, *Descript. anat. de toutes les parties du corps humain, exprimant au vif tous les membres, redigée en tables*, Paris, 1543.
J. Remmelinus, *Catoptrum microscopicum, suis aeri incisis visceribus spendens*, Augsburg, 1619.
Casserius Placentinus, *Tabulæ anat.*, Venice, 1627.
Bidloo, *Anatomia hum. corp., centum et quinque tabulis demonstrata*, Amsterdam, 1685.
Welchius, *Tabulæ anat., universam corp. hum. fabricam perspicue atque succincte exhibentes*, Leipsic, 1697.
Cowper, *Anatomia corporum humanorum, CXIV tabulis ad vivum expressis illustrata*, Leyden, 1739.
Petriolus and Berrettinus, *Tabulæ anat.*, Rome, 1741.
Gautier, *Exposition anat. de la struct. du corps hum. en vingt planches imprimées avec leur couleur nat.*, Marseilles, 1759.
Mayer, *Anatomische Kupfertafeln*, Berlin and Leipsic, 1783–1794.
J. C. Loder, *Tabulæ anatomicæ*, 1794–1803.
Rosenmüller, *Chirurg. anatom. Abbildungen für Aerzte und Wundaerzte.*

II. ABNORMAL STATE.

A complete work, exhibiting even generally all deviations of the external form and of the texture of the whole and of the parts of the human body, is still wanting, although we have excellent figures of the most abnormal deviations.

We find a considerable number of the different anomalies figured in

Baillie, *A series of engravings accompanied with explanations, which are intended to illust. the morbid anat. of some of the most imp. parts of the hum. body*, London, 1799.
Sandifort, *Museum anat. academiæ*, Leyden.

B. DIFFERENT ANATOMICAL WORKS, BOTH ON THE NORMAL AND THE ABNORMAL STATE.

I. PERIODICAL WORKS.

Reil, *Archiv für die Physiologie*, Halle, 1795.
A. F. Heckler, *Magazin für die pathol. Anat.*, Altona, 1796.
Iserflamm and Rosenmüller, *Beitraege für die Zergliederungskunst*, Leipsic, 1800.
P. F. Meckel, *Journal f. anatom. Varietaeten*, Halle, 1802.
J. F. Meckel, *Deutches Archiv f. die Physiol.*, Halle, 1815.

II. TREATISES WITH AND WITHOUT ENGRAVINGS.

Eustachius, *Opuscula anatomica*, Venice, 1564.
Arantius, *Observat. anatomicæ*, Venice, 1578.
Coiter, *Anatomicæ exercitationes observationesque variæ ad calc. Tabul. ext. et intern. corp. hum. partium*, Nuremberg, 1572.
Plater, *Mantissa observationum*, Basle, 1614.
Hyeronimus Fabricius ab Aquapendente, *Opp. omnia anat. et physiol.*, Leipsic, 1687.
J. Riolanus, *Opera anatomica*, Paris, 1649.
Fallopius, *Observationes anatomicæ.* Idem, *Institutiones anatomicæ.* Idem, *In librum Galeni de ossibus expositio.* In *Opp. omn.*, Francfort, 1600.
Bartholinus, *Hist. anat. Cent. VI.*, Copenhagen, 1654–1661.
Veslingius, *Observationes anatomicæ*, Copenhagen, 1664.
Blasius, *Observ. medicæ rariores*, Amsterdam, 1677.
Tulpius, *Observ. medicæ*, Amsterdam, 1672.
Le Clerc and Mangetus, *Bibliotheca anatomica*, Francfort, 1668.
Kerckringius, *Specimen anatomicum*, Amsterdam, 1670. Idem, *Opp. omn.*, Leyden, 1729.
Peyer and Harder, *Exercitat. anat. et medic. familiares*, Basle, 1682.
J. J. Harderus, *Apiarum observ. med., &c.*, Basle, 1687.
Stalpart v. d. Wiel, *Observ. var. anatom.*, Leyden, 1687.
Malpighi, *Opp. omn.*, Leyden, 1687.
Pechlinus, *Observ. phys. med.*, Hamburgh, 1691.
F. Ruysch, *Opera anatomico-medica*, Amsterdam, 1691–1742.
Bidloo, *Opp. omn. anat.-chirurg.*, Leyden, 1715.
Mangetus, *Theatr. anat.*, Geneva, 1718.
Morgagni, *Adversaria anatomica*, Leyden, 1723. Idem, *Epistolæ anatomicæ duæ*, Leyden, 1728. Idem, *Epist. anatomicæ XVIII. ad scripta pertinentes celeberrimi viri A. M. Valsavæ*, Padua, 1764.
Santorinus, *Observ. anat.*, Venice, 1724. Idem, *Tabulæ XVII. a Girardi editæ*, Parma, 1775.
Bassius, *Obs. anat.-chirurg.-medicæ*, Halle, 1731.
Trioen, *Observ. medico-chirurgicæ*, Leyden, 1743.
Haller, *Disputationes anatomicæ selectæ*, Gottingen, 1746–1751. Idem, *Opera minora*, Lausanne, 1762–1768.
Lambrecht, *Observ. et oblectat. anat.*, Francfort, 1751.
Böhmer, *Observ. anat. rarior. fascic.*, Halle, 1752.
Tabarranus, *Observ. anat.*, Lucca, 1753.
Löseke, *Observ. anat.-chir. medicæ novæ et rariores*, Berlin, 1754.
P. C. Fabricius, *Sylloge observ. anat.*, Helmstadt, 1759.
Duverney, *Œuvres anatomiques*, Paris, 1761.
B. S. Albinus, *Annotationes academicæ*, Leyden, 1754–1768.
P. Camper, *Demonstrationes anatomico-pathologicæ*, Amsterdam, 1761.
W. Hunter, *Medical commentaries*, London. 1762. *Supplem.*, 1764.
G. v. Döveren, *Specimen observ. academicarum*, Leyden, 1765.

Büttner, *In vielen Jahren gesammelte anat. Wahrnehmungen*, Koningsberg, 1768.
Eschenbach, *Observ. quædam anat. chir. medic.*, Rotterdam, 1769.
Siebold, *Coll. observ. med.-chirurg.*, Wirtemberg, 1769.
Forlanus, *Rar. observ. med. pr. et anat.*, Venice, 1769.
Ludwig, *abversaria medico-practica*, Leipsic 1769–1773.
Insfeld. *De lusibus naturæ*, Leyden, 1772.
J. G. Walter, *Observ. anat.*, Berlin, 1775.
Meig, *Observ. botan., anat., et physiol.*, Basle, 1776.
E. Sandifort, *Observ. anatomico-pathologicæ*, 1777–1781. Idem, *Exerc. academicæ*, Leyden, 1783. Idem, *Opusc. anat.*, Leyden, 1784. Idem, *Thesaurus dissertationum*, Leyden, 1778.
Azzoguidi, Pallettæ, Brugnoni, *Opusc. anatom. select. edit. curavit* E. Sandifort, Leyden, 1788.
Rezia, *Specimen observationum anat. et pathol.*, Padua, 1784.
G. Prochaska, *Annotat. academicar.*, Prague, 1784.
Neubauer, *Opera anatomica*, Francfort, 1786.
J. Hunter, *Observ. on certain parts of the animal œconomy*, London, 1786.
F. A. Walter, *Annot. academicæ*, Berlin, 1786.
Leveling, *Observ. anat. rariores icon. illustr.*, Nuremberg, 1787.
Monteggia, *Fasciculi pathologici*, Turin, 1789.
A. J. van Döveren, *Observ. pathologico-anatomicæ*, Leyden, 1789.
Penada, *Saggio d' osserv. e memorie sopra alcuni riscontrati nell' esercizio della med. e della anat. pratica*, Padua, 1793.
Van de Laar, *Observ. chirurg. obstetr. anat. med.*, Leyden, 1794.
Röhler, *Beschreibung der phys. und path. Praeparate, welche in der Samml. des Hrn. Hofr.* Loder *enthalten sind*, Jena, 1795.
Portal, *Mém. sur la nature et le traitement de plusieurs maladies, avec le précis des expériences sur les animaux vivans et d'un cours de physiol. pathologique*, Paris, 1800.
Wrisbergius, *Commentationes med., physiol., anat., et obstetr., argumenti soc. reg.*, Gottingen, 1800.
Flachsland, *Observ. anatomico-pathologicæ*, Rotterdam, 1800.
Rudolphi, *Anat.-physiologische Untersuchungen*, Berlin, 1802.
Vicq d'Azyr, *Œuvres*, Paris, 1805.
J. F. Meckel, *Abbandlungen aus der vergleichenden und menschlichen Anat. und Physiol.*, Halle, 1806. Idem, *Beitraege zur menschl. und vergl. Anatomie*, Leipsic, 1808–1812.
Kelch, *Beitr. zur pathol. Anat.*, Berlin, 1813.
Fleischmann, *Leichnöffnungen*, Erlangen, 1815.
Otto, *Seltne Beobachtungen zur Anatomie, Physiologie, und Pathologie gehörig*, Breslau, 1816.

III. PLATES.

A. Cant, *Impetus primi anatomici ex lustratis cadaveribus nati*, Leyden, 1721.

Haller, *Icon. anatomicar. fasc. VIII.*, Gottingen, 1743–1756.

Santorinus, *Septemdecim tabulæ quæ nunc primum edidit Girardi*, Parma, 1775,

C. F. Ludwig, *De quarundam ægritudinum hum. corp. sedibus et causis tabulæ XVII.*, Leipsic, 1798.

G. Sandifort, *Tabulæ anatomicæ situm viscerum thoracicorum et abdominalium ab utroque latere, ut et a posteriori parte dipingentes. Accedit observatio de aneurysmate arteriæ iliacæ internæ, rarioris ischiadis nervosæ causa*, Leyden, 1804.

Cruvelhier, *Anatomie pathol. du corps humain*, Paris, now publishing.

DESCRIPTIVE ANATOMY.

§ 457. *Descriptive anatomy*, or the *topography* of the human body, is the exact description of the parts which constitute it. It considers,

1st. The human body generally, and its different regions, without regard to the difference of the systems composing it; it points out the dimensions of the whole body and those of its parts, and also the mutual relations of these parts.

2d. The different systems which compose it, in respect to the situation, the number, the size, and the forms of its parts.

DESCRIPTIVE ANATOMY.

PART I.

GENERAL REMARKS ON THE HUMAN BODY.

§ 459. We have already stated the special characters of the human body: it only remains to examine,

1st. Its height.

2d. Its division into different regions.

§ 460. The *height* of man is not the same every where. Like that of all other organic formations, it depends in some measure on the climate: hence the tallest men are found in the warmest countries, while the shortest inhabit the colder regions. In considering the normal differences which belong to whole masses, we find the height varies from six feet and a half to four feet and a half, so that the mean is between five and six feet; that the male is a little taller than the female; and that we may consider as untrue all assertions that nations exist in which the height generally exceeds or is less than these limits. But, although all nations present a certain fixed height, when considered generally and in the mass, individuals differ much in this respect, sometimes exceeding the common measure, and sometimes falling short of it. If we take individuals into consideration, we find the height of man varies from eight feet to sixteen inches.(1)

In both cases the relations between the different parts of the body deviate usually from the ordinary rule. Generally the lower extremities of *giants* are very short; the superior, on the contrary, are very long: the head also is too small. In almost all *dwarfs*, the head is too large; but the relation between the upper and lower extremities is the same as in giants. The cause of dwarfishness is general disease, especially rachitis.

Besides those cases in which we see certain individuals taller than the rest of the species, it sometimes happens that the body prematurely acquires all the development in regard to height of which it is susceptible. This state, which is characterized also by the precocious appearance of puberty, is almost always attended with a proportional

(1) Haller, in his Physiology, mentions several giants and dwarfs.—Bonn (*Thes morb. oss. Hov.*, Amsterdam, 1783, p. 134–136) has given the dimensions of the skeletons of giants.—Zitterland, *De duorum sceletorum prægrandium rationibus*, Berlin, 1814.—The accounts of men more than eight feet in height are doubtful, or arrive from considering fossil bones of large animals as human bones, or finally depend upon the extraordinary development of the crania from hydro-cephalus.

imperfection in the development of the intellectual faculties, and a very short life.

§ 461. The human body is composed, *a*, of a right and a left, an upper and a lower, and finally of an anterior and a posterior half: we have already mentioned their principal characters (§ 23—28) in respect to the analogies and discrepancies. *b*. It is also divided into three parts, the ***trunk*** (*truncus*), the ***head*** (*caput*), and the ***limbs*** (*extremitates*). These are also subdivided into several regions.

§ 462. The ***trunk*** (*truncus*) comprises three parts: the ***neck*** (*collum*), the ***chest*** (*pectus, thorax*), and the ***belly*** (*abdomen*). Each of these parts is composed of some one of the different organic systems. The chest and the belly are hollow, and their *cavities* (*cava*) experience greater or less changes in their figure and their dimensions. These cavities contain organs which in the normal state do not adhere to their parietes, except anteriorly and posteriorly, but are in close contact with them, and are called for this reason the *viscera of the chest, of the abdomen*, and *of the pelvis*. The neck has no cavity: the parts which form it are united together, and with the skin which covers them all, by mucous tissue, while in the thorax and the abdomen, the skin and the bones, as well as the muscles directly united to the integuments, are separated from the subjacent parts by a proper serous membrane.

The vertebral column forms the base of the whole trunk. It is a hollow column composed of bones placed one upon another; these bones have the same general form, but this form is differently modified in the different regions. It extends from above downward, in the centre of the posterior face of the trunk, and is covered its whole length backward and on both sides, also forward in the neck and in the upper part of the abdomen, by muscles which move the vertebral column and the parts attached to it, the head and the limbs, and finally the organs contained in the cavities.

The parietes of the abdominal cavity, except the middle of its posterior face, are formed at their upper part, which is the most extensive, of several superimposed layers of muscles, most of which are broad and flat, called the abdominal muscles; and it is in this direction also that its dimensions and form vary the most. Its lower portion, on the contrary, the *pelvis*, admits of the least motion, because it is principally composed of firmly articulated bones, viz. the sacrum, a fusion of broad vertebræ, and the coxal bones, which unite with it backward, and with each other forward. The pelvis is also the narrowest visceral cavity of the trunk, and the narrower and more manifold connections of the organs it contains with its parietes, cause it in some measure to resemble the neck.

The parietes of the thoracic cavity, except the lower, which separates it from the abdominal cavity, and is formed by a broad muscle, the *diaphragm*, are composed of the ribs, which are movable, lateral prolongations of that portion of the spine which makes its base, of the sternum, which corresponds to the vertebral column forward, and of the muscles situated upon, under, and between the ribs. Hence its parietes, though movable, are not susceptible of such great changes in their dimensions as the abdominal parietes; its form is more constant, and normally depends upon these parietes, while that of the abdomen depends upon the parts contained in its cavity.

Finally, the *neck* is the narrowest and shortest portion of the trunk. The latter enlarges gradually from the neck to the lower part of the chest and the upper portion of the abdomen; but after leaving this point, it gradually contracts to its extremity, and terminates by a very narrow opening, which is susceptible of enlarging, from the mobility of the bones attached to the extremities of the vertebral column.

§ 463. The outer surface of the divisions of the trunk which we have mentioned is itself divided into several regions. In this respect we may imagine the abdomen divided into three parts, situated above each other, by two transverse lines which partially or wholly encircle it.

Of these two lines, the upper passes over the lower ribs, and the lower over the summit of the coxal bones. We have now three compartments: the first above the upper line, the second between this and the lower, and the third below the lower line: these also are divided into several regions by almost perpendicular lines.

The upper is called the *epigastric region* (*regio epigastrica*). It does not include the entire circumference of the body, but only its anterior and its lateral faces. Its form is triangular, and it is composed of four other regions, two lateral and two middle regions. The right and left lateral regions are called the *hypocondriac regions* (*R. hypocondriacæ*, *hypocondria*). They are bounded above by the anterior edge of the cartilages of the five false ribs, below by the upper transverse line, and within by the upper part of the two anterior perpendicular lines.

The two middle regions are situated one above the other. The inferior, which is the most extensive, is called the *epigastrium* (*R. gastrica*, s. *epigastrica stricte sic dicta*); the smaller, situated below the inferior extremity of the sternum, the *cardiac* or the *præcordial region* (*scrobiculus cordis*, s. *regio cardiaca*).

The middle region is termed the *mesogastric*, or the *umbilical* (*R. umbilicalis*, s. *mesogastrica*). It surrounds the centre of the whole abdomen, like a girdle, and is divided by perpendicular lines into five other regions placed at the side of each other.

The *umbilical region* (*R. umbilicalis*) forms the centre, and is so called because the umbilicus is in it. Those next to it, which comprise the external part of the anterior face and the anterior part of the lateral faces, are the *iliac regions* (*R. iliacæ*). Finally, the posterior parts, which run into each other in the centre of the posterior wall, are called the *lumbar regions* (*R. lumbares*).

The inferior region is termed the *hypogastric region* (*R. hypogastrica*). It comprises the upper but only the anterior part of the abdomen, and is formed of three other regions, the central, the proper *hypogastric region* (*R. hypogastrica stricte sic dicta*), extending from the upper boundary of this region to the pubis, to the anterior edge of the pelvis ; and the two lateral, the *inguinal regions* (*R. inguinales*), which are situated between the preceding and the iliac bones.

At the lower part of the abdomen, or at the pelvis, we distinguish, forward, the *pubic region* (*R. pubis*), which includes the external organs of generation, and is continuous below with the *mons veneris;* backward and downward, below the pubes, between them, the anus and the thighs, the *perinœum* (*perinœum* s. *interfeminœum*) ; and finally, backward, the *nates*.

§ 464. The chest is divided forward, on the sides and upward, into three *mammary regions* (*R. mamillares*), backward, into the *scapular regions* (*R. scapulares*). In the neck also we distinguish forward and downward, the *throat* (*jugulum*); backward, the *nape* (*cervix* s. *nucha*).

§ 465. The *head*, the bulging upper extremity of the trunk, is generally round. It cannot in most of its extent change its form, because its foundation is a bony case, all the parts of which, except the lower maxillary bone, are immovably articulated. It is divided very naturally into two parts, the *skull* (*cranium*), and the *face* (*facies*), the former composed of the brain, the walls of the cavity which contain it, and of the organ of hearing; the latter, of the organ of sight, of smell, of taste, and of mastication.

The *skull* occupies the upper and posterior part of the head and is round. The *face* is situated downward and forward, and is irregularly quadrilateral. The skull is always much larger than the face.

We distinguish in the skull, a lower part or *base* (*basis*), two *lateral faces*, an anterior or *temporal region* (*R. temporalis*, *tempora*), and a posterior or *auricular region* (*R. auricularis*), an *anterior face*, comprising an anterior region, the *forehead* (*R. frontalis*), of which the middle and lower part is termed the *glabella*, and the upper region is called the *sincipital* or *sinciput* (*R. sincipitalis* s. *sinciput*) ; finally, an upper face, the *top* of the head and of the whole body, called the *vertex*, and a *posterior* or *occipital region*, called the *occiput* (*R. occipitalis* s. *occiput*).

The face comprises the *region of the nose* (*R. nasalis*), that *of the mouth* (*R. oralis*), and the region *of the chin* (*mentum*), which are placed above each other on the median line, and also two other lateral regions, of which the upper, called the *cheeks* (*genœ*, *regio jugalis*), comprises almost all the breadth of the face, and the projection caused by the malar bones, while the lower, placed at the two sides of the mouth, and called the *buccal region* (*R. buccalis*), forms the parietes of the *buccal cavity* (*cavum oris*).

The three great cavities of the body, the cavity of the skull, of the chest, and of the abdomen, are also known by the common name of *splanchnic cavities* (*cava*, s. *ventres*). In each is situated one or several of the organs necessary to the preservation of the individual or of the species. The abdomen contains the most essential parts of the digestive apparatus ; and the genital organs are situated within it and in the lower part of its circumference, the pelvis. The heart, and the organs of respiration are placed in the chest ; the vocal apparatus in the neck; and the brain, and the most noble organs of sense in the head.

§ 466. The *members*, *limbs* (*membra*) are distinguished into the *upper* and the *lower*, or the *pectoral*, the *thoracic*, the *abdominal*, and the *pelvic*. They are long, composed of several sections which move upon, and are placed after each other in the trunk, and are articulated so as to perform motions as a whole or as different parts. They are formed essentially of bones which occupy their centre; of muscles and of tendons, which cover the different bones and direct their motions; of fibrous and of synovial ligaments which unite the bones together; of nerves; of vessels; of the skin which covers all these parts, and of cellular tissue which unites them as a whole, and at the same time separates them from each other. The parts composing the limbs become smaller and more feeble, as the distance from the trunk increases; but all the systems which compose them unite in the same proportion, so that their motions also are more extensive. Farther, the upper and the lower limbs correspond perfectly, not only in the number and the volume of their dimensions, but in the general arrangement of their different systems.

The parts of the upper limbs, after leaving the trunk, are,

1st. The *shoulder*, the under part of which is indented, and is termed the *arm-pit* (*fovea axillaris*).

2d. Of the *arm* (*brachium*).

3d. Of the *elbow* (*cubitus*), the union of the arm with the next portion.

4th. Of the *fore-arm* (*antibrachium*).

5th. Of the *hand* (*manus*).

The hand is divided into three parts, the upper, the shortest, which is called the *wrist* (*carpus*), the middle, the *metacarpus*, and the anterior, which is the longest and is composed of the *fingers* (*digiti*). Each finger comprises three divisions, termed *phalanges;* the *thumb* (*pollex*), however, has only two.

We distinguish in the arm four faces, the *external* (*regio* s. *facies externa*, s. *extensoria*), the *internal* (*regio* s. *facies interna*, s. *flexoria*), the *anterior* (*regio* s. *facies anterior*, s. *abductoria*), and the *posterior* (*regio* s. *facies posterior*, s. *adductoria*); in the fore-arm, only two, the *external*, and the *internal;* four in the hand, the *anterior* or the *radial* (*margo anterior*, s. *radialis*), the *posterior* or *ulnar* (*margo posterior*, s. *cubitalis*), the *external* or the *upper*, called also the *back of the hand* (*facies externa*, s. *superior*, s. *dorsum*), and the *internal* or *inferior*, called *the palm of the hand* (*facies interna*, s. *inferior*, s. *vola*).

The following are the divisions of the lower limbs:

1st. The *thigh* (*femur*).

2d. The *knee* (*genu*), the articulation of the thigh with the leg, the under part being called the *ham* (*poples*, s. *fossa genu*).

3d. The *leg* (*crus*), its upper and posterior fleshy part, being called the *calf* (*sura*).

4th. The *foot* (*pes*), which is sub-divided into the *tarsus*, the *metatarsus*, and the *toes* (*digiti pedis*); these last are composed of *phalanges* arranged in the same manner as those of the fingers.

The inferior limbs are characterized by firmness and strength, and the superior by suppleness and mobility; the former serve to move and support the body, the latter to grasp external objects. The pelvic are usually much larger than the pectoral limbs; some of their parts, however, as the toes, are less developed and smaller than the fingers.

§ 467. The configuration of the body presents remarkable differences at different periods of life, in respect to the forms and sizes of its component parts.(1)

At first, the anterior and the posterior faces of the body are divided longitudinally on the median line.

In a full grown man, the length of the head is one seventh of that of the whole body, measured from the vertex to the toes, and the space between the extended arms almost equals this length.

At first, the head cannot be distinguished from the rest of the body; hence, it increases very much in size afterwards. The neck is not separate from the trunk. We see no trace of the limbs. These do not appear till the sixteenth week, and then as small stumps, the superior being larger than the inferior. In the adult, the pelvic members are some inches longer than the thoracic; but in the fetus, the pectoral are longer until the eighth month, so that the want of proportion gradually diminishes. Until the age of five years, the four limbs have nearly the same length; but at this period, the inferior gradually lengthen, so that when fully developed, they are as long as the trunk and the head together.

In the early periods of existence, all the lower half of the body, in proportion to the upper, is generally much smaller than in the adult.

The abdomen projects considerably, not only from the greater development of the liver, but also because the smallness of the cavity of the pelvis does not allow the bladder and the internal organs of generation of the female to descend into the cavity of the pelvis.

The lumbar portion however is then much longer in proportion than in the adult, owing, no doubt, to the great size of the liver, as also to the slight development of the respiratory organs, and of the cavity of the chest, which is not only lower, but flatter.

The principal sexual differences are,(2) besides those already mentioned, the considerable size of the skull in relation to the face, and of the head in proportion to the rest of the body, the smaller size of the thoracic cavity, the greater uniform breadth of every part of the abdominal cavity in the female, while it is narrower upward, and broader downward, in man; the greater length, and finally, the capacity of the pelvis, which is much greater in every respect, in the female.

(1) Sue, *Sur les proportions du squelette de l'homme, examiné depuis l'âge le plus tendre jusqu'à celui de vingt-cinq, soixante, et au-delà*, in the *Mém. présentés de Paris*, vol. ii. p. 572.

(2) Ackermann, *De discrimine sexuum præter genitalia*, Mayence, 1788.

From this, it happens that when a man lies on his back, the anterior face of his chest projects above the symphisis pubis, which is not the case in the female.

§ 468. Such is the normal form of the human body; but it offers numerous anomalies, of which we shall briefly state those only which are primitive.

1st. *Of the Anomalies in quantity.*

A. Imperfect development. This anomaly is greatest when the upper part of the body is deficient to a greater or less extent, constituting *acephalia.*(1)

This monstrosity can exist in an infinite number of degrees, from the existence of only one inferior limb to a slight defect in the formation of the bones of the skull, by which its cavity is imperfectly closed. It is divided into *true* and *false acephalia* (*A. vera et spuria*); the latter, however, should be called simply *acrania, anencephalia.* Sometimes more than the head is deficient in true acephalia. The reverse of the imperfect development of the skull is that of the face, distinguished principally by the union of the two eyes or of the two cavities of the nose, the smallness or absence of the lower jaw.

The reverse of the imperfect development of the upper part of the body is that of the lower part, consisting essentially in the union of the two legs into one, placed on the median line, at the same time being bent, so that its anterior face becomes posterior, and the posterior, anterior.

Here we may remark generally, that the imperfect development of the lower portion of the body never exists to so great a degree as that of the upper part, which is probably owing to the laws of formation; for in birds, at least, the trunk seems to be formed from below, upward.

The imperfect development of the anterior and posterior faces of the body is shown by the want of union between the two lateral halves, and by the imperfect formation of the cavities by fissures; in the head, by the fissure of the skull in false acephalia, and by the different degrees of the want of union between the two portions of the palate; in the trunk, by the spina bifida posteriorly, and anteriorly by fissures of the chest and abdomen, through which the different viscera protrude. These fissures arise by the part remaining stationary at some of the degrees through which it passes. We are not however authorized by any phenomenon to admit with Tiedemann,(2) that they are caused by a want of development in those vessels which in the normal state unite on the median line. It is much more correct to consider the deviations

(1) Mappus, *De acephalis.*—Meckel, *Beyträge zur vergleichenden Anatomie*, 1808, vol. i. part ii.—Id., *Pathologische Anatomie*, 1812, vol. i. ch. iii. and iv.—Tiedemann, *Anatomie der kopflosen Missgeburten*, Landshut, 1814.—P. Hostecks, *Diss. de monstrositatum origine*, Berlin, 1819.—F. Feiler, *Ueber angeborne menschliche Missbildungen*, Leipsick, 1820.—Geoffry St. Hilaire, *Philosophie anatomique; monstruosités humaines*, Paris, 1823.—Serres, *Essai d'une théorie anatomique dés monstruosités animales;* in the *Bulletin de la soc. méd. d'Em.*, September, 1821.—Dugès, *Considérations sur les causes et les différences des monstruosités du crâne et du rachis chez le fœtus;* in the *Revue médicale*, vol. x. p. 353.

(2) *Anatomie der kopflosen Missgeburten*, p. 105.

of formation of all the parts situated near the fissure as the common effects of one and the same cause. We pass over the fissures in some particular organs which coincide with these monstrosities.

The imperfect development of the limbs, which presents so many degrees, expresses that of the two sides of the body. Sometimes all the limbs are totally wanting, and again, one only is deficient, either in whole or in part; they often present only some defect in their development.

§ 469. *B.* The *abnormal redundance* in the number of the organs is the reverse of their imperfect development. This deviation of formation presents numerous varieties. They relate principally to the manner in which the supernumerary parts unite with the others; this permits the abnormal redundance to be divided into *common* and *generic*. In the former, the redundant organs are united to the others in the same manner as the latter are joined together. In the latter, they are united the same as the fetus is with the organism of the mother.

The principal circumstances of the common redundance are:

1st. The degree varies both in the number and development of the parts.

α. The redundant parts rarely, perhaps never, are more than double, so that it may also be called *doubling*.

β. This doubling extends to some small part of the body more frequently than to a greater extent; for the smaller organs are double more frequently than those which are larger. The fingers are redundant more frequently than an entire limb, a trunk, or a head.

γ. The supernumerary part is often below the standard, in regard to the size and number of the parts which compose it. The supernumerary fingers are often only fleshy appendages; their bones, simply the excresences of a normal bone, &c. The redundancy, however, extends to an entire region more frequently than to a single system. If the number of vertebræ be increased by one, we find the same increase in the nerves, the vessels, and the muscular slips of the same region.

2d. The external parts alone are double much more frequently than the internal, or the central parts present this anomaly, no similar one being presented externally. Hence, we find supernumerary fingers (*digiti*) more frequently than abnormal vertebræ; the former exist often, even without any increase in the number of the corresponding parts of the metatarsus, the metacarpus, the tarsus, and the carpus, while the contrary never occurs. So likewise we not unfrequently find more than two mammæ, while a redundancy of the viscera is very extraordinary.

3d. Those parts which in the normal state are numerous are abnormal much more frequently than those which are single, or at most double. Hence we find supernumerary fingers, toes, or teeth, much more frequently than other parts.

4th. The most complex parts are doubled less frequently than those of simpler structure.

5th. A multiplication in one part is usually attended with a diminution in number or in development in another part.

6th. The multiplication of the whole body takes place, 1st, in the dimension of thickness, forward or backward ; 2d, in the dimension of length, upward or downward ; 3d, in the dimension of breadth, on the right or left side.

§ 470. *a. Alterations in regard to quality.* This section comprises two classes of anomalies, those in regard to the *form* or to the *situation*, or to both at the same time.

α. Anomalies in form are seen in the division of parts naturally *simple*, or in the union of parts generally separated. The vascular system, the osseous system, and the spleen, furnish us with examples of the first, the same two systems and the kidneys present instances of the second.

β. Anomalies in situation alone are rarely primitive, in the strictest sense, although often met with as resulting from retarded development. We however find sometimes a greater or less portion of the intestinal canal in the chest, the kidneys situated lower than usual, the heart too low, and sometimes, though very rarely, even in the abdomen.

γ. The inversion of parts ought to be considered as the union of anomalies in situation and form, since we not only find in the left side parts which should be in the right, and *vice versa*, but they are also formed of a directly opposite type. This lateral inversion also presents very different degrees. The inversion from before backward resembles that from one side to the other ; it takes place in the greatest degree, when the upper half of the body is turned forward and the lower backward. Inversion from before backward is also seen in the surface of the body ; the other is not apparent externally, as it affects only the asymmetrical organs.

b. The second species of anomaly relative to the quality or *hermaphrodism*, is seen in the general form, independently of the genital organs, either when the body externally is of a character contrary to that of the sex (*viragines et mares effeminati*), or when a part of the body is formed in the type of the male, and the other in that of the female.

DESCRIPTIVE ANATOMY.

PART II.

OF THE TOPOGRAPHY OF THE ORGANIC SYSTEMS.

BOOK I.

OF OSTEOLOGY.

§ 471. The topography of the *osseous system*(1) should precede that of all the other organic systems, since the situation, the direction, and

(1) Besides the books already mentioned, those most in repute upon osteology are,

A. DESCRIPTIVE.

Hippocrates, *De articulis liber*, in *Opp. omn.*, Venice, 1526.—A. C. Celsus, *De re medicâ liber octavus, editio nova curante Fouquier et Ratier*, Paris, 1823, 8vo.—Galen, *De ossibus*, Lyons, 1535.—J. Sylvius, *In Galenum de ossibus commentarii*, Paris, 1561.—Fallopius, *Expositio in librum Galeni de Ossibus*, Venice, 1571.—Eustachius, *Ossium examen*, in *Opuscul. anat.*, 1726.—P. Paaw, *Primitiæ anatomiæ de humani corporis ossibus*, Leyden, 1615.—Riolan, *Osteologia ex veterum et recentiorum præceptis descripta*, Paris, 1614, in 8vo.—Leclerc, *Ostéologie exacte et complète*, Paris, 1706, in 8vo.—B. S. Albinus, *De ossibus corporis humani*, Leyden, 1746.—Boehmer, *Institutiones osteologicæ*, Halle, 1751.—Tarin, *Ostéographie*, or *Description des os de l'adulte, du fœtus*, &c., Paris, 1753.—B. S. Albinus, *De sceleto humano*, Leyden, 1762.—J. T. Walter, *Abhandlung von trocknen Knochen des menschlichen Körpers*, Berlin, 1763.—Lecat, *Cours abrégé d'ostéologie*, Rouen, 1763.—Knackstedt, *Osteologie oder Beschreibung der Knochen des menschlichen Körpers*, Brunswick, 1781.—C. T. Hoffmann, *Succincta descriptio ossium et musculorum*, Nuremberg, 1783.—Sandifort, *Descriptio ossium hominis*, Leyden, 1785.—Berholdi, *Initia doctrinæ de ossibus et ligamentis corporis humani*, Nuremberg, 1794.—Sonnenburg, *Compendium syndesmo-osteologicum*, Berlin, 1797, one of the most remarkable productions of medical literature.

B. PLATES.

B. S. Albinus, *Tabulæ sceleti et musculorum*, Leyden, 1747; *Tabulæ ossium humanorum*, Leyden, 1753.—G. G. Muller, *XXIV. Kupfertafeln, welche die Knochen das ganzen menschlichen Körpers vorstellen*, Francfort, 1749.—Trew, *Tabulæ osteologicæ*, Nuremberg, 1767.—Innes, *Eight anatomical tables of the human body*, Edinburgh, 1776.—Loschge, *Die Knochen des menschlichen Körpers und ihre vorzugl. Bander*, Erlangen, 1789.—E. Mitchell, *A series of engravings respecting the bones of the human skeleton*, Edinburgh, 1820.

C. DIFFERENCES IN REGARD TO SEX.

Ackermann, *De discrimine sexuum præter genitalia*, Wurzbourg, 1788.—Sœmmerring, *Tabulæ sceleti feminini*, Francfort, 1797.

D. DIFFERENCES IN REGARD TO RACES.

Sœmmering, *Ueber die hörperlichen Verschiedenheit des Europaers vom Neger*, Francfort, 1785. Other descriptions and plates refer solely to the cranium, and will the forms of the latter, are for the most part determined by those of this system.

§ 472. The number of the bones in the normal state amounts to two hundred and fifty-six, fifty-six of which belong to the trunk, sixty-six to the head, sixty-eight to the upper, and sixty-six to the lower extremities.

The bones of the trunk are,

1st. The twenty-four *vertebræ*.

2d. The *sacrum*.

3d. The four bones of the *coccyx*.

4th. The twenty-four *ribs*.

5th. The three bones of the *sternum*.

The bones of the head are,

1st. The seven bones of the skull, viz. the *spheno-occipital* bone, the two *temporal* bones, the two *parietal* bones, the *frontal* bone, and the *ethmoid* bone.

2d. The four bones of the ear; the *malleus*, the *incus*, the *stapes*, and the *os orbiculare*.

3d. The fourteen bones of the face; the two *upper maxillary* bones, the two *malar* bones, the two *palate* bones, the two *nasal* bones, the two *lower turbinated* bones, the two *lachrymal bones*, the *vomer*, and the *lower maxillary bone*.

4th. The thirty-two *teeth*.

5th. The five pieces of the *hyoid* bone, a central and four lateral pieces.

The bones of the upper extremities are,

1st. The two bones of the shoulder, the *clavicle* and the *scapula*.

2d. One to the arm, the *humerus*.

3d. Two to the fore-arm, the *radius* and the *cubitus* or *ulna*.

4th. Eight to the carpus, the *scaphoid* bone, the *semi-lunar* bone, the *pyramidal* bone, and the *pisiform* bone, the *trapezium*, the *trapezoides*, the *os magnum*, and the *unciform* bone.

5th. Five to the metacarpus.

6th. To the fingers, fourteen *phalanges*, two of which are for the thumb, and three for each of the fingers. Finally,

7th. Two *sesamoid* bones.

The bones of the lower extremities are,

1st. One to the haunch, the *coxal* or *iliac* bone (*os innominatum*).

2d. One to the thigh, the *femur*.

3d. Three to the leg, the *tibia*, the *fibula*, and the *rotula* or *patella*.

4th. Seven to the tarsus, the *astragalus*, the *calcaneum*, the *scaphoides*, the *cuboides*, and the three *cuneiform* bones.

5th. Five to the metatarsus.

be pointed out hereafter. Some also treat of the differences in the bones during their development, and also of their diseases.

E. We have already mentioned the general works in the diseases of the bones. In describing each bone we shall mention those in which details of their anomalies may be found.

6th. To the toes, the fourteen *phalanges*, arranged as in the hand. Finally,

7th. Two *sesamoid* bones.

Most of these bones exist in pairs, that is, one on each side. Thirty-eight are single and situated on the median line, but are, however, formed of a right and a left similar half; we have as examples, all the bones of the vertebral column, the pieces of the sternum, the middle piece of the hyoid bone, the vomer, the spheno-occipital bone, the frontal bone, the ethmoid bone, and the lower maxillary bone. We shall leave the teeth, until we treat of the alimentary canal.

The order in which the bones are formed calls our attention, first, to the bones of the trunk, not only because this region is first developed, but because many of the other bones of the body, particularly those of the head, are formed in their type.

SECTION I.

OF THE BONES OF THE TRUNK.

§ 473. The bones of the trunk may be divided into two classes; the *essential* or the *primitive bones*, and the *accessory* or the *secondary bones*. The first comprise those forming the vertebral column (*columna vertebralis*), the second, those situated opposite this column, and those which unite these to the spine. The first comprehends the *vertebræ*, the *os sacrum*, the *ossa coccygis*; the second, the *sternum*, and the *ribs*.

CHAPTER I.

OF THE PRIMITIVE BONES OF THE TRUNK, OR OF THE VERTEBRAL COLUMN.

ARTICLE FIRST.

GENERAL REMARKS ON THE PRIMITIVE BONES.

§ 474. The *vertebral column*(1) occupies the centre of the posterior face of the trunk, and determines its length. When perfectly developed, it is composed of twenty-nine, rarely of thirty bones. The upper twenty-four bones are called the true *vertebræ* (*vertebræ veræ*), the twenty-fifth is the *sacrum*, and the four lower bones belong to the *coc-*

(1) For some remarks on the vertebræ considered in the whole animal series, and for the different osseus parts or organic elements which form them in their state of perfect development, and before all fusion caused by the rudimentary state of some one of these elements, see the *Considérations générales sur la vertèbre*, by Geoffroy St. Hilaire, in the *Mémoires du Muséum*, vol. ix. p. 89.

cyx. The first twenty-four vertebræ are called *true* vertebræ, to distinguish them from those pieces of bone composing the sacrum, which are, at first, so many vertebræ, but become fused into a single bone when the body is entirely developed, and hence are called *false* vertebræ. All the bones which form the vertebral column are arranged one upon another, covering each other reciprocally and intimately united, so that the dimension in length is much greater than any other in the column they form; each piece possesses but a slight degree of mobility, and this degree varies in the different regions. The vertebral column does not describe a perfectly straight line but a curve, for its superior or *cervical* portion (*pars cervicalis*) is convex forward, and concave backward, the *dorsal*, *thoracic*, or *pectoral* portion (*pars dorsalis*, s. *thoracica*, s. *pectoralis*) is concave forward, the *lumbar* or the *abdominal* portion (*pars lumbaris*, s. *abdominalis*) is convex forward, and concave backward and, finally, the *sacral* part (*pars sacralis*) is very concave forward, and convex backward. This curve is most marked in the sacral and in the lumbar regions.

I. GENERAL CHARACTER OF THE BONES OF THE VERTEBRAL COLUMN.

§ 475. All bones of the vertebral column present certain general characters. If we include the pieces of the coccyx among them, we can make no general remark, except that they have a rounded form; but when the coccyx is not included, we can assign to them characters much more precise. The most general condition of all the vertebræ is their annular form. This ring, the opening of which is always very considerable in proportion to the mass which forms it, gives support to several processes. The annular form is connected with one of the uses of the vertebral column, which is to lodge the spinal marrow. The name of *medullary foramen* (*foramen pro medulla spinali*, *foramen medullare*) is applied to the hole in each of the vertebræ, and that of *medullary canal* (*canalis pro medulla spinali*) to the channel resulting from the union of all the foramina of the vertebræ placed one upon the other.

The part of the vertebral column situated before the spinal marrow, is, except in one place, the strongest and thickest; hence it is called the *body of the vertebra* (*corpus vertebræ*). It is always a little narrower on its anterior face and its two sides, so that its superior and its inferior faces project slightly beyond the lateral faces. The remainder of the lateral portion and all the posterior part of the vertebra is called the *arch* (*arcus*). The body is always straight and transverse, and the arch very convex. The processes on one hand contribute to a second use of the vertebral column, that of giving attachments to the muscles, which move it, the ribs and the skull, and also to strengthen the union of the vertebræ. They may then be divided into *articular* and *muscular* processes (*processus articulares et musculares*), according to their principal uses, though all seem to fulfill these two functions at the same time. The processes originate only from the arches of the vertebræ.

There are always seven processes. Four are *articular*, (*processus articulares, condyloidei*), these are also called the *oblique processes* (*P. obliqui*), and derive their name from the direction of their cartilaginous articular surfaces; we find on each side a superior and an inferior, which arise from the lateral part of the arch. Of the other three which are *muscular*, two, one on the right, the other on the left, arise transversely from the arch, between the superior and the inferior articular processes; these are called the *transverse processes* (*P. transversi*) from their direction.

The third is situated on the median line; it arises from the middle of the posterior portion of the arch and proceeds backward. It has been called the *spinous process* (*P. spinosus*), as it is very long and pointed in many of the vertebræ.

In all the muscular processes we distinguish a *base* (*basis*), and a summit (*apex*).

Between the base or the anterior extremity of the arch of the vertebræ and the two articular processes of each side, the upper and the lower edge of the arch present *grooves* (*incisura vertebralis*); when the vertebræ are fitted to each other, these grooves form the *holes of conjunction*, or *the intervertebral foramina* (*foramina intervertebralia*), which communicate with the interior of the spinal canal, and through which the spinal nerves emerge.

§ 476. All the vertebræ are united, in the main, in the same manner and at the same points. The upper and the lower faces of the bodies are firmly attached to each other in their whole extent, by the fibro-cartilages which admit of but slight motion. The arches and spinous processes are united by fibrous ligaments, and the articular or oblique processes are connected together by capsules.

II. OF THEIR DEVELOPMENT.

§ 477. Besides these general characters presented by the vertebræ when perfectly formed, they resemble each other in the essential characters of their mode of development. In fact, they are always formed of at least three pieces; a middle piece corresponding to the body, and two posterior and lateral pieces representing the two halves of the arch. Each probably arises by six or eight pieces, since we find a small nucleus of bone at the extremities of the spinous and of the transverse processes, and also on the upper and on the lower face of the body. We have observed this in the bodies of several individuals eighteen years old, and the facts mentioned by Ungebauer(1) accord with our own experience. Perhaps by examining the vertebræ in young subjects we shall ascertain that the body is formed by the union of the two lateral portions,(2) at least we have found this to be the case in

(1) *Epistola osteologica de ossium trunci corporis humani sero osseis visis earumdemque genesi*, Leipsic, 1739.

(2) Béclard thinks differently, he adduces an argument drawn from the anterior *spina bifida*, which very rarely, although sometimes, occurs, and in the neck only, because the fore part of the vertebral column developing itself from the centre to-

the upper pieces of the coccyx, and several times even in the body of the first cervical vertebra, and also in the odontoid process of the second. The analogy of the sternum and of the spheno-occipital bone also leads us to believe that this is the case in all. Then the number of points of ossification is not three, as is generally asserted, but nine, or more properly speaking, eight. The lateral portions begin to appear at the third month; the body shows itself later. The terminal points of ossification of which we spoke are not visible till long after birth; for in the full-grown fetus the processes of the vertebræ are not ossified. When the child is born, the different osseous points are still perfectly distinct.

III. OF THE SEXUAL DIFFERENCES.

§ 478. The bodies of the vertebræ are flatter, the transverse processes stronger and straighter in the male. In the female, these last are inclined a little backward so that the groove between them and the arch is deeper; the spinal canal and the inter-vertebral foramen are also broader.

ARTICLE SECOND.

OF THE DIFFERENCES BETWEEN THE TRUE AND THE FALSE VERTEBRÆ.

§ 479. The characters hitherto mentioned apply both to the true and to the false vertebræ.

The true vertebræ differ from the false vertebræ of the sacrum, as they are not fused together when fully developed. We must however remark, that, after the age of fifty, we often find the true vertebræ united in one or many parts of the vertebral column.

The true are also distinguished from the false vertebræ in their mode of ossification. In the normal state, the lateral portions unite on the median line, to form one piece before blending with the body; in the sacrum, however, they are separated from one another long after they are united to the body.

wards the two extremities, while the posterior lateral parts are developed successively from above downward, this separation ought to occur backward and downward, which is most common, or forward and upward. He rejects also analogous proofs drawn from the anatomy of tetards, of birds, and of rabbits, as resting on erroneous observations. Having studied the commencement of ossification in the bodies of the vertebræ of the tetard and frog, he observed that it was a single point; the same occurs also in the other batracia, in the mammalia, and in birds. As to the cause of error, he thinks it arises from making observations upon subjects too young, and from considering the peduncle of each apophysis as the commencement of the body. On this subject we must remark, that in those animals which have a horizontal position, the body of the vertebra being the least important part, is developed the last, by a relatively smaller point, while in man the reverse is true, especially in regard to the lumbar, the sacral, and the inferior dorsal vertebræ. See *Nouveau Journal de médecine*, vol. viii. 1820, p. 82. F. T.

ARTICLE THIRD.

PARTICULARS OF THE TRUE VERTEBRÆ.

§ 480. The true vertebræ are divided into the *cervical* (*vertebræ cervicales*), the *thoracic*, or the *dorsal* (*V. thoracicæ*, *dorsales*), and the *lumbar* (*V. lumbares*) vertebræ, according to the region of the trunk which they occupy. We number seven cervical, twelve dorsal, and five lumbar vertebræ. They differ very much in their size and thickness, in their form, and the size of the spinal canal, and finally in the form and proportion of their parts.

§ 481. 1st. The vertebræ gradually increase very much in size from above downward, so that the cervical are the smallest, and the lumbar vertebræ the largest. The bodies particularly become broader, higher, and thicker. A lumbar vertebra is four times as massive as a cervical vertebra.

§ 482. 2d. The spinal canal is smaller and rounder in the dorsal vertebræ, particularly in the central; it is largest in the upper lumbar vertebræ. In fact, that of the first cervical vertebra is much larger than any of the others, but this canal is not entirely filled with the spinal marrow. This opening is more oblique in the upper lumbar vertebræ; in the lower lumbar, and in the cervical vertebræ, it has a triangular form, the summit of which is directed backward.

§ 483. 3d. *a.* The bodies of the different vertebræ differ from each other in several respects. In the cervical vertebræ, this part is not only smallest but it is very low in proportion to their depth and breadth. The upper face is a little concave from before backward, and especially from right to left, for the two lateral edges are very much raised above its level; it also inclines forward. The lower face is equally and even still more inclined in the same direction, but a little flattened towards its lateral edges.

The upper face of the upper dorsal vertebræ offers but slight traces of this arrangement of the body. In them, the upper and lower faces are perfectly straight, except in the centre, where they are a little depressed.

The bodies of the dorsal vertebræ become much thicker from before backward, and from above downward, less from one side to the other, so that the body of the middle is narrower than that of the upper dorsal vertebra,and of the lower cervical vertebra, but the inferior are the largest in every sense.

The contraction of the body mentioned before is marked most strongly in the dorsal, and least in the cervical vertebræ.

The bodies of the dorsal vertebræ are particularly distinguished from those of all others by having small articular surfaces situated on the sides, immediately before the union of these same bodies with the two portions of the posterior arches. We generally find an upperand a lower, on each side of the body the former being continuous with the upper edge, and the latter with the lower edge of the lateral face. Each of these facets is imperfect; they do not become complete until they unite to the corresponding facet of the vertebra below, so as to form with it only one cavity, composed of the two portions joined together at an obtuse angle, the upper being the smaller and the inferior the larger. In the last three vertebræ, we find on each side only one of these articulating surfaces. The tenth has only the usual upper semi-facet which unites with the inferior facet of the ninth. On the eleventh and twelfth, we see one only, which is straight and separated with the upper edge. Hence why those of the superior ten dorsal vertebræ are called *common lateral articular facets*, and those of the last two, the *proper lateral articular facets* (*facies articulares laterales communes et propriæ*). They receive the heads of the ribs.

§ 484. *b.* The processes of the vertebræ differ considerably.

First, of the articular processes. The *articular processes* are less oblique in the cervical vertebræ; their direction in the first two is almost horizontal. In the dorsal vertebræ, especially the lower, they are almost perpendicular; the same is true also of the lumbar vertebræ. Their articular surfaces are arranged in the cervical vertebræ, so that the superior look upward and backward, the inferior downward and forward. In the dorsal vertebræ the superior are turned directly backward, the inferior directly forward. In the lumbar vertebræ the superior are directed inward, and the inferior outward. The last vertebra in this region is the only one which in some measure resembles the formation of the dorsal vertebræ in this respect.

The articular facets of the lumbar vertebræ are the strongest and highest, and those of the cervical vertebræ are the most feeble. The broadest are found in the first vertebra of the neck.

These surfaces also vary in form. They are straight in all the cervical and dorsal vertebræ, while in the lumbar vertebræ the superior are concave, and the inferior convex. Those of the first cervical vertebra are very deep.

In the cervical vertebræ, excepting the first, and in the upper dorsal vertebræ their greatest breadth is from one side to the other, and in the inferior dorsal and in the lumbar vertebra it is greatest from above downward. In the first cervical vertebra, the superior are broader from before backward than from one side to the other, while the inferior are round, as are also the superior of the second cervical vertebra, which correspond to them.

The form and proportions of the articular processes and of their surfaces admit then of only one movement in the lumbar region, viz. from above, downward; while they have also a lateral motion in the regions of the back and the neck. At the lower part of the dorsal region, the motion from above downward is very limited by the height of the processes and by their greater perpendicular direction, and the lateral motion by the backward direction of the transverse processes which closely connect the joint. The vertebræ of the neck have the most motion, because, their surfaces being more horizontal, their articular processes are shorter.

§ 485. The transverse processes present no less remarkable differences.

The longest and strongest are those of the upper and middle dorsal and the superior lumbar vertebræ. Those of the cervical vertebræ are shorter, except those of the first, which are long. The smallest are those of the last two dorsal vertebræ.

Their direction varies. In the cervical vertebræ they are directed forward; in the dorsal vertebræ, especially the inferior, backward; and in the lumbar vertebræ they are more transverse, and incline also a little backward.

They differ still more in their form. In this respect the cervical vertebræ are distinguished from the others, as their transverse processes are perforated from above downward, and a round canal is formed, which is sometimes divided by a transverse ridge of bone into an anterior and a posterior part, the latter being generally the smaller. This canal gives passage to the vertebral artery, and hence has been called the *vertebral canal* (*foramen vertebrale*). Hence why the transverse processes are considerably broader from before backward, and why their anterior and posterior edges, especially in the lower five cervical vertebræ, are more or less curved upward; they form a groove in which the nerve from the spinal canal crosses the direction of the vertebral artery which passes before it.

This groove is strongly marked in the sixth cervical vertebra. That part only of the transverse process which is situated behind the vertebral canal corresponds to the transverse processes of the other vertebræ. The anterior corresponds to the ribs; however, the former is usually called the *posterior* root, and the latter the *anterior* root, of the transverse process.

The outer part of the vertebral foramen is sometimes imperfect. The first cervical vertebra is the only one in which the portion of the transverse process situated outside of this opening, and which is considerably broad from before backward, is at the same time very broad from without inward.

The transverse processes of the dorsal vertebræ are the most massive. They are not terminated externally by a point, as are those of the other vertebræ, but gradually swell out, and their thickness equals or nearly equals their breadth. The upper ten are distinguished from the others, as we perceive on the anterior face of their summits an articular surface (*facies articularis transversalis*) covered with cartilage, which unites to the tubercles of the ribs. This surface is concave in the upper vertebræ, but plane and often convex in the lower; in the upper it is turned forward and upward, in the others its direction becomes more and more oblique outward and downward. Its extent also diminishes as it approaches the loins.

The transverse processes of the lumbar vertebræ increase in length from the first to the third, and afterwards shorten from the latter to the fifth, so that in this last they form only small thin points. They are very much compressed from before backward, and consequently are much weaker than those of the dorsal vertebræ. Their base usually projects at its posterior part into a small tubercle called the *accessory process* (*processus accessorius*), which is found in these vertebræ only.

§ 486. The spinous processes of the cervical vertebræ are thinner upward than downward, and broader across than those of all the other vertebræ; their superior face is convex, and the inferior concave; their posterior extremity terminates in two teeth, one on the right, the other on the left, which diverge, and are often bifurcated. They increase much in length from the first cervical vertebra, and are almost horizontal, although a little inclined downward. We shall mention their differences in the first, second, and seventh cervical vertebræ when describing these vertebræ.

The spinous processes of the dorsal vertebræ are the longest of all: they lengthen especially from the first vertebra to the seventh; at the same time they are thicker and triangular. The upper ones are the broadest in proportion to their height; but they gradually become thinner, so that at last their upper edge is sharp. Slightly contracted in the middle, they always swell out at their point, and terminate in a single small tubercle.

The spinous processes of the lumbar vertebræ are a little longer than those of the last three dorsal, and longer also than those of the cervical vertebræ. They are the highest and most compressed of all, so that in this respect they offer an arrangement contrary to that seen in the spinous processes of those of the neck. Their direction differs from that of the others: it is not directly backward, or backward and downward, but is from behind forward, and from below upward.

ARTICLE FOURTH.

OF THE SPECIAL CHARACTERS OF SOME OF THE TRUE VERTEBRÆ, VIZ. OF THE FIRST, THE SECOND, AND THE SEVENTH CERVICAL VERTEBRÆ.

§ 487. The first, second, and seventh cervical vertebræ present some peculiarities in their forms, and deserve a separate description.

A. NORMAL STATE.

I. Of the first cervical vertebra.

Although all the cervical vertebræ are characterized by a less difference between the body and the arch, this is much more marked in the first cervical vertebra than in the others. This vertebra is called the *atlas*. Its middle and anterior portion is broader across than in any other direction, as in all the vertebræ, but it is thinner from before backward than the arch itself, which almost equals it in height also. Hence this part is not called the body, but the *anterior arch* (*arcus anterior*). This vertebra is distinguished from all others by the thinness of the superior and inferior edges of its anterior arch, while in the other vertebræ, except the second, the thickness from before backward exceeds the height. These two edges are destitute of cartilage. On the middle of the anterior face is a *small tubercle* (*tuberculum anterius*), to which a slightly concave and cartilaginous *articular facet* (*sinus atlantis*, s. *medius*) on the posterior face corresponds.

The posterior arch is more oblique than in all the other vertebræ. From its centre arises a *tubercle* (*tuberculum posterius*) which frequently is almost imperceptible, but sometimes it also bifurcated, and goes horizontally backward.

The anterior parts of the posterior arch, which support the transverse and articular processes, are much stronger in proportion to the other parts of the atlas than in the other vertebræ; hence they are termed the *lateral masses* (*massæ laterales*). We have already mentioned the form and arrangement of the articular processes. Behind each process, and not, as in the other vertebræ, before each one or between it and the body, is a slight depression, forming the *upper intervertebral groove* (*incisura intervertebralis superior*, s. *sinus lateralis*, s. *posterior*), which gives passage not only to the first spinal nerve, but also to the vertebral artery and vein. This groove is sometimes changed into a canal by a ridge of bone which extends from the posterior extremity of the upper articular process to its posterior edge. Sometimes also another ridge of bone detaches itself from the posterior root of the transverse process, and extends to the posterior edge of the posterior arch, also forming a small canal. The upper articular surface is here directly continuous with the body, while in the other vertebræ it is separated from it by a groove. In the centre of the internal face of the lateral masses, we observe a considerable depression and asperities which are seen only in the atlas.

The first cervical vertebra is the broadest of all, if we except the third lumbar vertebra. This circumstance is not to be ascribed, as in the other vertebræ, to the breadth of its body or to the length of its transverse processes, but to the great development of its articular surfaces, which depends upon its articulation with the occipital bone.

The first cervical vertebra differs from the others in its mode of articulation by the greater looseness in the parts which hold it. In fact the upper and lower edges of the posterior arch are not connected with the occipital foramen and with the body of the second vertebra by a fibro-cartilage, but by much weaker fibres.

II. Of the second cervical vertebra.

§ 488. The second cervical vertebra is distinguished from the others particularly by the height of its body, which is elevated considerably above its articular parts. This projection is called the *odontoid* *process* (*processus odontoïdes*, s. *dens*). It is narrower than the body, and rounded. Above the *base* (*basis*) it becomes narrow; this part is called the *neck* (*collum*). Towards its extremity it bulges again into a *small head* (*capitulum*), and finally terminates in a blunt *summit* (*apex*).

The anterior face of the head presents a slightly convex, smooth, cartilaginous surface, which corresponds to the excavation on the anterior arch of the atlas. A similar one is seen on the posterior face. The odontoid process of the second cervical vertebra seems to divide the body of the first cervical vertebra, to a certain extent, into an anterior and a posterior part, of which the former alone is ossified, while the other is the *transverse ligament of the first cervical vertebra*. In this vertebra also the upper articular surface is uninterruptedly continuous with the body, and sometimes even there is no superior groove behind it, while the inferior groove is found as usual. The upper articular process is not situated above but directly before the lower; so that it is supported on the body which is enlarged laterally, and its weight, consequently that also of the atlas and the cranium, bears upon the body, and not on the feeble and more movable lateral portions.

The anterior face of the body presents two lateral depressions, and above, a longitudinal ridge, which corresponds to the anterior tubercle of the atlas.

The second cervical vertebra is stronger, and its spinous process is longer than those of the other cervical vertebræ, except the last.

The atlas, which articulates with it by means of the odontoid process and the upper articular processes, and the head, which in fact is one with the atlas, rotate upon this vertebra, and turn around its odontoid process as around an axis. Hence it has been called the *axis* (*epistropheus*, *axis*).

The second cervical vertebra differs from all the others in regard to its connections, articulating not only with that which precedes and follows it, but also with the occipital bone, by its upper part; and farther, the upper part of its odontoid process is not connected with the lower edge of the vertebra situated above it.

III. Of the seventh cervical vertebra.

§489. The seventh cervical vertebra presents fewer peculiarities than the first two, and is particularly remarkable as uniting the characters of the cervical and thoracic vertebræ; so that it would be more correct to call it one of the latter; we should then have thirteen dorsal and six cervical vertebræ.(1) It resembles the cervical vertebræ only in the breadth and lowness of its body, and in the existence of the vertebral foramen. But the body of the first dorsal vertebra presents the same form, and the vertebral foramen here loses all its importance, since

(1) This remark is so just, that were it not in obedience to long usage, we should not admit seven cervical and twelve dorsal vertebræ.

the vertebral artery never passes through it,(1) it is frequently deficient, and it sometimes exists in the dorsal vertebræ.

This vertebra resembles the dorsal in the great length of its transverse processes, which on each side suddenly increase at least four lines, while from the second to the sixth cervical vertebra they are of the same or of nearly the same length. It also resembles them in being thrown back, so that the medullary canal is farther backward than in the other vertebræ; because it has on the lower part of the side of its body a small, lateral, articular semi-facet (*facies articularis lateralis*), which forms a complete surface by uniting to the upper semi-facet of of the first dorsal vertebra; and finally because its spinous process suddenly exceeds those of the other cervical vertebræ very much, and, although broader than those of the dorsal vertebræ, is not bifurcated, and is thicker than those of the cervical vertebræ. It has been called the *prominent vertebra* (*vertebra prominens*), because the posterior part of its body projects beyond the other cervical vertebræ.

B. DEVELOPMENT.

§ 490. These three vertebræ differ also from the others in their mode of development.

The atlas is usually formed like the other vertebræ as respects the number of its points of ossification, but differs in regard to the time at which they appear. In the second and seventh cervical vertebræ the number of points of ossification is not the same.

In the other vertebræ the body exists long before the fetus is matured. In the atlas, on the contrary, we have rarely found it before the child is six months old. Of thirty skeletons of full-grown fetuses, and even of children, in one only have we seen a round nucleus of bone, two lines in diameter, in the cartilage of the anterior arch. Even at the age of two or three years, the two lateral masses are frequently united only by a band of cartilage containing one or more irregularly formed osseous nuclei, which are placed one at the side of the other. Some symmetry usually exists between the right and the left half of the body in this respect, so that although ossification often proceeds farther on one side than on the other, it never extends beyond the median line; but in some few instances, even when the cartilage has entirely disappeared, we find the body formed of two very unequal parts, doubtless because of two or more osseous nuclei which are usually found on one side, the internal is united with that of the opposite side sooner than with the nucleus next to it on the same side. At the same time we sometimes perceive a round nucleus of considerable size between the posterior extremities of both sides. This nucleus unites with the halves of the arch much earlier than the anterior, from which it is entirely separated, although by a very thin layer of cartilage, long after the different parts of the other vertebræ are fused in a single piece.

(1) Sœmmerring (*Knochenlehre*, p. 259) has mentioned this, and we have frequently verified his remark.

We have never seen, what Bichat asserts is the most common arrangement, that the atlas is developed by five points of ossification, one for the anterior arch, two for the posterior arch, and one for each of the lateral masses.

The second cervical vertebra is developed, leaving out of view its small processes, by at least five points of ossification, and not by four, as is generally said; for the odontoid process is at first formed of two symmetrical osseous nuclei, which are usually visible at the end of the seventh and even in the middle of the eighth month of uterine existence; they are at first united and much smaller than the nucleus of the body, but exceed it in size in the full-grown fetus, at which period they have long been united. Besides these, two other nuclei probably exist which do not belong to all the other vertebræ; we refer to a large, round, osseous germ, situated forward, between the nucleus of the body, and that of the odontoid process, and the anterior extremity of the lateral mass, and which is much narrower from before backward than the body. We have almost always found it in children less than a year old, and even till the third year, although lessened in size, and to be seen only on one side.(1)

The osseous germs seen first are those of the lateral masses; next we observe that of the body, and then those of the odontoid process; those which appear last are the intermediate germs, which are not developed till after birth.

The halves of the arch in the axis and the atlas unite later than in the other vertebræ, and among all the atlas is that in which they most frequently do not unite on the median line. In the second vertebra the two osseous germs of the odontoid process are first united, then the posterior extremities of the lateral masses fuse. The intermediate germs, which are the last developed, then unite with the body and with the lateral masses; the body is fused with the latter; finally the odontoid process unites also with them, so that the last trace of separation of the different osseous nuclei is a transverse furrow on the anterior face, between the body and the odontoid process.

The seventh cervical vertebra is developed by five points of ossification. Besides the three which usually exist, the anterior circumference of the vertebral canal is already formed in great part in the fetus of seven months, by a separate oblong osseous nucleus, which extends from the lateral parts of the body to the posterior root of the transverse process. The anterior root is then developed separately, while in the other cervical vertebræ it is merely a prolongation, the anterior and internal extremity of the transverse apophysis turned outwardly. Our observations have satisfied us that this arrangement, which Hunauld(2) considers simply as a variety, ought to be regarded as the normal state, as Sue(3) and Nesbitt(4) think, although it is not mentioned in the trea-

(1) Nesbitt (*Osteogenie*, p. 66) mentions these osseous particles as existing also in the fetus at birth; but we have never seen them.
(2) *Mém. de l'ac. des sc.*, 1740. p. 537.
(3) *Mém. prés. à l'ac. de Paris*, vol. ii. p. 572.
(4) *Osteogenie*, p. 66.

tises on osteology. The union does not take place till after the second year. This peculiarity also demonstrates that it would be more proper to regard the last cervical vertebra as the first dorsal; for the small bone in question is evidently a rudiment of a rib, corresponding only to the neck of this rib, but representing it perfectly, and differs from the other ribs because it does not unite to the sternum by means of a cartilage, but fuses regularly with the vertebra to which it is united;(1) but it often remains distinct during life, and elongates itself like a rib.(2) The seventh cervical vertebra approximates those of the neck and back still nearer than they have hitherto appeared, as the anterior root of their transverse process decidedly corresponds to a rib, although it has not been developed by a special point of ossification.

This transition from the cervical to the dorsal vertebræ would seem still more gradual if, as we think ourselves authorized to conclude from facts, the sixth cervical vertebra is also formed by the union of five osseous germs. In a child which died when nine months old, we found a small rounded nucleus of bone on each side, next to the body, in the part corresponding to the anterior and internal extremity of the anterior root. We have even seen traces of this bone in another child, two years old. This nucleus, however, is much smaller than in the seventh vertebra, and there is only a simple layer of cartilage extending from it to the outward extremity of the posterior root, before the vertebral foramen. Besides, judging from the last instance, it never unites just at the posterior root, but the internal extremity of the lateral part glides forward and outward between them.

The second, sixth, and seventh cervical vertebræ resemble each other then very much in their mode of development, so that we are authorized to consider this intermediate rounded nucleus of bone as the rudiment of a rib, although in truth it is very imperfect. We ought also to consider the small lateral germs in the body of the axis as allied to it. It is then somewhat remarkable that they are found exactly in the upper and lower cervical vertebræ; in the latter, because the ribs arise from them; in the former, because the articular portions of the occipital bone and the styloid processes of the temporal bone result from their development and enlargement.*

(1) This peculiarity of the seventh cervical vertebra is important in two respects: first, it establishes between the skeletons of the mammalia and of the other vertebrated animals a greater analogy than has hitherto been admitted; for an analogy to the upper ribs of birds and reptiles had never been found in the mammalia. Secondly, it furnishes a new argument in support of the law that the formations which are transitory in the superior animals become permanent in those of the inferior classes.

(2) Meckel, *Handbuch der pathologischen Anatomie*, vol. ii.—*Deutsches Archiv für die Physiologie*, vol. i. part iv. fig. 6.

* Most anatomists distinguish also,

1st. The *first dorsal* vertebra. It presents an articular face above, and a semi-facet below, on the sides of its body.

2d. The tenth dorsal vertebra. It frequently presents an articular face on both sides of its body.

3d. The eleventh dorsal vertebra. Its body is almost round, and presents an

ARTICLE FIFTH.

OF THE FALSE VERTEBRÆ.

I. OF THE SACRUM.

§ 491. The *sacrum*, or *sacral bone* (*os sacrum, clunium, latum*), follows the last lumbar vertebra, with which it is articulated in the same manner as two vertebræ are united. Although not the last bone of the vertebral column, it however supports it, being the broadest and the strongest.

Its form is irregularly quadrilateral, being larger and thicker upward, but becomes narrower and thinner downward. It resembles a large vertebra formed by the fusion of five placed over each other, and combines all the characters of the true vertebræ. The *sacral canal* (*canalis sacralis*) extends from the upper to the lower extremity, between a central and anterior portion, the *body*, and a thinner posterior portion, the *arch;* this canal gradually contracts, especially from before backward. The upper face of the body is slightly concave, and covered with fibro-cartilage ; the inferior, to which the first piece of the coccyx is attached, is also covered with cartilage. On each side of the arch is detached a transverse process ; in the centre of the arch is a more or less interrupted series of elevations, which represent the spinous processes of the vertebræ. Along this crest we observe on each side, on the posterior face of the arch, another series of small asperities, which correspond to the articular processes. Finally, between these and the body we find holes called *sacral foramina* (*foramina sacralia*), which correspond to the intervertebral foramina.

The differences between the sacrum and a common vertebra arise principally because it is composed of several vertebræ fused together, and because this fusion occurs at points too where there is no union between the true vertebræ.

Hence we find no simple spinous processes, but spines sometimes separated and equal in number to the pieces of the sacrum, and sometimes all or many of them fused together in a *crest* (*crista*).

The articular processes are fused, and instead of them are tubercles sometimes hardly perceptible. The two upper and the two lower are very distinct, and are called the *horns of the sacrum* (*cornua sacralia*). We usually find, instead of the broad, loose, and cartilaginous articular surfaces, only sharp and slightly projecting edges ; sometimes

entire articular surface on each side; its transverse processes are very short, and have no articulating surface.

4th. The twelfth resembles the eleventh; but its lower articular process is convex and looks outward.

5th. The fifth lumbar vertebra. Its body is flat, and the lower surface is oblique to articulate with the sacrum.

however the inferior articular processes of the first false vertebra have also, like the other vertebræ, extensive and loose articular surfaces.

The foramina from which the last spinal nerves emerge appear double, so that we have an *anterior* and a *posterior series of sacral foramina*. But these foramina open into the spinal canal at the same place, and are double only because the transverse processes are united at their superior and inferior edges, outside of the holes through which the nerves pass.

These foramina are the anterior and the posterior openings of one connected canal, of which the upper are much larger than the lower, and diminish much from above downward.

The halves of the arches of the sacrum are united late; so that the ring of the two lower false vertebræ not unfrequently remains imperfect during life.

The anterior face of the sacrum is more or less concave, and the posterior more or less convex, according to the sex. The former is smoother than the latter; it presents only four transverse ridges, placed each between two pairs of sacral foramina, and which are the traces of the primitive separation of the five vertebræ. We perceive also four pairs of anterior sacral foramina. The posterior face presents five ranges of eminences: one in the middle, which is unmated, formed by the spinous processes, and termed the *crest of the sacrum* (*crista sacralis*); near it, on each side, a second, which arises from the fusion of the articular processes; finally, outward, a third, which marks the fusion of the transverse processes with each other. Between these two pairs of eminences we find the four posterior sacral foramina.

The lateral face of this bone is very broad and thick at its upper part. Its anterior part is smooth, covered with cartilage, and called the *auricular surface* (*facies auricularis*); the posterior part is very rough. The lower portion of this surface is so thin that it seems simply an edge.

§ 492. The sacrum is developed in the following manner. Long after the bodies of the true vertebræ are perceptible, we see, in the fourth month of pregnancy, the bodies, then the lateral masses of the false sacral vertebræ. The lateral masses are not all formed of the same number of osseous germs, for there are two on each side in the three upper pieces, while we find only one in the two inferior. Of these two nuclei, one, which forms one half of the arch, is found backward; the other, forward: both unite with the body. The posterior faces of the lateral parts of each vertebra are developed long before the anterior parts, which form almost all the articular surfaces for the iliac bones. In this manner the twenty-one osseous germs which compose the sacrum in the matured fetus are gradually formed. The first three false vertebræ contain five each; the other two have three. All have a central and larger piece, the nucleus of the body. The two inferior have on each side only the half of an arch, composed in the first three of two osseous germs—an anterior, which is curved forward, and a posterior, which is curved backward. They continue separate till the age of three years. However, the extremities of the two portions of the arches which are turned backward and toward one another are developed, as are those of the inferior vertebræ, which in the full-grown fetus are directed precisely from before backward. At the age of three years, the three pieces of the lower vertebræ begin to unite, and then the same occurs with the posterior and the anterior pieces of the lateral portions of the three upper pieces; finally, these lateral parts also unite with the body. We not unfrequently find in subjects five years old the first vertebra composed of five pieces, and even at seven years of age we can trace this former separation.

The bodies and transverse processes of the different vertebræ are joined together much later, and only when the growth is terminated; the same remark applies to the posterior extremities of the halves of the arches.

§ 493. The sacrum, before its growth is perfected, is very analogous to the other vertebræ, inasmuch as its false vertebræ are not yet united. The latter resemble the proper vertebræ in regard to their mode of development, being composed of a body and of lateral parts. However, the number of these lateral parts in the upper vertebræ differs from what occurs in most of the vertebræ; but among the cervical vertebræ we find some which arise also from the union of several pieces. A more important difference is that of the period at which these osseous pieces are developed and united. In fact, in the true vertebræ the lateral masses appear first, while in the false vertebræ the bodies are seen first. In the former, the posterior extremities of the lateral parts unite before the anterior are joined to the bodies; in the latter, they are fused with the bodies long before they are united to one another.

§ 494. The sacrum is articulated, at its upper part, with the body of the last lumbar vertebra by means of a fibro-cartilage, and with its inferior articular processes by two capsular ligaments; laterally, with the os ilium by a fibro-cartilaginous mass and several fibrous ligaments, and with the os ischium by fibrous ligaments. Finally, its lower extremity is articulated by ligaments and cartilage with the first piece of the coccyx.

§ 495. The sacrum is wedged in between the iliac bones, and forms the posterior wall of the pelvis. It properly sustains and supports the vertebral column and the head. It however projects backward very much, and forms, at its point of union with the last lumbar vertebra, a very prominent angle, called the *promontory* (*promontorium*).

§ 496. The sacrum is one of those bones in which the differences of sex are very manifest, as it forms a constituent part of the pelvis; these depend upon the difference in the functions of the male and female. In the female it is much broader and shorter and much less curved than in the male. The promontory also projects more than in the male.*

* Cloquet states that the dimensions of the sacrum in the female are generally from 4 to 4½ inches long; its breadth at the upper part nearly equals its length; at the lower part it is not more than 6 or 7 lines; from the middle and projecting part

OF THE COCCYX.

§ 497. The *coccyx* (*ossa coccygis*) is a collection of the smallest and most imperfect vertebræ. As the inferior false vertebræ of the sacrum do not form a complete ring, because the two portions of their arch do not unite, so those of the coccyx present no trace of the posterior arch ; and when we perceive at its posterior part two projections opposite to one another, which correspond to the lateral portions of the vertebræ, they are never long enough to touch.

§ 498. We usually find four bones of the coccyx, rarely five, and then always in the female. These pieces are placed one above another, like the true vertebræ, and form a series of bones convex backward and concave forward.

The upper piece, and generally the first only, is much more perfectly developed than the others. We can always distinguish in the first, and sometimes also in the second, a middle piece, which is stronger, the *body*, and two lateral parts. The latter become two transverse processes, terminated by a blunt summit, turned a little forward, curved very much from below upward, which are the rudiments of the transverse processes, and two posterior, which are those of the articular processes. These latter are slightly inclined towards each other, but are not very distant from the posterior face of the body. They are always much elevated above the upper edge of the bone. Sometimes they are extended also beyond its base, but they never exceed its total height by the base, so as to produce a rudiment distinct from an inferior articular process. Sometimes we can see the superior *horns* and the transverse processes only in the second coccygeal bone ; the inferior horns are never seen, and the superior horns of the second are not arched towards each other.

The last two pieces of the coccyx are only round bones, the breadth of which is greater than the other two dimensions.

All these pieces rapidly diminish in size and development. In this respect they resemble the vertebræ of the sacrum, of which they are a continuation, and with which the coccyx is often fused in the same manner as the false vertebræ of this bone are united, that is, by the body, the horns (articular processes), and the transverse processes, of which the last two are in general not directly united, but are attached only by fibrous ligaments. Sometimes only some pieces of the coccyx are fused together, and the others remain separate and distinct.

§ 499. In the full-grown fetus, the first coccygeal bone generally contains at its centre a very small but distinct rounded nucleus of bone.(1) The others do not ossify till the seventh year. In a subject two years old, instead of all the osseous germs, we found the second piece formed of two separate lateral halves.

of its base to the first tubercle of its posterior surface, its thickness is 2 and 2½ inches.

(1) Albinus says that the whole coccyx remains cartilaginous till long after birth. This assertion however is not correct.

ARTICLE SIXTH.

OF THE VERTEBRAL COLUMN IN THE ABNORMAL STATE.

§ 500. The anomalies of the bones of the vertebral column may affect, 1st, the separate bones, 2d, all of them collectively.

These two kinds of anomalies may be primitive or consecutive.

I. OF THE PRIMITIVE ANOMALIES.

§ 501. Here we must remark generally, that of the different regions of the vertebral column, the fewest anomalies occur in the cervical vertebræ, at least as regards number; this depends upon the circumstance that the cervical vertebræ are more constant in number in the mammalia, proving that the influence of the general law extends even to the anomalies.

§ 502. A. *Anomalies in regard to quantity. a. Feebleness of formation.* It is marked in various ways.

α. By the defect of entire vertebræ. Of this anomaly there are several degrees. When the upper half of the body is not completely developed (§ 468), the pectoral or the whole cervical region is sometimes deficient; and when the skull is not perfectly developed, as in *acephalia falsa* (§ 468), one or more of the cervical vertebræ are frequently deficient. We have instances however of the absence of a vertebra when the formation is otherwise regular; but this rarely occurs in the neck; the regions in which it is most frequent are the lateral regions and that of the coccyx. Sometimes also only one half or the opposite halves of two vertebræ are deficient. We ought here to distinguish the *real* from the *false* or *apparent* defect; in the latter case, it happens only that a vertebra of one region assumes the characters of those of another region. This occurs, for instance, when there is an excess or defect of a pair of ribs, when the last lumbar vertebra assumes the form and size of a sacral vertebra, when it unites with the latter on one or both of its two sides, &c.

β. By the deficiency of some parts of the vertebræ. The most usual anomaly of this kind is a want of union between the right and the left halves, (*spina bifida*), which is observed by far the most frequently in the lumbar region, and exists in several degrees. The body itself is rarely divided into two parts. Generally the two halves of the arches are not united on the median line. This deviation of formation exists also in several degrees; for sometimes one portion of the lateral half is deficient, while the remainder is turned outward; sometimes there is simply a want of fusion between the two portions; and sometimes they are separated only by a small opening. Although, when spina bifida exists in a great degree, and is attended with an imperfect development of the spinal marrow and with an accumulation of serum within the vertebral column, it is met with in the lumbar region more frequently than in any other; yet when the osseous system alone is affected, the first cervical vertebra furnishes the most numerous instances of this anomaly, and this from the want of union in its two lateral halves. This deviation of formation is symmetrical, and is rarely confined to one side of the body; and then one semi-arch only is deficient.(1)

γ. *By the want of union between the posterior part and the body.* This is the slightest degree of the anomaly.(2)

δ. *By excess.* This includes the too great number of the vertebræ. One general law of this relation is that the superfluous vertebra is developed between and not at the side of the others. Here then the nature of the anomaly is determined by the rule itself. This anomaly, to which all our remarks of the contrary state apply, exists most frequently in the dorsal and in the lumbar regions. It is probable, however, that we cannot divide this into total and partial, and that when supernumerary vertebræ seem to exist, this anomaly is generally included in the class of anomalies in regard to quality.

§ 503. B. Of the *anomalies in regard to quality.* We may consider as such,

a. An unusual mode of development in the vertebræ. Sometimes certain parts of these bones arise from special nuclei. This is true, in certain cases, of the spinous processes; we have already remarked it of the atlas (§ 487). Bichat also states that he has seen this anomaly, but does not refer to any particular vertebra. Probably we must attribute to it, at least sometimes, those cases in which the vertebræ are composed of an unusual number of pieces of bone, united either by a broad cartilage or by ligaments which permit them to play upon each other. Thus we have found the whole or a part of the spinous process(3) or of the transverse process(4) forming a distinct bone. The former is seen in the second cervical vertebra, and the second is met with more particularly in the lumbar region.

b. The abnormal change of one vertebra into another. This head includes, to a certain extent, the preceding anomaly, especially the appearance of the transverse processes as separate pieces of bone; because it refers the formation of the vertebræ properly so called to the laws of the development of the sacrum (§ 492). This resemblance seems more just because all the examples of this anomaly found in authors have occurred in the lumbar vertebræ, where it has been seen, moreover, three times by Ungebauer and twice by Rosenmüller.

The vertebræ may also present characters differing in another manner from those which belong to them in their normal state. This head includes the enlargement and the increase in volume of the last lumbar

(1) Rosenmüller, *De singul. et nativ. ossium corp. hum. varietatibus*, Leipsic, 1804, p. 58.
(2) Rosenmüller, *loc. cit.*
(3) Kelch, *Beiträge zur path. Anat.*, Berlin, 1813, p. 7.
(4) Unguebauer, *loc. cit.*, p. 257.—Rosenmüller, *loc. cit.*, p. 58.

vertebra, and particularly of its transverse processes ; its firm articulation with the iliac bones ;(1) its fusion, with or without this change, with the sacrum ;(2) the fusion (which is sometimes original, and not produced by an external cause,) of the other vertebræ, for instance, of two dorsal, which assimilates them to the false vertebræ of the sacrum ; the change of the first piece of the sacrum into a true (viz. into a lumbar) vertebra, by the narrowness of the transverse processes, the want of fusion with the second, and its mobility upon the iliac bones ; finally, the change of true vertebræ into others, for instance, of the last cervical into a dorsal vertebra, by the absence of the vertebral foramen, the elongation of its transverse processes, and sometimes even the want of union between the anterior roots and the posterior roots of the transverse processes and the body.

A general law in this respect is that *the adjacent vertebræ are those which are most disposed to change into each other.* Hence perhaps why the spina bifida is so often seen in the lumbar region ; for some analogy exists between this anomaly and the normal formation of the sacral vertebræ.

Another law, which is in fact less general, is that *the corresponding vertebræ at the two extremities of the vertebral column tend the most to change into each other.* This law is supported by the want of union between the two semi-arches, of which the first cervical vertebra furnishes so many instances, and the numerous cases where the body of this, of the second, and even of the third cervical vertebra is found formed of several pieces, of which the lateral correspond to the anterior germs of the transverse processes of the sacral vertebræ.

c. Various other deviations from the normal formation. Such, for instance, as the obliquity of the vertebræ, arising from the body being higher on one side than on the other. When this anomaly is not corrected by an inverse arrangement of the adjacent vertebræ, there results from it a greater or less obliquity of the vertebral column. This arrangement is usually the first degree of the partial defect of a vertebra ; for the side of the oblique vertebra which is least elevated is lower than usual, while the other side is not higher than usual.

II. OF THE ACCIDENTAL DEVIATIONS OF FORMATION.

§ 504. *a.* The most common of all the accidental deviations of formation, which are rarely congenital, is the *curvature* (*curvatura*) of the spine, of which we have three species, according as the column is curved *backward* (*cyphosis*), *forward* (*lordosis*), or *laterally* (*scoliosis*). The first is the most common, the second the rarest. We may establish, as a general law, that a greater or less portion of the deformed vertebræ is destroyed on the concave side, that they are generally fused together on this side, and that the different kinds of curvature are most common

(1) Kelch, *loc. cit.*, p. 7.
(2) Albinus, *Ann. acad.*, book iv.—Van Doeveren, *Obs. acad.*, p. 206, 7.

in those parts where in its normal state the vertebral column is bent in the same direction (§ 475). This deformity necessarily shortens the trunk in proportion to the loss of substance experienced by the vertebræ. We not unfrequently find curves in several directions at the same time, especially in the first and second. The vertebral column also not uncommonly presents two curves, but in opposite directions, thus preventing in some measure the obliquity of the body, which is otherwise unavoidable.

b. The *fusion* of the vertebræ together, when not congenital and not dependent upon a curvature, rarely occurs, except in extreme old age. The bodies are very rarely fused, or united into one, by the ossification of the fibrous ligaments. Most usually they are connected to one another externally, on their anterior face, by means of a bony substance developed between them. We sometimes find the sacrum united with one and even with both of the ossa ilia.

c. Fractures of the vertebræ are very rare, and require considerable force, because the vertebral column is composed of a great many bones articulated so as to move slightly upon each other. These fractures are almost always in a transverse direction.

d. From the same cause *dislocations* are very rare, unless they result from caries of the bones and the destruction of their ligaments. Hence why we often find dislocations of the vertebræ attended with union in a greater or less extent. Farther, these injuries are seldom seen, except in the most movable cervical vertebræ, and particularly in the first.

CHAPTER II.

OF THE ACCESSORY BONES OF THE TRUNK, OR OF THE STERNUM AND THE RIBS.

I. OF THE STERNUM.

A. NORMAL STATE.

§ 505. The *breast-bone* (*sternum, ossa pectoris, xiphoïdes*)(1) is situated, like the vertebral column, on the median line of the body, directly under the skin, and opposite the spine. It forms the central anterior part of the chest, in the same manner as the spine forms its central posterior part. It may then be justly regarded as an anterior vertebral column.(2) This anterior vertebral column when perfect is composed

(1) See an excellent memoir of G. F. St. Hilaire, on "*Le sternum considéré dans les quatre classes d'animaux vertébrés, et sur la détermination philosophique des pièces dont il se compose*," in his *Philosophie anatomique*, vol. i. p. 17, 1818.

(2) We have collected in our *Memoir on the analogy of animal forms* many arguments drawn from comparative anatomy and from the history of the development of the fetus which favor this opinion (*Beyträge*, vol. ii. part 2).

of three pieces placed perpendicularly, and called, the first, the ***superior*** sternal bone, or the ***handle*;** the next, the ***central***, or the ***body*;** and the third, the ***inferior***, or the ***xiphoid*** or ***ensiform appendage*** or ***process.***

a. PERFECT STATE.

§ 506. This anterior vertebral column, or the breast-bone, is elongated, its length exceeding its breadth and also its thickness. Its upper end is much broader than its lower end. The bone does not grow narrower regularly, but becomes broader in the middle, after which it contracts again, and finally terminates in a point. Its anterior face is slightly rounded, and the posterior is also a little concave.

§ 507. The sternum is placed between the two clavicles and the seven pairs of ribs. The handle is the broadest and thickest part, the body the longest, and the xiphoid process the smallest in every dimension.

§ 508. The *handle* (*manubrium*) extends from the upper edge to where the cartilage of the second rib unites to the sternum. We remark, at the upper edge, on each side, a broad, oblong, cartilaginous cavity (***cavitas clavicularis***), where the sternal extremities of the clavicles are attached. Between these two cavities is a much smaller semicircular fissure (***incisura semilunaris***). The lateral edges converge from above downward ; they are slightly concave and sharp in almost their whole extent, except at their upper and usually the thickest part, where they are broad, and hollowed out to receive the cartilage of the first rib. Hence each of the two edges is divided into a superior and an inferior fissure.

§ 509. The *body* (*mucro, corpus*) extends from the inferior extremity of the handle to the insertion of the cartilage of the seventh rib. Its form is the reverse of that of the handle, that is, it is narrower at its upper than at its lower extremity, and rounds off at its termination.

Its lateral edges usually present four ***semicircular grooves*** (***incisuræ semilunares laterales***). At each of the places where these grooves are fitted to each other, we perceive a ***small cartilaginous articular cavity*** (***sinus articularis costalis***), which receives the cartilage of a rib. These grooves approach each other as we proceed downward ; hence the articular cavities approach also. The third, fourth, fifth, and sixth costal cartilages are united to the sides of the body alone ; the second articulates with it and with the handle ; the seventh is also attached to its lower edge, and slightly to the upper part of the xiphoid process ; the sixth and seventh are so near each other, that it is only in a very narrow and very elongated sternum that we can perceive a fifth and very small semicircular fissure between the articular cavities designed for them.

§ 510. The *xiphoid appendage* (*processus xiphoïdes*) unites at its upper edge to the lower part of the body. It is usually loose, but is sometimes covered by the cartilages of the sixth and seventh ribs, which rise before it to go to the body, in which case the last attaches itself to its anterior face. Its lateral edges are free in most of their extent. Its inferior extremity remains cartilaginous (*cartilago xiphoides*) until the most advanced age; it terminates by a summit which is sometimes single, sometimes divided into two generally asymmetrical points.

b. DEVELOPMENT.

§ 511. The three pieces of the sternum(1), the *handle*, the *body*, and the *xiphoid process*, are usually separate at puberty. We have observed the xiphoid process united with the body more frequently than the body with the handle. Sometimes however, especially in old subjects, we find the three pieces fused into one bone.

The development of these bones varies much. As the trunk does not close anteriorly till very late, so the sternal bones do not appear early. From the fifth to the sixth month of pregnancy, we cannot perceive any points of bone in their broad cartilages. At this period the first germ shows itself usually in the handle, while the other two pieces present as yet no traces of ossification.

This nucleus of bone is generally single, oblong, and rounded; sometimes however we find two, almost always situated one above the other, the superior being much larger than the inferior. When the single nucleus is not oblong and rounded in the full-grown fetus or after birth, but has the form of the figure 8, we have reason to think that there were two primitive nuclei, one above the other. It is much more rare to find two lateral germs arranged in such a manner that sometimes one is larger than the other, which then seems to be only an auxiliary piece, or they are both equal in size, and are perfectly symmetrical.(2)

It is less unfrequent to find more than two osseous nuclei in the handle. Albinus has seen three in one subject situated one above another, the lowest of which was very small;(3) he also found in another individual four, one superior, occupying the breadth of the handle, and three inferior, a middle and two lateral.(4)

As the osseous nuclei of the handle appear before those of the other parts of the sternum, they are also of course much larger than the others when the other parts of the sternum have begun to ossify. Of forty cases now before us, there is only one exception to this rule, a fetus of eight months, in which the handle presents two nuclei of bone, situated one above the other; the superior is smaller than the inferior,

(1) Béclard has sometimes observed in the breast-bone of adults two pisiform osseous points, placed one on each side, on the tracheal groove of the sternum. He calls them *super-sternal* or *pre-sternal*. See *Nouv. Journ. de méd.*, vol. viii. 1820, p. 83. F. T.

(2) We know of but one instance of this arrangement, which is described and figured in our *Beyträge*, vol. ii. part i. p. 145, plate 1, fig. 8.

(3) *Loc. cit.*, p. 87.

(4) *Loc. cit.*, p. 92.

(which is another anomaly equally curious,) and both are not so large as the smallest of the three osseous germs.

After the seventh month we begin to perceive, in the body of the sternum, osseous nuclei which present several differences. In fact they vary much in number, size, and situation. They are developed at the side of each other more frequently than those of the handle, and almost symmetrically; for of thirty-three sternal bones of fetuses and young children, we have found only nineteen in which the nuclei of bone were placed one above another. In eight of them the superior nuclei are single and unmated, and the inferior double, forming sometimes only one and sometimes several pairs. But in the other six, all the nuclei of the body are arranged in pairs, not however perfectly symmetrical in respect to size or situation; the single are the most rounded, and the pairs are more elongated and smaller than those which are single, and hence each of them resembles only one half of a single one: on this point our observations agree with those of Albinus.

The osseous nuclei, whether single or many, are always arranged so as to fall between two articular surfaces of the costal cartilages, whence it follows that one nucleus of bone is always developed between two ribs.

Usually, at least in all those cases we have now before us, when the osseous nuclei are situated over each other, we find only one between two costal cartilages. The observations of Albinus lead to the same result; for this anatomist states that even when he has found several nuclei in an intercostal space, they were always placed one at the side of another.

The superior nuclei are usually developed before the inferior; hence they are larger than the latter, although subsequently the body of the sternum is broader at its inferior part.

We often find, in the fetus at birth, four osseous nuclei in the body of the sternum, viz. in the intervals of the second and third rib, of the third and the fourth, of the fourth and the fifth, and of the fifth and the sixth; but sometimes we find three only, and more rarely two. These differences arise from two causes: sometimes, but least commonly, the third and fourth osseous nuclei are fused into one which is larger; sometimes, and this is much more frequent, the fourth and even the third do not exist. In the last two cases, particularly when the third osseous nucleus is also wanting, it often happens that those which exist are divided—a remarkable coincidence, as it shows but little energy in the formative act.

In the xiphoid appendage a single rounded osseous particle only is generally developed, and we rarely find two(1) which are not symmetrical. The nucleus first appears at the upper part of the appendage; it gradually extends towards the base, but very seldom through the whole cartilage. Sometimes it is found even in the mature fetus, but, generally, it is not developed till after birth, sometimes even very

(1) Albinus, *loc. cit.* p. 80.

late, not until the age of twelve, which is however abnormal, as in most subjects it is found before the expiration of the first six months.

The fusion of the four osseous nuclei, or of the four pairs of nuclei, of which the body of the sternum is usually composed at birth, commences with those which are placed at the side of each other. We have observed, at least, in examining the skeletons of old persons in which there are two lateral nuclei of bone in the same interval, that all those found above each other are still separate. The first which are fused together are the inferior two, so that the seventh, sixth, and fifth costal cartilages are entirely, and the fourth is partly attached to to this piece of bone. The body is then formed of three pieces of about the same size, or of which, in old subjects, the inferior is much larger than the other two; but the two upper primitive pieces are still entirely distinct from the lower, which is formed by the union of the third and fourth. The second unites with the last more late, while the first continues separated and is not fused till puberty, at which time the sternum is composed of only three bones, the *handle*, the *body*, and the *xiphoid process*, which are not usually joined together till at a very advanced period.

The sternum then gradually develops itself by osseous pieces, which, as long as they are not fused together, have the greatest analogy with the last false vertebræ, those of the coccyx, and which, like the latter, both in form and in their mode of articulation with the ribs, represent only the bodies of the vertebræ. It is easy, especially in the sternum of several animals, to demonstrate a cervical, dorsal, and lumbar portion; and as the nuclei of its middle portion become a single piece long before puberty, as all the parts fuse together and form only a single bone, so, too, the false vertebræ of the sacrum always, and the true vertebræ frequently unite in a single bone, while on the other hand in all the mammalia, the osseous nuclei, or the vertebræ of the sternum, one of which is always found between two ribs, remain separate and distinct through life.

§ 512. The sternum in the female is generally proportionally longer and narrower than in the male. The handle also is often, but not always proportionally larger and broader in the female than in the male.

The sternum is articulated, in the points mentioned, with the clavicles and with the cartilages of the seven upper ribs.

B. ABNORMAL STATE.

§ 513. The most abnormal state of the sternum is its entire absence, with or without a similar deficiency of the common integuments and of the ribs: in the former case the heart is seen naked, in the latter it may be felt beneath the skin.(1) A modification of this state is the existence of openings which exist most generally at the lower part of the body of the bone, or in its xiphoid appendage, or the fissure of this appendage.

(1) Wiedemann, *Ueber das fehlende Brustbein*, Brunswick, 1794.

It is remarkable that these openings are found only at the lower part of the body and in the xiphoid appendage,—another argument in favor of the parallel between the vertebral column and the sternum, since spina bifida is seen more frequently in the lower part of the spine, the lumbar vertebræ, which corresponds to the lower portion of the sternum. The sternum is sometimes too short. This defect in formation is generally attended with the imperfect development of the chest. Then, generally, the bone is much *broader* than usual and more or less arched forward.

It is less common to find the sternum longer than usual, which is also curious, as furnishing another character of analogy between the anterior and the posterior vertebral column.

II. OF THE RIBS.

A. NORMAL STATE.

I. PERFECT STATE.

a. General characters of the ribs.

§ 514. The *ribs* (*costæ*) are twelve pairs of thin bones; their length exceeds their breadth; they are slightly arched, convex outward, and concave inward, and are situated on the two sides of the chest, and form most of its bony parietes; and they extend from the vertebral column to the sternum which they unite, allowing them to play on each other.

§ 515. All the ribs present the following general characters:

They all terminate backward in a round *head* (*capitulum costæ*), which is faced with cartilage. They are formed more or less perceptibly by the union of the segments of two different circles, that to which the posterior part belongs being much smaller than the anterior, and both of which run into each other very gradually. The ribs are broadest where these two circles meet, and their inferior edge often projects into a line, termed the *angle* (*cubitus*). Their posterior extremity, which is of a rounded square form, is thicker, firmer, and narrower than the anterior, in which direction they become flatter, and evidently present two faces and two edges. The upper edge is usually slightly rounded, and the lower is sharp. In most of the ribs, the internal face, near the lower edge, and at the back part, becomes thinner and presents a groove, called the *costal groove* (*sulcus costarum*). Towards their anterior extremity, the ribs gradually become thinner and terminate by a slight, but not oval prominence. Most all of them present externally, behind the place where the posterior circle is confounded with the anterior, an elevation covered with cartilage and called the *tubercle* (*tuberculum costæ*). The part between the head and the tubercle, which is usually contracted, is called the *neck* (*cervix, collum*); the rest of the bone, that is, its anterior portion, is called the *body*.

The ribs are articulated by their heads, which are covered with cartilage, with the *lateral articular facets* (*facies articularis lateralis*) (§ 483) of the bodies of the twelve dorsal vertebræ, and by their tubercles, with the *transverse articular facets* (*facies articularis transversa*) (§ 485) of the transverse processes of these same vertebræ. At their anterior extremities, we find the *costal cartilages* (*cartilago costæ*).

The direction of the ribs is such that their posterior extremities are always higher than their anterior.

The situation of the ribs, and their relations with the dorsal vertebræ, prove, that they may be regarded only as a greater development of the anterior roots of the transverse processes of these same vertebræ; and their cartilages may be considered as imperfect ribs of the sternum.

b. Of the differences of the ribs.

§ 516. The ribs differ, 1st, in their size; 2d, in their curve; 3d, in their direction; 4th, in their form, and in the relations of their constituent parts; and, 5th, in their attachments.

1st. The ribs increase in size after leaving the two extremities of the chest. The first and the twelfth are the shortest. They increase from the twelfth to the seventh, and from the first to the sixth. The sixth and the seventh are about equal in length, and are longer than all the others.

But although the first and the twelfth are almost equal in in length, the mass of the latter is much less; it is much thinner than the other. The twelfth rib is much shorter than the first; besides, its size varies much more than that of the first.

2d. The *curve* diminishes considerably from the first to the twelfth: the second, however, is usually more curved than the first. The inferior ribs are very flat; the twelfth is sometimes straight. Whatever may be the case in respect to the proportional size of the curve, the first and the twelfth are similar in their curve as their composition by two segments of circles of different areas, is less evident than in the others. This arrangement is seen particularly in the last.

3d. The ribs descend much less from behind forward according as they are more superior. At the same time, the upper ribs have one of their faces turned upward, the other downward, one of their edges turned inward, the other outward; while, in the lower ribs, the edge which is internal in the others, is directed upward, and that which is external downward; the upper face outward, and the lower face inward, so that the ribs seem turned on their axes.

The direction of the costal cartilages also varies. That of the first rib follows the direction of the bone, and descends obliquely to the sternum: that of the second, is perpendicular to it. All the others ascend, their inclination upward increasing as we descend, except the last, the anterior extremity of which is unattached.

4th. The ribs differ in several respects in respect to their form.

a. The proportion of the neck to the body varies. The neck is proportionally longer as the rib is situated higher up, although its absolute length increases from the first to the eighth rib. The neck of the ninth rib is not generally much longer than that of the first, although the latter is very short; that of the succeeding is still shorter. The last two which have no tubercle, have likewise no neck. At the same time, the tubercle projects the more the higher the rib is. As it enlarges, we most generally see developed two surfaces covered with cartilage, an interior and superior, and a posterior and inferior, which unite to form an angle; and which, often, particularly in the upper ribs, with the exception of the first, are separated by a depression which has no cartilage. In the inferior ribs, this tubercle projects less, and has only a plane surface; and in the last two ribs it is entirely deficient.

b. The grooves and angles (*cubiti*) formed at the union of the anterior and posterior segments are much more distinct and much longer from the third rib to the ninth, than in the others; and the length of the posterior segment, between the head and the angle, increases considerably from above downwards.

c. The first rib is the strongest, and especially the broadest, not only in proportion to its length, but positively. Its upper surface is more rough and uneven than any other.

5th. In respect to their attachments, the ribs vary in three different modes:

a. They differ in their manner of articulation with the dorsal vertebræ; and here we have two different cases:

α. The ten, sometimes only the nine upper ribs, or even the first eight, are attached by their heads to a deep articular surface, forming a re-entering angle, and hollowed from the two nearest dorsal vertebræ. The others are received in a single round and convex articular surface of a single vertebra.

The form of the head also varies, having two surfaces united at a projecting angle in those ribs which are attached to two vertebræ, while in the others it has only a slightly convex surface.

β. The ten upper ribs only are articulated by a tubercle, with the summits of the transverse processes of the corresponding dorsal vertebræ. The last two are not arranged in this manner, and their posterior extremities are not connected, except with the bodies of the vertebræ.

b. Neither are all the ribs united by their anterior extremities with the sternum, in the same manner.

Here, also, we have two different cases.

α. All the costal cartilages do not extend to the sternum. Those only of the upper seven ribs are attached to this bone, being fixed in its articular cavities (§ 509) by ligaments. The thin cartilages of the last five do not arrive at the sternum, but are only attached to the cartilage above. This is not, however, the case with all, as is seen in the twelfth, and sometimes the eleventh; but their anterior extremities remain unattached, and they are connected with the other ribs only by the intercostal muscles, and by the broad abdominal muscles. On this is founded the distinction into *true ribs* (*costæ veræ*) and the *false* *ribs* (*costæ spuriæ*). The upper seven are the true ribs, and the other five are the false ribs.

β. The cartilages of the ribs have not the same length. Like the ribs, they increase in length from the first to the seventh, and then diminish from this to the last.

c. The ribs differ in respect to their connections with each other. While the superior six are not united, the cartilages of the sixth, seventh, eighth, ninth, and tenth are joined together. Of the last, the upper are usually united by the prolongations of the upper cartilage which correspond to the depressions in the upper edge of the cartilage below, and which are kept in place by capsular ligaments. This is not the case with the last, which are simply applied to one another.

§ 517. The differences between the ribs, principally the greater length of the neck, the angular form of the articular surface of the head and of the tubercle, the greater projection of the latter, the diminution in length, and increase in breadth of the costal cartilages, and, finally, their connections with the sternum, by its anterior extremity, demonstrate this important proposition—*that the ribs are less movable the higher they are situated, and that their mobility diminishes very much from above downward.*

II. MODE OF DEVELOPMENT.

§ 518. The ribs are among those bones which are formed and developed the first. From the beginning of the third month of fetal existence, their oseous portion is, proportionally speaking, as large as when fully developed. They arise, however, from three points of ossification; for the head and tubercle have each a nucleus, which begins to appear at the age of sixteen years, and is soon fused with the remainder of the bone. These nuclei do not exist in the two or three lower ribs.

III. SEXUAL DIFFERENCES.

§ 519. The ribs of the female are generally straighter than those of the male. The posterior segment unites sooner with the anterior; its curve differs less from that of the last, and disappears sooner in the female: hence the chest is narrower. The ribs are usually thinner; hence the edges are sharper. Sometimes, however, this is far from being true. Their length is nearly the same: but we are satisfied from numerous observations that, in general, the length of the two upper ribs is proportionally, and when the subject is short, *absolutely* greater in the female than in the male.

B. OF THE RIBS IN THE ABNORMAL STATE.

§ 520. The ribs present four different anomalies.

I. The primitive deviations of formation, which are very interesting, belong, almost all, to the class of anomalies in regard to quantity.

§ 521. The deficiency in formation is seen:

a. In less than the usual number. As a general rule, we say, that there is seldom or never deficient more than one rib on each side; that this is never the upper, but the last; that one on each side is deficient, more commonly, than on one side only: finally, that the absence of a rib is attended, or not, with the absence of a vertebra. Sometimes only a costal cartilage is deficient, and then two ribs are inserted in the same cartilage.

b. In their shortness. The lower ribs, particularly the twelfth, are those which are unusually short, either on one side or on both; so that they seem only as small vertebral processes. Sometimes these bones have the usual length, but are very slightly arched, which establishes a resemblance with most of the mammalia, and generally, with most animals in which the cavity of the thorax is almost always narrower than in man. This deviation of formation is generally confined to some ribs. In some cases this anomaly extends to all, either on one side, or on both sides; and then, sometimes, the ribs do not reach the sternum: and sometimes they are connected with this bone, as usual. When the latter case occurs, the cavity of the chest is very much contracted.

c. By imperfect ossification, whence the ribs are sometimes divided in a part of their length by a cartilage, as in birds; or the costal cartilages are more or less deficient, so that the ribs are not connected with the sternum, as in the lowest reptiles and in the fishes. The least and the most common degree of this anomaly is that which consists in the shortness of the cartilage of the seventh rib; by which arrangement the number of the false and of the true ribs is equal.

§ 522. The excess of the formative power is seen in a still different manner in the ribs.

a. The slightest degree is an abnormal length and height of the ribs, or of their cartilages, or of both, which is seen in some ribs only more generally than in all, and exists on one or on both sides. We not unfrequently find the anterior extremities of these bones much broader than usual, which *gradually* leads to an increase of their proper number. Their enlargement establishes an analogy between man and many animals, especially the pachydermata and the myrmicophaga, among the mammalia, and the chelonia among the reptiles.

The prolongation of the cartilage of the eighth rib increases the number of the true ribs to eight, as in apes.

b. A greater degree of this anomaly is a division of the ribs which always commences at their anterior extremity; we have never seen them divided into an internal and external piece, but always into a superior and an inferior process. This last arrangement may also be construed into a general rule, the more important as it seems to indicate that nature imitates the fundamental type even in her anomalies, as we have before shown when speaking of the vertebræ. The two processes rarely have the same length. When the deviation of formation exists in a slight degree, the ribs close before the fissure, so that only a small opening is seen. When existing in a greater degree, one of these two prolongations is united with the cartilage, and when more anomalous, both are connected with it. The cartilage of the rib then is sometimes single, and only broader than usual, and sometimes divided partially, or in its whole extent, on the side of its posterior extremity; this last anomaly may also exist without a division of the ribs, which may be broader than usual. In this case, the cartilage is broader than usual, or an opening penetrates through it; or it may be bifurcated at one or the other extremity, and finally it may be entirely double, and then its posterior part is unattached or united to a rib.

Another result of an excess in the development of the ribs is the formation of processes at their posterior part, particularly near the tubercle. This anomaly may exist in several degrees. Sometimes the process does not extend to the adjoining rib; sometimes the two ribs unite either by a single process of a certain length belonging to only one of them, or by the union of a process from two ribs; sometimes even there is a distinct bone between the two prolongations. This arrangement not unfrequently causes the fusion of two or more ribs, which fusion takes place usually at their posterior part. The former case is similar to the formation of birds and the latter to that of the chelonia. The upper costal cartilages are sometimes united in a similar manner by prolongations or unusual processes.

c. The redundance of the ribs, to which their division and increase in breadth gradually lead, differs in regard to the situation, the number, the size, and the attachments of the supernumerary ribs.

α. The supernumerary rib usually forms below the twelfth and not above the first, in which case the number and the arrangement of the upper ribs and the cervical vertebræ are the same as usual, while there is one dorsal vertebra too many, or at least the inferior ribs are only a little more developed. This supernumerary rib is sometimes found above the first; in this case, it generally arises from the anterior root of the transverse process of the seventh cervical vertebra, which is unusually developed and which is not united to the rest of the bone; the first rib is then generally longer and thinner than usual.

The increase in the number of the lower ribs is similar to the formation of the mammalia, and that of the upper to what is seen in birds.

β. *Number*. 1st. The number of the ribs may be increased on one side or on both.

2d. We may find one or more supernumerary ribs on one side or on both at the same time. We generally find a supernumerary rib on one side only, which, by a double fissure, apparently increases the whole number of ribs to fifteen; but we find a supernumerary pair of ribs more commonly than one supernumerary rib.

γ. The size of the supernumerary ribs varies much. They are generally very small, and appear only as imperfect rudiments. The first degree of this anomaly at the top of the chest, is the unusual prolongation and sharpness of the transverse process of the seventh cervical vertebra, below, at the bottom of the thorax, the existence of a moveable little bone in the transverse process of the first lumbar vertebra.

δ. The mode of union also varies. The lower supernumerary rib unites no more than the twelfth with the cartilages of the ribs above it. The superior is also almost always free, as are the upper ribs of several birds and reptiles; but when it is more developed, its anterior extremity unites to the body of the one next to it, the first properly speaking, and when still longer, it may extend to the cartilage of the first rib, or may have a proper cartilage, going directly to the upper bone of the sternum.

§ 523. 3d. The anomalies in regard to *quality* are,

a. A too slight curve, the straightness of the ribs without any shortening.

b. Being curved in such a manner that their convexity is turned inward and their concavity outward.

c. The insertion of the anterior or of the posterior extremity of one or more ribs above or below, before or behind the usual point. This arrangement sometimes exists on one side only, and sometimes on both sides at the same time, either in regard to one rib, or several; but it is less important and less curious than the first two kinds of anomalies.

524. II. The accidental deviations of formation of the ribs, offer nothing peculiar. From their mobility and the difficulty of fixing them permanently, it often happens that false joints are formed in them by fractures.

SECTION II.

OF THE BONES OF THE HEAD.

A. NORMAL STATE.

§ 525. The series of true vertebræ, those which are movable upon each other, terminates below in the sacrum, which is composed of five false vertebræ fused together; this column supports, at its upper part, the head, which is formed in a similar manner (§ 465). The cranium and face, which compose it, include numerous bones, which usually may be easily separated from each other at the period of puberty, although, with one exception, viz. the lower maxillary bone, they are articulated by sutures (§ 243) which admit of no motion. At this period, the skull is formed usually seven, rarely of eight bones. In the face we number fourteen bones.

CHAPTER I.

OF THE SKULL.

A. DESCRIPTION OF THE INDIVIDUAL BONES.

§ 526. The bones of the skull, regarded from below upward and from behind forward, are the *basilar bone* (*os basilare*,) the *temporal bones* (*ossa temporum*), the *parietal bones* (*ossa parietalia*), the *frontal bone* (*os frontis*), and the *ethmoid bone* (*os ethmoiedum*). Many of these are very similar to entire vertebræ, or to the parts of vertebræ. Most of them are flat altogether or in part (§ 234), concave internally, and convex externally. They unite and inclose a considerable cavity. One face presents *elevations* and *depressions* (*fossæ et eminentiæ*, s. *juga digitalia*, *cerebralia*), similar to those produced by the finger in a soft mass, and which resemble the external surface of the brain. Most of them are developed by several points of ossification.

I. OF THE BASILAR BONE.

§ 527. The *basilar* bone (*os basilare*) was first described as a single bone by Sœmmerring. Its anterior portion corresponds to the *sphenoid* bone (*os cuneiforme*, s. *sphenoideum*, s. *alatum*, *pterygoideum*, *multiforme*, *polymorphon*), and its posterior portion to the *occipital* bone (*os occipitis*), which are generally described as separate bones, because they are separable from each other in the skulls of young subjects; but as they are found fused together when the other bones of the body are perfectly developed, and as the different parts of which they are composed are then united and blended, Sœmmerring's opinion is more correct than that of those who preceded him.(1) The basilar bone may then be termed also the *spheno-occipital* bone (*os spheno-occipitale*).

§ 528. The basilar bone occupies the inferior, middle, and posterior part of the skull. It is so wedged in between the other bones of the skull, that it articulates with all. Although it should be considered as one bone, the best way of describing it is to distinguish it, as is generally done, into two portions, the anterior, or the *sphenoid* bone, and the posterior, or the *occipital* bone.

(1) *Knochenlehre*, p. 109.—Spix attributes this opinion to Mondini, and blames it (*Cephalogenesis*, Munich, 1815, p. 16); but we think he is wrong in both respects. Mondini, it is true, speaks (*Anat.*, Marburg, 1540, p. 48, 57) of a *basilar bone* of the head; but he expressly considers the occipital bone as a separate bone, and understands by the term *basilar* the sphenoid, the temporal, and the ethmoid bones; so that he counted only five bones in the skull. On the other hand, as the sphenoid and the occipital bones are always fused together, even before all the bones are perfectly developed, we cannot consider them as two distinct bones, at least in man, although they are always distinct in most animals, for then we could not regard the sphenoid bone as a single bone with any more propriety.

a. OF THE OCCIPITAL BONE.

§ 529. The *occipital* bone (*pars* s. *os occipitale*) forms the lower and posterior portion of the basilar bone, and appears in every respect as an enlarged vertebra. Like all the vertebræ, it presents a ring composed of a thicker anterior portion and a thinner posterior portion; the latter however is much more developed, is absolutely and relatively broader and higher than in the other vertebræ, while the anterior is at least smaller than the bodies of the dorsal and lumbar vertebræ.

§ 530. We distinguish, in the occipital bone, the *basilar* portion (*pars* s. *processus basilaris*), the *condyloid* parts (*partes condyloideæ*, s. *jugulares*), and the *squamous* portion (*pars squamea*).

§ 531. The *basilar* portion corresponds to the bodies of the other vertebræ, and consequently should be called the *body*. It is the most anterior, the smallest and the narrowest portion of the bone. In form it is an irregular hexagon, broader backward and downward, and thinner forward and upward. The middle part of its posterior edge is jagged, and forms the anterior edge of the occipital foramen. The two posterior lateral edges are inclined from behind forward and from within outward, and are blended with the anterior edges of the condyloid portions. The two anterior lateral edges converge towards each other forward. Its transverse anterior face is covered with cartilage, and when the basilar bone is perfectly developed, it is fused with the centre of the sphenoidal portion.

The upper or posterior face of the body strongly inclines from before backward, which depends particularly on the considerable thickness of the anterior portion. From one side to the other is a deep depression, called the *fossa of the medulla oblongata* (*fossa medullæ oblongatæ*). The line of demarkation which separates it from the anterior lateral edge is generally marked by the *furrow of the posterior petrous sinus* (*sulcus sinus petrosi posterioris*). The inferior or anterior face is straight in comparison with the preceding. When, however, the skull is in its natural situation, it ascends from behind forward. We remark there, on the median line, a projection from before backward, called the *basilar crest*, or *spine* (*crista*, s. *spina basilaris*, s. *pharyngea*); or the sides, two transverse symmetrical elevations; and behind these, several depressions. At its most posterior portion, it assists a little in forming the anterior extremity of the occipital condyles.

§ 532. The *squamous* portion forms the posterior and lateral parts of the occipital bone. It is thin, flat, broad, and curved in its upper and posterior portion which is the most considerable; and in its inferior and anterior part, which is the smallest,—uneven, thick, and irregular. The latter corresponds to the anterior part of the arch of the vertebræ, which supports the transverse and articular processes; the former, to the posterior part of the same arch, in the middle of which is the spinous process directed backward. The second is the proper *occipital* portion of most anatomists; the other embraces the *condyloid*, *articular*, or *jugular* parts (*partes condyloideæ, articulares, jugulares*) of authors.

§ 533. The *condyloid* or *articular* portions are narrower and thicker forward, and backward they are broader and thinner. Their faces and edges are very uneven. On the upper face, where it joins the basilar portion, is a protuberance called the *jugular tubercle* (*tuberculum jugulare*). Backward and outward is a considerable furrow, which proceeds from behind forward, and from without inward; this is called the *groove of the transverse sinus* (*sulcus sinus transversi*). Between this furrow and the process is the anterior opening of the *posterior condyloid canal* (*canalis condyloideus posterior*).

On the inferior face we notice a convex eminence, the *condyloid process* (*processus condyloideus*) which is directed from behind forward, and from without inward. Before, above, and on the outside of this eminence, is the external opening of the *anterior condyloid canal* (*foramen condyloideum anterius*). Directly behind its posterior extremity is the posterior opening of the *posterior condyloid canal* and the *condyloid fossa* (*sinus condyloideus*). Behind and on the inside of this opening, in the circumference of the posterior part of the lateral parietes of the large occipital foramen, are well marked muscular impressions.

Internally, the articular portion is broad before, and presents an inner surface inclined from above downward and inward. Its internal edge is uneven. It forms the lateral wall of the large occipital foramen. Behind and below the jugular tubercle, it presents the *internal orifice of the anterior condyloid canal.*

The external edge commences by the *large jugular* fissure (*sinus jugularis*), at the extremity of the fossa of the longitudinal sinus. Next comes a small eminence covered with cartilage, and called the *jugular process* (*spina jugularis*), and then a slightly serrated edge (*margo mamillaris*).

Backward, the condyloid portion is continuous with the proper occipital portion.

§ 534. This last portion, which several anatomists, as Loder, contrary to all analogy, have called the *body*, curves from below and forward upward and backward. It is triangular, and seems formed of two portions, the inferior of which is broader than the superior, which unite at an obtuse angle.

The upper half of the external face is smooth, while the muscular impressions and the depressions render the lower half uneven. The upper circuit of the latter is formed by the *upper curved line* (*linea semilunaris superior*), which is convex above, and extends from one side of the squamous portion to the other. Towards the middle of the inferior portion is a second semicircular elevation, the *lower curved line* (*linea semilunaris inferior*), which extends as far as the preceding. This inferior half is itself divided into a right and a left portion, by a longitudinal eminence more or less distinct according to the individual, *the external occipital crest* (*crista occipitalis externa*), which always begins with a greater and broader projection, termed the *external occipital protuberance* (*spina occipitalis externa*); this extends to the posterior edge of the large occipital foramen. The enlarged edge of the latter produces in some measure a third curved line, the *occipital crest* (*crista occipitalis*), concentric with the two preceding, and having the same uses.

The internal face of the squamous portion is divided by the *crucial ridge* (*eminentia cruciata*) into four nearly equal depressions. The upper half of the longitudinal branch of this eminence is the fossa of the termination of the longitudinal sinus of the dura mater (*sulcus longitudinalis*). The two transverse branches are the lateral fossæ (*sinus transversi*), which receive the lateral sinuses. The falx cerebelli is attached to the *internal occipital crest* (*crista occipitalis interna*), which is that part of the longitudinal branch situated below the intercrossing, and so called because it projects more or less, and is seldom grooved. The fossæ are bounded by two parallel elevations. They are rarely symmetrical: in fact, the lower part of the longitudinal branch corresponds exactly to the median line; the upper, however, rarely presents the same arrangement, so that the two lateral elevations, between which the fossa extends, descend at an equal distance from this line, and the centre of the fossa falls exactly upon it. The fossa more commonly separates to the right and left, and one of the edges descends along the median line; and not unfrequently the fossa extends to one side, so that its internal edge passes very far, sometimes even half an inch, beyond the median line; hence the defect in symmetry is much more evident. Most frequently, in two of every three cases, the longitudinal fossa goes to the right; hence the left transverse fossa is longer, but at the same time the right is broader. The latter is a direct continuation of the longitudinal fossa, while the left joins the two by an oblique fossa. It sometimes though rarely happens that one of the transverse fossæ follows the same direction as the longitudinal, so that the inferior extremity of the latter is uninterruptedly continuous with it; but then the transverse eminence, which is single, occupies its usual place, even so that when the longitudinal fossa is turned very much to the left, the upper half of the longitudinal eminences is found on the median line.

The cerebellum is situated in the inferior fossæ, which are hence called the *inferior occipital fossæ*, or the *fossæ of the cerebellum* (*fossæ cerebelli*). The superior fossæ receive the posterior portion of the lobes of the cerebrum; hence they are called the *cerebral* or *upper occipital fossæ* (*fossæ cerebrales*). The former are often smooth; sometimes, however, we find alternate elevations and depressions, which are convex above and concave below, forming a concentric, narrow, and plane series, which proceeds from the median line to the lateral edges,. The digital impressions and mammillary eminences of the inferior fossæ are more rounded, straighter, broader, and more distinct.

At the place where the fossæ cross, the internal face of the squamous portion has a large projection called the *internal occipital protuberance* (*spina occipitalis interna*). As this protuberance corresponds to one on the outside, the thickness of the bone is greatest in this place, being sometimes half an inch.

b. OF THE SPHENOID BONE.

§ 535. The *sphenoid* bone occupies the middle and a part of the anterior region of the base of the skull, and a small part of the lateral regions.

It is composed of a central portion, the *body*, and several *processes*, some of which are on the sides, and others below. This arrangement causes it to resemble a vertebra.

§ 536. The body is continuous posteriorly with the basilar portion of the occipital bone. Above this point it curves more or less upward and forward, so that the upper and unattached portion of its posterior face succeeds the upper part of the basilar portion (§ 530). This posterior face is veryrough, and its upper edge is more or less prolonged, to give origin to the *posterior clinoid processes* (*processus clinoidei posteriores*).

The upper face is nearly always distinctly divided into three successive parts. The posterior part is grooved in a transverse direction, and forms the *sella turcica*, in which the pituitary gland is situated. The middle, which is smaller, ascends more or less obliquely from behind forward; it is most generally a little convex or plane, and is rarely grooved. It is the crossing-place of the optic nerves. The anterior is horizontal.

The anterior edge of the upper face is serrated, and forms in its centre a large projection.

The lateral faces descend slightly from within outward. On the limit which separates them from the superior face is a groove, the *carotid groove* (*sulcus caroticus*), which lodges the internal carotid artery. Near their anterior extremity, or on the limit between the inner and the upper face, we see on each side a more remarkable projection, in which the line of demarkation betweem the middle and posterior portions of the superior face terminates; these are the *middle clinoid processes* (*processus clinoidei medii*). These processes sometimes unite, when largely developed, with the posterior and the anterior clinoid processes; the latter union is more common than the former, and is sometimes seen alone, while the former never occurs without it.

The anterior face, which is slightly convex, is not always formed by a plate fused with the rest of the bone, but often by two distinct pieces of bone, which are very thin, and are called the *sphenoidal horns* (*cornua sphenoidea*). It is always imperfect at its upper part, and presents in its centre a longitudinal eminence called the *sphenoïdal crest* (*spina* s. *crista sphenoidalis*).

The under face is slightly grooved. Forward and in its centre it forms a small, thin, longer or shorter eminence, called the *sphenoidal beak* (*rostrum sphenoidale*).

The crest and the beak of the sphenoid bone are more or less continuous with each other.

The body of the sphenoid bone is formed in the adult of very thin walls, and is hollowed into two large cavities, the *sphenoidal sinuses* (*sinus* s. *antra sphenoidalia*), a right and a left, which are separated by a longitudinal partition, of which the crest and the beak are prolongations, and the surface of which is often increased by the projections which arise from it.

§ 537. The processes of the sphenoid bone are the *large wings* (*alæ magnæ*), or the *middle processes* (*processus medii*); the *small wings* (*alæ minores*), or the *superior processes* (*processus superiores*); and the *pterygoid* or *inferior processes* (*processus pterygoidei* s. *inferiores*).

§ 538. The *large wings* arise below from the lateral wall of the body. At first narrower, they become broader forward and backward, curve forward and outward, and terminate in an upper and a lower point. Their form is triangular. Their concave face, which is turned inward, is uneven (§ 535); the anterior, which is square and also turned inward, is almost straight, or rather slightly concave. The external is convex from above downward, and a little concave from before backward. The inferior, a continuation of it, is straight.

§ 539. The *upper*, or the *small wings*, are much smaller than the preceding, and are lateral projections of the anterior part of the upper face of the body. They arise by two roots, an anterior and superior, which is thin; a posterior and inferior, which is thicker. Their direction is forward and upward, but principally outward. They are flat and thin, convex and sharp before, concave and thicker behind, and terminate outward in a free point. The inner circuit of their posterior edge, is a tubercle, called the *anterior clinoid process* (*processus clinoideus anterior*). This process is opposite the posterior clinoid process. It often unites with the middle clinoid process (§536); by which arrangement there is behind the optic foramen a second opening, situated at the anterior extremity of the carotid groove, and through which the carotid artery passes.

We less commonly find a third opening which results from the union of the middle and posterior clinoid processes.

It rarely happens that the anterior clinoid processes are united with the posterior, only by a long slip of bone.

All these anomalies occur on both sides more frequently than on one only.

§ 540. The *lower*, or the *pterygoid processes* detach themselves from the boundary which separates the inferior and lateral face of the body from the origin of the large wings, where the bone is thickest. They direct themselves from above downward, at the same time being inclined slightly outward. They divide posteriorly, soon after arising, and even at the place of origin, into two thin layers, called the *pterygoid wings* (*laminæ pterygoideæ*), which are fused together in almost their whole extent forward. The internal, which separates them behind, is termed the *pterygoid fossa* (*fossa pterygoidea*); at their lower part, they separate also from each other forward, thus forming the *pterygoid*, or the *pterygo-palatine notch* (*fissura pterygoidea*, s. *pterygo-palatina*).

The inner and longer layer terminates in a rounded hook turned outwardly, called the *pterygoid hook* (*hamulus* s. *uncus pterygoideus*). As this hook is the continuation of the posterior edge, and as the anterior edge is equally prolonged, although a little less so, there exists between them a more or less considerable furrow.

The external layer, which is the shortest, terminates much higher than the preceding. At its summit, it curves inward, under the inferior face of the body, with which it is often intimately connected. This reflected part is termed the *vaginal process* (*processus vaginalis*).

§ 541. In and between the different parts of the sphenoid bone are deep fissures, notches, and openings, through which the vessels, and especially the nerves, pass.

Between the two roots of the upper wing, we find the *optic foramen*, or more properly the *optic canal* (*canalis opticus*), which is short, rounded, and more broad than high.

Below this hole, between the upper and the middle process and the anterior part of the lateral face of the body, we remark a considerable irregular space of an elongated triangular form, broader inward and downward, and extending obliquely from without inward. This is the *sphenoidal fissure* (*fissura sphenoidea propria* s. *spheno-sphenoidea*). It is usually open externally, because the point of the small wing does not touch the upper edge of the large wing: but these two parts often touch, forming a true foramen.

The *foramen rotundum* is found in the root of the great wing, below this fissure; and it is separated from its inferior and posterior extremity by a small bridge of bone. It is a very short canal, which is continuous forward and backward with a semi-canal.

The posterior semi-canal unites more or less evidently with a much larger opening, near the posterior angle of the large wing. The direction of this is from above downward; it is situated much more behind and outward, and is called the *foramen ovale*.

Between the foramen ovale and the foramen rotundum, we sometimes find a much smaller hole, which also penetrates the large wing from above downward.

Directly behind the foramen ovale, and outside of its external extremity, the large wing is always pierced from above downward by another *foramen*, the *spheno-spinous* (*foramen spinosum*).

Finally, the *vidian* or the *pterygoid canal* (*canalis vidianus*) passes through the substance of the sphenoid bone to where the large and small wings are detached from the body, immediately below its division. Its direction is from before backward, from below upward, and from within outward.

§ 542. The history of the development of the basilar bone is very complex, because each of its two parts, which are still separate from each other but a little time before the whole organism is perfectly developed, are successively formed by a considerable number of osseous nuclei.

§ 543. The occipital portion appears long before the sphenoidal portion. According to our researches, it is usually formed by eleven points of ossification, which gradually develop themselves; eight for the squamous portions, (1) the other three for the articular and basilar portions. The rudiment of the squamous portion begins to show itself at the second month, directly behind the large occipital foramen, in the form of a pair of triangular nuclei, separated in the middle. These two osseous pieces fuse together. At the same time, a second pair appears, situated upward, corresponding to them in form, and representing the upper half of the squamous portion; these also, at the fourth month, unite with each other, and also with the inferior pair, except in the region of the jugular tubercle, where a sensible opening still remains. About the same period, we find a third pair, situated outward and upward, on the sides of the second: while this unites to the last, a fourth forms in the highest part, above the second. Thus the same formation is thrice repeated, until all the pieces are united, which most generally happens sooner or later, but sometimes never takes place. The squamous portion is usually formed at the fifth month. We, however, remark on each side of the fetus at birth, frequently even much later, one suture extending from the upper extremity of the serrated edge, and following the jugular process, inward and upward; a second, which goes directly downward, from the upper extremity of the bone; and a third, which proceeds exactly upward from the lower edge of the squamous portion. These three sutures indicate that the squamous portion is composed of several pieces, which often remain insulated during life, and are then called the *wormian bones* (*ossa wormiana* s. *triquetra*).

The condyloid portions appear a little later than the squamous portion, but always earlier than its upper part. They first show themselves as small, single, oblong and rounded osseous nuclei. The middle basilar portion is ossified the last.

These four portions fuse together in the same order as that in which they were ossified. The squamous part is separated from the rest long after its different nuclei are united in a single bone. In the full grown fetus the occipital portion is still formed of four pieces, of which the two condyloid portions are united before with the basilar portion, behind with the squamous part, but in no place with each other. This insulation remains even after birth, for we have seen it in a subject seven years of age.

As in all the vertebræ, the posterior part of the ring is developed the soonest, since the pieces of the squamous portion are first united, then

(1) Without doubting the existence of four pairs of germs in the squamous portions of the occipital, or *proral* bone, Beclard asserts that this arrangement, far from being constant, should be considered a rare variety. He admits but four points of ossification in this portion. F. T.

this portion joins the two condyloid portions, and these last three have long been united when the basilar portion is still entirely distinct. The marks of separation between the condyloid and the squamous portions disappear internally later than they do externally; the contrary rarely happens.

§ 544. The *sphenoid portion* ossifies much later than the occipital portion. The osseous nuclei first appear in the third month of pregnancy in its two large wings; next, one forms for each internal layer of the pterygoid processes. Afterward, we see a third pair of osseous germs in the circumference of the small wings; then, at the age of eight months, a seventh and eighth nucleus which are fitted to one another in the body. At five months, a fifth pair forms near this fourth pair, between it and the large wing. The two middle nuclei of the body then fuse with each other. A sixth pair is soon developed at the internal part of the circumference of the optic foramen; finally, a seventh appears between this and the fourth. Thus, towards the beginning of the seventh month, the sphenoid portion is composed of thirteen distinct nuclei, since although seven pairs of nuclei are formed, the first two germs of the body are already united.

After this period, the number of osseous nuclei continues to diminish as they unite. The nuclei which unite first are those of the parts of the sphenoid portion, which still continue for a long time to form so many separate pieces; thus the fourth, the fifth and the seventh pairs become one; the first and the second become the second and third; the third and the sixth, a fourth and fifth; whence it follows that at eight months, the sphenoid portion is composed of five pieces, the two large wings, the anterior wings, and the body. In a short time the anterior wings unite, and the bone is then formed of four pieces only, next the body and anterior piece unite, so that in the full-grown fetus the sphenoid portion comprises three pieces, because the large wings and the pterygoid processes are still separated from those of the centre. These three pieces unite during the first months after birth.

The body and the large wings are very rarely united before joining with the small wings, already blended with each other; then, the sphenoid portion is composed of two parts, an anterior, which is larger, and a posterior, which is smaller. This anomaly is certainly very remarkable, because it coincides perfectly with the arrangement existing in most mammalia during the whole period of existence.

The body of the sphenoid portion is full and solid for a long time after birth. The sphenoid sinuses are however gradually developed, 1st, because the bony substance disappears in the middle; 2d, because a special layer of bone, called the *sphenoidal horn*, forms on each side, and from below upward; this seldom remains distinct, but is generally fused with the sphenoid bone, rarely with the ethmoid or palate bone.

The sphenoid bone is thus gradually developed by sixteen, and the basilar bone by twenty-seven points of ossification.(1)

(1) See, on this subject, our *Considérations anatomiques et physiologiques sur les pièces osseuses qui enveloppent les parties centrales du système nerveux, et sur leurs*

§ 545. The occipital portion of the basilar bone articulates backward and upward with the parietal bones, in most of its extent, which gives rise to the lambdoidal suture. At the place where the parietal bones cease, the articulation of the mastoid portion of the temporal bone with the lower extremity of the squamous portion and the posterior part of the condyloid portion of the occipital bone, commences; this produces the mastoid suture, at the end of which the jugular process joins the posterior part of the internal edge of the petrous portion of the temporal bone. We then find between this last and the condyloid portion a space for the sinus of the jugular vein. Finally, the external edge of the condyloid and of the basilar portion unites, by a fibro-cartilage, with the anterior part of the internal face of the petrous portion of the temporal bone.

The sphenoid portion articulates with the summit of the petrous portion of the temporal bone, by the posterior edge of the large wing by a broad layer of fibro-cartilage, and by the sphenoidal spine by means of a suture; with the anterior edge of the squamous portion of the temporal bone, by the internal edge of its large wing; with the frontal bone above, and with the malar bone below, by the anterior edge of this same wing. Between the lower edge of the anterior face of the large wing and the posterior edge of the upper face of the body of the superior maxillary bone, we find the *spheno-maxillary* or *inferior sphenoidal fissure* (*fissura spheno-maxillaris*, s. *sphenoidea inferior*), which is applied at an acute angle backward, inward and upward against the sphenoidal fissure. The upper edge of the anterior and internal face of the sphenoid portion, articulates with the posterior edge of the orbital portion of the frontal bone. Where the large wing separates below to form the inferior edge of the upper sphenoidal fissure, the suture is continuous between the small wing and the frontal bone.

Where the frontal bone terminates, the anterior edge of the body of the sphenoid portion articulates with the posterior edge of the cribriform plate. The posterior edge of the perpendicular plate of the ethmoid bone lies along the sphenoidal crest, and the beak of the sphenoid bone insinuates itself into the cleft of the vomer. Finally, the perpendicular portion of the palate bone descends, in front, on the inside of the internal plate of the pterygoid process, and its pyramidal portion insinuates itself into the pterygoid fissure.

In this manner the basilar bone articulates with all the bones of the skull, and with five of those of the face.

§ 546. The occipital portion of the basilar bone presents numerous and very various anomalies, while those of the sphenoid portion are rare, and of an entirely opposite character. The original defects of formation of the former consists essentially in its division into several pieces; this anomaly is most common in its squamous portion. The least anomaly is the existence of a greater or less number of small bones in the lambdoidal suture. We not unfrequently find one of them at the summit of this suture, where it results from a want of

annexes, in the *Journal complémentaire du Dictionnaire des sciences médicales*, vol. i.p.211. Spix has arrived at the same conclusion as ourselves, (*Cephalogenesis*,p.17.)

union of the last pieces of which the squamous portion is composed with the others. It is less frequent that the third piece, on one or both sides, is not united, and forms a large bone, which descends obliquely in the lower part of the lambdoidal suture.

More rarely still the second pair remains separated from the first which is the lowest, by a suture passing obliquely through the middle of the squamous portion.

Finally, the rarest anomaly is where a longitudinal suture traverses all the height of the squamous portion from the angle of the lambdoidal suture to the large occipital hole, and divides it into two lateral portions.

So, too, the condyloid portions seldom remain a long time separate from the squamous and basilar portions: still less do they continue distinct during life.

The condyloid portions and the basilar process vary from the normal state, principally by the existence of unusual processes, which are directed from above downwards, and are often considerably long; these exist most generally near the occipital foramen, either on one or both sides, and are more or less firmly articulated with the transverse processes of the first cervical vertebra. These processes are much more rarely found before the occipital foramen, between the anterior extremities of the two condyles.(1)

II. OF THE TEMPORAL BONES.

§ 547. The *temporal bones* (*ossa temporum*) (2) are situated on the sides of the head, and are separated from each other below by the basilar bone, and above by the parietal bones. They occupy part of the middle region of the base of the skull, and the inferior part of its lateral faces. We distinguish in it a part which is more solid and thick, and which may be compared to the bodies of the vertebræ, and the lateral parts, or the arches, from whence processes arise. Each of these bones, however, only represents the half of a vertebra. The *rock*, or *petrous portion* (*pars petrosa*) is the body; and the *squamous portion* (*pars squamosa*), which reaches above the last, is the arch. Usually, this bone is divided into three parts,—the *squamous*, the *petrous*, and the *mastoid* portion. The last, however, is only an appendage of the second.

§ 548. The most important part of the temporal bone is that which corresponds to the body of the vertebræ,—the petrous portion, and is so called from the hardness which characterizes it when perfectly developed. It is also called the *pyramid*, from its triangular form. Its base is turned outward and backward, its summit forward and inward. One of its three faces looks forward and upward, a second backward and inward, and a third downward. The first and the second are separated

(1) Meckel, *De monstr. duplic.* p. 24.—*Deutsches Archiv für die Physiologie*, vol. i. part iv. p. 6.

(2) We shall not mention here the internal structure of the temporal bone, nor the little bones of the internal ear. These will be described when speaking of the organ of hearing.

from each other by the upper, the second and the third by the inner, the third and the first by the outer angle.

§ 549. The internal organ of hearing is situated within the petrous portion. The internal carotid artery passes through it to penetrate the skull, and the facial nerve to go to the face. On its surfaces and edges we can trace these two passages. We see also others which correspond to the anastomoses of the nerves, and to the venous sinuses of the dura-mater.

§ 550. The most important of these marks relate to the organ of hearing.

Near the centre of the upper face, we find a large transverse ridge, formed by the projection of the upper semicircular canal of the labyrinth, which is here naked during the early stages of uterine existence, at which period it is not yet covered with a plate of bony substance; and we remark above it a deep fossa, which receives the dura-mater, the traces of which are gradually effaced after birth.

In the middle and forward, we see on the internal face a considerable rounded opening, depressed from above downward, in which the auditory and the facial nerves are situated. This is the *internal auditory foramen* (*porus acusticus internus*). This opening leads into a cavity, divided by a transverse portion into two openings; a superior, which is smaller, and an inferior, which is larger; the former leads into the *Fallopian canal* (*aqueductus Fallopii*) by several openings, the other to the *labyrinth*.

Below this opening, on the boundary between the inner and the lower face, we find the *triangular orifice of the aqueduct of the cochlea;* behind which we see, at the same height, *the orifice of the aqueduct of the vestibule*, which is turned back and flattened.

On the limit between the upper and the lower face, are two imperfect bony canals, separated from each other by a bony projection.. The inferior, which is also larger, is the *osseous portion of the Eustachian tube* (*tuba Eustachiana ossea*). The upper is smaller, and gives attachment to the tensor muscle of the membrane of the tympanum (*musculus tensor tympani*).

The external portion of the inferior face, which is the most extensive, forms an elliptical canal, *the osseous portion of the auditory passage* (*meatus auditorius osseus*), which opens externally by a broad orifice, called *the external auditory foramen* (*foramen* s. *porus acusticus externus*).

The Fallopian canal proceeds first obliquely from above downward, and from within outward; then from behind forward, and from below upward, to arrive at the inferior face, where it terminates in the *stylo-mastoid foramen* (*foramen stylo-mastoideum*). It gives passage to the facial nerve.

On the upper surface, along and over the canal for the tensor tympani muscle, is a fissure leading to a canal which opens with the aqueduct of Fallopius.

At the anterior extremity of this surface, above and within the anterior orifice of the carotid canal, we observe a semicircular and superficial depression, which corresponds to the nerve of the fifth pair.

§ 551. The traces of the vessels are, 1st, the *canal of the internal carotid artery* (*canalis caroticus internus*), which curves from below upward and from within forward, of which the *external orifice* (*foramen caroticum externum inferius*) is found in the centre of the inferior face, while the *internal* (*foramen caroticum anterius* s. *superius*) is seen at the summit of the superior face, where this canal, deprived of its upper wall in a considerable extent, forms in reality only a semi-canal.

2d. On the inferior surface, directly behind the orifice of the aqueduct of the cochlea and the posterior opening of the carotid canal, is a more or less extensive *fossa* (*fossa bulbi venæ jugularis internæ*), for the sinus of the internal jugular vein; a fossa which communicates by fissures with the two aqueducts.

3d. At the upper angle, the *fissure of the superior petrous sinus* (*sulcus petrosus superficialis*).

4th. On the internal surface of the mastoid process, the *fissure of the transverse sinus* (*sulcus sinus transversi*), which is generally directed very far forward and upward, and occupies most of this surface. Very rarely, this fissure is very small, or is even entirely deficient, when the transverse sinus, varying from its usual rout, descends entirely or almost entirely on the occipital bone alone, or follows a longitudinal direction. Of more than fifty well developed temporal bones before us, the fissure is entirely deficient in but one, and extremely small in two only.

5th. We generally see on its posterior face, a little above the centre, the *mastoid hole* (*foramen mastoideum*), the internal orifice of a canal which usually extends some lines within the bone, and commences on the boundary between the mastoid portion and the occipital bone, or on the outer face of the mastoid portion.

§ 552. The muscular eminences and depressions are,

1st. The *styloid process* (*processus styloideus*), at the posterior extremity of the under edge of the pyramid: this varies much in length, and sometimes exceeds two inches. This process is sometimes entirely free, and is often composed of several pieces—a curious analogy with animals. It arises between two broad, flat, bony processes, called the *vaginal processes* (*vaginæ processus styloidei*).

2d. Behind the styloid process is the conical *mastoid process* (*processus mastoideus*). The *stylo-mastoid foramen* (§ 550) (*foramen stylo-mastoideum*) is situated between these two eminences.

3d. Behind the mastoid process is the *mastoid fissure* (*incisura stylo-mastoidea*).

§ 553. The *squamous portion* is slightly rough on its outer face for the insertion of the temporal muscle. Forward and downward the external face extends in a thin process, flattened from without inward, called the *zygomatic process* (*processus zygomaticus jugalis*), and of which the external and longer root is placed over the external auditory foramen, the orifice of which it closes above, while the lower, which is transverse, and called the *articular eminence* (*tuber articulare*), is found before the *transverse articular cavity* (*cavitas articularis*) of the lower maxillary bone. Anteriorly, it circumscribes this cavity with which it is insensibly continuous. Behind, the cavity is bounded by a transverse projection, situated before the anterior part of the osseous auditory passage, but entirely separate from it, and which varies much in thickness and height.

Advancing from behind forward, the zygomatic process separates a little from the squamous portion, and its anterior extremity reaches over the anterior edge of the same.

The internal surface of this portion of the temporal bone presents digital impressions and mamillary eminences, and generally, at its upper part, a transverse arterial fissure.

§ 554. In the full-grown fetus, the temporal bone is formed of four pieces of bone, the *petrous*, the *mastoid*, and the *squamous* portions, and the *ring of the tympanum* (*annulus membranæ tympani*). This last is the only vestige of the osseous auditory canal. It is elliptical in form, longer from above downward than from before backward, is not entirely closed at its upper part, is attached to the petrous portion immediately before the cavity of the tympanum by almost its whole external circumference, and to the lower part of the squamous portion by its two upper extremities, is broader and thicker before than behind, and offers, at its internal circumference, a deep fissure, in which the membrane of the tympanum is inserted.

Some time after birth, these four parts are fused together. The separation which existed between the upper extremities of the ring of the tympanum and the squamous portion disappears first. The trace of separation which continues the longest is between the petrous and the squamous portions, especially on the internal face; for, although the marks of separation between the squamous and the mastoid portions disappear entirely on the outside, we see through life a suture which exists, in most of its length, between the internal face of the squamous, and the upper face of the petrous portion. This suture, called the *squamo-pyramidal suture* (*sutura squamoso-pyramidalis*), extends forward, where it is called the *fissure* of *Glaser* (*Fissura Glaseri*), passes under the articular cavity, before the bony portion of the auditory canal, through all the substance of the bone, and terminates in the cavity of the tympanum.

The ring of the tympanum gradually enlarges, and unites with the petrous portion on all sides, and, increasing out of proportion with the other parts of the bone, from a simple ring rounded and flattened from without inward as at first, it becomes a canal half an inch long and compressed from before backward, *the osseous portion of the auditory canal*, which remains however for a long time imperfect and cartilaginous at the lower part of its circumference, backward.

However, the petrous and squamous portions increase also very much, by the development of the mastoid process. At the same time, the squamous portion is not only higher, but becomes more convex externally, instead of being straight as hitherto. The zygomatic process also changes its form; it throws itself outward, separates very much from the squamous portion, and extends beyond its anterior edge in the same proportion. A remarkable change supervenes also in the situation of the glenoid cavity and of the articular process, which, previously plain, very broad from before backward, and very oblique from above downward and from without inward, become almost transverse, and are considerably developed, which gives more firmness to the temporo-maxillary articulation.

§ 555. The temporal bone articulates, 1st, by its mastoid, petrous, and squamous portions, with the basilar bone behind and forward. 2d. By its mastoid and squamous portions above, with the inferior edge of the parietal bones. The first articulation is by a serrated suture, and the second by the squamous suture (*S. squamosa*), the two bones gradually becoming thin to the extent of from four to six lines, and fitting to one another, so that the squamous portion covers the parietal bones. 3d. The temporal bone articulates with the malar bone by a dentated suture, and 4th, with the lower maxillary bone which moves upon it, by ligaments.

III. OF THE PARIETAL BONES.

§ 556. The *parietal bones* (*ossa bregmatis*, s. *verticis*, s. *parietalia*), are only portions of a vertebra. We ought to consider them as the complements of the lateral parts of the temporal bones and of the sphenoid bone, between which they are wedged in. They stand together on the median line and are often united in a single bone. They occupy the upper part of the lateral faces and the summit of the skull, have an almost regular quadrilateral form, and are flat in every part.

§ 557. The edges which circumscribe them are the *upper*, *inner*, or *sagittal edge* (*margo sagittalis*), the *anterior*, *frontal*, or *coronal edge* (*margo frontalis*, s. *coronalis*), the *inferior* or *squamous edge* (*margo squamosus*), and the *posterior* or *occipital edge* (*margo occipitalis*). The angles formed by the union of these four edges are called, the *upper* and *anterior* or the *frontal angle* (*angulus frontalis*), the *upper*, *posterior* or the *occipital angle* (*angulus occipitalis*), the *lower* and *anterior* or the *sphenoid angle* (*angulus sphenoideus*), and the *lower* and *posterior* or the *mastoid angle* (*angulus mastoideus*).

§ 558. They appear especially on their outer face, and, more particularly, in young subjects, formed very distinctly of two portions, united at an obtuse angle, the upper, which is larger, and the inferior, which is smaller. The skull is broadest where these two portions join; this part is called the *parietal protuberance* (*tuber parietale*). The upper is smooth, the lower is slightly uneven, and separated from the other by an arched rim, whence it has been called the *semi-circular surface* (*planum semi-circulare*).

The internal face, besides the usual cerebral and digital impressions, presents ascending and branching channels, which lodge arteries and veins (*sulci meningei*), called, from their arrangement, the *fig-leaf.* We also remark, especially in old subjects, along the upper and internal edge, *slight depressions* (*foveæ glandulares*), which sometimes extend even to the external table. At the inferior and posterior angle, a transverse furrow (*sulcus transversus*), constantly exists and completes that seen on the occipital and temporal bones (§ 551); along the sagittal edge is a slight fossa, which, united to that on the opposite side, forms the *fossa of the upper longitudinal sinus* (*sulcus sinus longitudinalis*).

Near the sagittal edge, we usually perceive on one or both of the parietal bones, the *parietal foramen* (*foramen parietale*).

§ 559. Each parietal bone develops itself by a single point of ossification, which first appears in the parietal protuberance.

§ 560. These bones articulate with each other upward and inward, along their upper edge, by the *sagittal suture* (*sutura sagittalis*), which goes directly from before backward on the median line; backward, with the occipital bone (§ 555); downward, with the temporal bone, by most of their squamous edge, and with the large wing of the sphenoid bone (§ 555) by the rest of this edge, as also by the sphenoid angle; finally, with the frontal bone, by their anterior edge and by the *coronal suture* (*sutura coronalis*).

§ 561. The sagittal suture is sometimes wholly or partially effaced, and the two parietal bones become one, although all the other bones remain separate and distinct.

On the other hand, we sometimes, but much more rarely, see one or both of them divided by a transverse suture into an upper and a lower portion. We do not know that they are ever divided by a longitudinal suture into an anterior and a posterior portion.

IV. OF THE FRONTAL BONE.

§ 562. The *frontal* or the *coronal* bone (*os frontis*) occupies the anterior part of the skull. It corresponds to the squamous and condyloid portions of the occipital bone. We observe also, in the place corresponding to the large occipital foramen, an analogous opening, which however is not closed behind, because the frontal bone has no basilar process. Perhaps this last is represented by the body of the sphenoid bone.

§ 563. This bone is divided into a *frontal portion* (*P. frontalis*), an *orbitar portion* (*P. orbitalis*), and a *nasal portion* (*P. nasalis*).

§ 564. The *frontal portion* is by far the largest. It corresponds to the squamous portion of the occipital bone in form and situation. Like that, it is composed of two parts, united at an obtuse angle, the upper being more extended than the lower. Where both of these join is the part where the bone projects the most, and presents on each side the *frontal tubercle* (*tuber frontale*). Below these eminences, we find on each side also, directly above the upper edge of the orbit, and inward, another protuberance separated from it by a depression, called the *superciliary ridge* (*tuber superciliare, supra-orbitale*), where the two tables of the bone are separated from each other to form the *frontal sinuses* (*sinus frontales*). The triangular space on the median line which separates the two ridges is called the *glabella*. But a small extent of the region of the anterior face, that which looks a little outward, and completes the semicircular surface of the parietal bone (§ 558), is rough.

The inner face is divided into two lateral parts by the *frontal crest* (*crista frontalis*). This, which is found on the median line, forms sometimes a very considerable projection, and terminates upward by a furrow, the commencement of the *longitudinal fossa* (*sulcus longitudinalis*). These two portions are uneven, like those of the internal face of the parietal bones.

§ 565. The *orbitar portion*, which unites with the preceding at a right angle, is separated from it externally by a projecting and round edge called the *orbitar arch* (*margo superciliaris*, s. *supra-orbitalis*). At the internal extremity of this edge passes the *frontal fossa* or *canal* (*sulcus* s. *canalis frontalis*), extending from the under face of the orbitar portion to the external face of the frontal portion. This edge enlarges outwardly, as does also the inferior part of the anterior face of the frontal bone, to produce the short but strong *malar protuberance* (*tuber jugale*).

The orbitar portion, which forms the arch of the orbit, is contracted from before backward, convex upward on the side of the skull, concave downward on the side of the orbit, and very thin. At the internal part the two tables separate from each other (§ 564).

The inferior face presents, outward and forward, the *lachrymal fossa*, which is usually superficial; inward and forward, a small eminence or depression, called the *trochlear spine* or *fossa* (*spina* s. *fovea trochlearia*).

§ 566. Between the frontal and orbitar portion is the *nasal* part, which is properly only the most internal part of the two others, and is in the form of a horse-shoe. It is composed of two portions, which unite anteriorly in an arch below the middle of the frontal portion, and the tables of which, very widely separated, especially in front, contain the access to the frontal sinuses, and are separated by the *ethmoidal fissure* (*incisura ethmoidalis*). The *nasal spine* (*spina nasalis*), which often forms a separate piece of bone, arises from their place of union. Between this spine and the inferior extremity of the frontal crest, we observe a considerable opening, improperly called the *foramen cæcum*.

§ 567. The frontal bone is developed at the second month in two lateral pieces, separated longitudinally on the median line, the union of which generally begins during the first year, and is finished toward the end of the second. These two pieces by their mutual articulation produce the *frontal suture* (*sutura frontalis*), which has the same direction as the sagittal suture, and whose lower part is always effaced the last.

§ 568. The frontal portion of the frontal bone articulates above, 1st, with the parietal bones, by the *coronal suture* (*sutura coronalis*) (§ 560); 2d, the orbitar portion articulates downward and backward with the small and large wings, as well as with the body of the sphenoid bone (§ 545), by the malar process; 3d, with the malar bones (§ 595), by the lateral parts of the nasal portion; 4th, with the ethmoid bone (§ 574), by the anterior part of this portion and by the nasal spine; 5th, with the proper bones of the nose; and 6th, on the outside of these with the upper maxillary bones.

§ 569. The most usual anomaly presented by the frontal bone, and which is not rare, consists in the want of union of its lateral portions. The frontal suture then remains during life. More rarely the frontal sinuses are not developed.

V. OF THE ETHMOID BONE.

§ 570. The *ethmoid* or *cribriform* bone (*os ethmoideum* s. *cribriforme*) is found at the anterior and middle part of the base of the skull. It slightly resembles a vertebra in its thin and perpendicular middle layer, and in its two lateral portions, which are folded on each other in different ways. We might rather consider it a bone of the face, and more so because it is wedged in between these bones, among which are numbered some not more perceptible externally than this, and resembling it in form and functions.

§ 571. We distinguish in the ethmoid bone a central and two lateral portions. The first is formed almost wholly by a *perpendicular plate* (*lamina perpendicularis*) much higher in its anterior than in its posterior portion. Behind, where the posterior portion terminates, we see detached from its upper edge a horizontal layer, called the *cribriform plate* (*lamina cribrosa*), which extends on both sides. This plate is placed along the perpendicular plate, the upper part of the anterior portion of which consequently rises much above it. This latter, called the *crista galli process*, projects within the cranium; it is much thicker than the part below.

The *cribriform plate* presents two series of oblong openings, the largest of which are situated inward, along the *crista galli* process and in the same direction from before backward, while the smallest are found along its external edge. The anterior and middle are the largest, and are oblong, often three or four lines in extent. Between these two ranges are others, which are smaller and irregular.

All these are the tunnel-shaped orifices of small canals; the internal pass several lines along the lateral faces of the perpendicular plate, and then divide into others which are smaller, and degenerate into simple fissures, which descend very low in the septum.

§ 572. The *lateral portions* of the ethmoid bone, or the *labyrinths* (*labyrinthi*), are extremely thin and complicated. Each generally represents a quadrangular cavity, which is longest from before backward, and shortest from within outward. The upper wall is generally partially or wholly deficient, and is covered by the sides of the nasal part of the frontal bone, which serves as a top to it; the anterior wall is also open. The outer side is sometimes, but more rarely, imperfect: it is smooth and straight, and is called the *os planum*, or *lamina* *papyracea*, because it has the smoothness of parchment. The inferior wall is very uneven; the posterior is deficient; the internal is straight, and rendered uneven by the external range of openings found on the cribriform plate, as also by the descending canals and fissures which penetrate its substance by small openings. Posteriorly, this internal wall forms two projections placed one over the other, separated by a deep space, convex within and concave externally, called the upper and middle turbinated bones (*concha superior et media*). The latter turns on itself anteriorly, hence it is convex externally. The lower turbinated bone forms the inferior wall of the labyrinth.

Transverse, irregular, and partly imperfect plates proceed from the outer to the inner part of the labyrinth, forming a greater or less number of *ethmoidal cellules* (*cellulæ ethmoidales*). The anterior cells are also called the *orbital* or *lachrymal* (*C. orbitariæ* s. *lachrymales*), the middle, the *frontal* (*C. frontales*), and the posterior, the *palatine* (*C. palatinæ*).

From the upper edge of the middle turbinated bone a transverse septum proceeds to the posterior edge of the os planum, and closes, but imperfectly, the middle cellules.

This septum and the os planum are extended backward and downward at their anterior and inferior angle into a thin, sometimes a slightly curved process, called the *small ethmoidal process* (*processus minor*). Another arises farther forward and inward, from the anterior part of the labyrinth and the transverse septa of the anterior cellules, between the anterior extremity of the middle turbinated bone and the os planum. This varies much in length, and is called the *large* or *unciform process of the ethmoid bone* (*processus major*, s. *unciformis*, s. *hamulus*).

§ 573. The ethmoid bone is not developed till the fifth month. The lateral portions appear first, and the middle part is not formed till after birth.

In the full-grown fetus, this middle part is entirely cartilaginous: the two lateral portions are separated from each other, and but slightly developed, for the external and the internal walls almost touch. However, the eminences we have mentioned, already exist, although, even relatively speaking, much smaller. The cribriform plate is very broad, and broader in young children than in adults: it contracts when the internal and external walls of the labyrinth are separated from each other. Even long after these three parts are fused together, the middle, which ossifies from above downward, continues to be almost cartilaginous. Its inferior and anterior part, which belongs to the cartilaginous septum of the nose, always retains this character.

§ 574. The ethmoid bone is articulated; 1st, forward and upward, by the anterior edge of its perpendicular plate, with the middle nasal portion of the frontal bone and the posterior edge of its nasal spine; 2d, upward, on each side, by the upper wall of the labyrinth, with the nasal and orbitar portions of the frontal bone; 3d, before, and on the side with the unguiform bone: 4th, by the posterior edge of its cribriform plate, and by its perpendicular plate, with the middle edge of the upper face of the body of the sphenoid bone and with the sphenoidal spine; 5th, by the posterior part of the labyrinth, with the palate bone; 6th, by the inferior edge of the os planum, with the body of the superior maxillary bone in the orbit, and by the anterior part of the labyrinth, with the ascending process of the same bone in the nasal cavity; 7th, by the inferior edge of the septum, with the vomer; 8th, by the anterior part of the labyrinth, with the nasal bone; 9th, finally, sometimes by its large process with the inferior turbinated bone.

§ 575. The os planum sometimes divides into several distinct laminæ, which are generally situated one behind another.

CHAPTER II.

OF THE BONES OF THE FACE.

§ 576. The *face* is composed of fourteen bones. We may, however, oppose the region of the upper jaw to that of the lower jaw; for, 1st. The different bones which form the first, are united by the suture which admit of no motion, while the lower maxillary bone is articulated so as to play freely. 2d. Most of the bones of the upper maxillary region may be considered as the appendages of one large piece, the upper maxillary bone. 3d. The lower maxillary bone is not, in many animals, a single bone as in man, but is composed of several, and often of a great number of bones.

§ 577. Most of the bones of the region of the upper maxillary bone, are in pairs. Of these, there are six, viz. 1st, two *upper maxillary* bones; 2d, two *palate* bones; 3d, two *malar* bones; 4th, two *nasal* bones; 5th, two *lachrymal* bones; 6th, two *turbinated* bones; 7th, the *vomer* is a single bone. Both Lietaud and Portal have remarked, after the ancient anatomists, that the vomer usually unites early with the ethmoid bone, so that connecting these together we have then only six pairs to describe with the superior maxillary bone. The region of the lower maxillary bone is composed of a single bone. In the face, as in the skull, the unmated bones are situated on the median line, or are composed of two lateral corresponding portions.

§ 578 All these bones are not developed by a single point of ossification, but their different osseous nuclei unite, the lateral portions of the lower maxillary bone excepted, long before those of the skull, and generally before those of most bones; perhaps, because they are smaller, and not like the pieces of the skull and vertebral column, because immediately connected with an organ, in which the formative power exerts all its energy.

I. OF THE UPPER MAXILLARY BONES.

§ 579. The *upper maxillary bones* (*ossa maxillaria*, s. *mandibularia superiora*, s. *maxillæ superioris*) principally determine the form of the whole face, because they are the largest, and are situated in the centre of the others.

Their form is almost quadrilateral. We usually distinguish a body and four processes, inclining upward, outward, downward, and inward.

The upper face of the body is smooth; its direction is obliquely downward, outward, and a little forward. We generally observe from before backward, a semi-canal, open at its upper part, and extending from the posterior edge to about its centre; this is continuous, after leaving this point, with a perfect canal called the *infra-orbital canal* (*sulcus* s. *canalis infra-orbitalis*) which passes below it, to open on its anterior face. The track of this canal is generally indicated also at the upper face of the body of the upper maxillary bone, by a very narrow fissure, which does not, however, always extend there, although it did originally. More rarely, this duct forms in its whole length a perfect canal; and then, sometimes the fissure exists in its whole extent, and sometimes it is entirely deficient, but only in the place where it is found in the normal formation. Sometimes also, this fissure is occasionally interrupted, independent of the arrangement of the posterior part of the duct. Finally, it often happens that the semi-canal is extended very far, almost even to the anterior edge of the upper face. These differences are worthy of remark, as they indicate the different degrees in the development of the bone.

§ 580. On the upper face, we generally see upward and inward, the extremity of the fissure described, which leads to the *infra-orbital foramen*. This hole is rounded, terminates sharply above; while, below, it is prolonged into a more or less deep depression, and is not far from the anterior edge of the upper face. Sometimes, but rarely, instead of one foramen, there are several: we then find, at a greater or less distance from the usual large foramen, another opening, which is smaller and situated more inwardly; in which case, the canal is divided sooner or later into two branches. In certain cases, the two holes are more than half an inch apart, and the canal is divided at its posterior extremity; differences which are remarkable as establishing an analogy with the formation of the simiæ and cetaceæ.

Below the infra-orbital foramen, we find a deep muscular impression, the *maxillary fossa* (*fossa maxillaris*).

The posterior part is convex, and presents below the *maxillary protuberance* (*tuber maxillare*).

The inner part is very uneven. We remark anteriorly and about its centre, the *inferior turbinated spine* (*spina turbinalis inferior*), an eminence almost straight, which, however, descends a little obliquely forward, and is very rough. We then see the *lachrymal groove* (*sulcus lachrymalis*), which goes downward and backward from the upper edge, and is sometimes changed into a canal in a small part of its extent, when its anterior and posterior edges touch. Further still, at the upper part of this face, a large hollow occupies a part of it, which extends almost to the posterior edge, and leads into the antrum Highmorianum.

The body is hollow, and its walls, especially the upper, are very thin. The *maxillary sinus*, or the *antrum Highmorianum* (*antrum maxillare*, s. *Highmori*), which is within it, and opens into the nasal cavity by its internal wall, is often curved with eminences which render its surface uneven.

§ 581. The *ascending*, *upper* or *nasal process* (*processus ascendens*, s. *superior* s. *nasalis*), leaves the anterior and internal angle of the upper face of the body, and is flattened from within outward. The posterior and smaller part of its external face is separated from the anterior by an eminence sharper below than above, and is continuous with the upper anterior edge of the body. This part is hollowed out, and forms the beginning of the *lachrymal groove*. Its internal face is a little concave, and we see on it, near the middle, the *ethmoidal spine* (*spina ethmoidalis*), parallel to the inferior turbinated spine; sometimes when the nasal process is very broad, it is divided by a sharp crest into an anterior and a posterior portion, the latter of which is much more hollowed, and assists in forming the anterior cellules of the ethmoid bone.

§ 582. The *palatine process* (*processus palatinus*) detaches itself from most of the inferior edge of the internal face, at a right angle, and goes horizontally inward. Its upper face is smooth, and the under is rough. It terminates backward by a serrated edge, inward by an uneven and broad surface, especially at its anterior part. It is continuous forward with the alveolar process. In this place it is traversed from above downward, and from behind forward, by the *palatine* or *incisory channel* (*canalis palatinus* s. *insicior*), which usually forms only a simple semi-canal, because its internal wall is deficient, as is the entire length of the external wall, from which a fissure usually proceeds forward and outward, and, in this manner becomes apparent both at the upper and the lower face of the palatine process. Here, particularly, the fissure is longest and broadest, and goes towards the space situated between the outer incisor and the canine tooth. It rarely bifurcates at its inferior face, presenting an inner which is smaller, between the two incisor teeth. Sometimes, also, a small process is detached which goes backward. The fissure, visible at the inferior face, is the *intermaxillary suture* (*sutura intermaxillaris*).

One or more furrows proceed from the posterior edge from behind forward, to the inferior face.

§ 583. The *alveolar process* (*processus alveolaris*), is a prolongation of the anterior and external face of the body; it is convex outward and concave inward, forming a considerable edge, and contains cavities for the teeth called the *alveolar* cavities (*alveoli*), which are separated by thin osseous partitions. The alveoli are known externally by the projections, and the intermediate partitions, by the depressions which correspond to them.

§ 584. The *malar* or *jugal process* (*processus malaris* s. *jugalis*), is very short. It comprises only the broad rough surface, by which the posterior, superior, and anterior faces of the body are united. A portion of the bony partition of the maxillary sinus is often deficient in this region.

§ 585. The upper maxillary bones articulate, 1st, on the median line, with each other, by the internal face of the palatine portion; 2d, with the frontal bone (§ 568), by the upper extremity of the nasal process; 3d, with the external edge of the proper nasal bones, by their anterior edge; 4th, with the unguiform bones, by their posterior edge and the anterior extremity of the internal edge of the upper face of their body; 5th, with the ethmoid bone (§ 574), by this same edge, and by the crest of the ethmoid bone; 6th, with the palate bones, by the posterior extremity of this edge, the posterior part of the posterior and internal face of the body, and the posterior edge of the palatine portion; 7th, with the inferior turbinated bone, by the inferior turbinated spine; 8th, with the vomer, by the palatine process.

§ 586. According to Portal, the upper maxillary bone is developed by several points of ossification,—two for the body, one below the infra-orbital foramen, and another in the floor of the orbit; a third in the nasal process, and two or three in the palatine process.

In several fetuses of three months, we have found it composed of three pieces; of these, the anterior comprises the portion of the palatine and alveolar processes situated before the palatine duct, with the nasal process; the middle, the body and the central part of the palatine process; finally, the third placed externally, the posterior part of this same process. The palatine canal, which is still only a simple hole, the *incisive* or *anterior palatine foramen* (*foramen incisivum* s. *palatinum anterius*), appears enormous. The inner, the upper, and the posterior walls of the body are not yet formed. Then, *the anterior portion is separated from the posterior*, and *a real intermaxillary bone exists*,—a curious analogy with what is normally observed in almost all the animals inferior to man. Even when the two segments are not more entirely distinct, in the full grown fetus and afterwards, the line of separation extends much farther, both in breadth and in length, across the palatine portion, so that it traverses all the breadth of the upper face. It often happens that it does not stop there, but is reflected upward, and insulates a part from the internal face of the body as an internal thin layer, which is only applied against the external part. Farther, a branch of this upper fissure goes inward, and passes, behind the lachrymal channel, through the antrum Highmorianum, to the posterior face of the body, where it unites with the infra-orbital *fissure* in the infra-orbital canal. We also find some slight traces of this arrangement in the adult; it deserves to be remarked, as indicating, even in man, that the portion of the upper maxillary bone, in which the incisor teeth are situated, is separated from the others during the early periods of life, and then forms a real *intermaxillary bone* (*os incisivum*, *intermaxillare*), We always find in the young fetus the internal branch of the fissure on the under face of the palatine portion (§ 582), and this observation, together with the instances of division of the upper maxillary bone in the full grown fetus,(1) seems to prove the primitive existence of a special piece of bone for each incisor tooth.

The maxillary sinus is already very large in the full grown fetus, but does not extend so much outwardly.

Considered generally, the maxillary bone in the child, particularly its alveolar portion, is much longer and broader in proportion to its height, than in the adult.

§ 587. The anomalies of this bone are, the non-development of the maxillary sinus, and the shortness of its palatine process, which leaves a greater or less interval on the median line between the maxillary bones, and whence generally results (at least when the division extends to the anterior extremity, or occupies the anterior part of the length of the upper jaws) the insulation of the anterior portion which supports the incisores, or of the intermaxillary bone. On the other hand, it sometimes happens also that the palatine process is prolonged posteriorly to a great extent, and even forms the posterior spine.

II. OF THE PALATE BONES.

§ 588. The *palate bones* (*ossa palati*) should be regarded as the posterior appendages of the upper maxillary bone. They correspond, from behind forward, to the intermaxillary portion of the upper, jaw.

They are thin layers curved on themselves, the upper larger and perpendicular part of which corresponds to the inner wall of the body of the upper maxillary bone, and the horizontal to the palatine process of this same bone, of which they are the continuation and the termination.

§ 589. The internal face of the horizontal portion presents two parallel eminences, separated very much from one another, which extend from the posterior to the anterior edge, and are called the *upper and lower turbinated crests*, or the *transverse eminences* (*crista turbinalis superior et inferior*, s. *lineæ eminentes transversæ*). The external face is concave in the points corresponding to these two eminences, smooth in its anterior portion which is the most extensive, and hollowed posteriorly, by one or two longitudinal furrows, called the *pterygo-palatine fossæ* (*sulci pterygo-palatini*), which are continuous with the furrow of the palatine face of the upper maxillary bone.

The rough posterior edge presents downward, backward and outward, where the perpendicular part unites to the horizontal portion, a thick eminence called the *pyramidal* or *pterygoid process* (*processus pyramidalis* s. *pterygoideus*). The anterior edge is thin, uneven, and extends below the inferior transverse line, in a small projection called the *nasal process* (*processus nasalis*). Above, the perpendicular portion divides into two eminences, the anterior called the *orbital process* (*processus orbitalis*), and the posterior the *sphenoidal process* (*processus sphenoidalis*).

(1) Meckel, *Path. Anat.* vol. i.

The first is deeply concave inward, convex upward, backward and outward, straight forward, downward and outward, rough externally, and smooth in all other parts of its surface.

The sphenoidal process is lower than the orbital, a continuation of the posterior edge of the palate bone upward: it is directed toward the posterior part of the orbital process, but rarely meets it.

The space which remains between these two processes, and which is always filled by the dura mater in the recent state, constitutes the *spheno-palatine foramen* (*foramen spheno-palatinum*).

The horizontal portion is terminated forward by a sharp, rough and thin edge; inward by a broad and uneven edge; backward by a smooth edge. The last is notched, and terminates internally by a pointed eminence.

§ 590. The palate bones articulate, 1st, with each other by their horizontal portions. The union of the internal eminences of their posterior edges gives origin to the *nasal* or the *posterior palatine spine* (*spina palatina posterior*); 2d, with the upper maxillary bones (§ 585); the anterior part of their perpendicular portion contracts the orifice of the antrum Highmorianum; the anterior part of the external face of this portion applies itself to that of the thin wall of the maxillary sinus found behind its orifice; the posterior remains a little distance from it, producing the *pterygo-palatine canal* (*canalis pterygo-palatinus*) between it and the edge of the posterior face of the maxillary bone; 3d, with the ethmoid bone, by the orbital process, so that the internal and concave face of this process covers and enlarges the posterior ethmoid cells, and the posterior extremity of the middle turbinated bone meets the upper process of its internal face; 4th, with the sphenoid bone; for the posterior edge of the perpendicular portion embraces the anterior face of the pterygoid processes, the pyramidal process insinuates itself between the two wings of these last, and the posterior face of the orbital processes applies itself to the anterior of the body: the horns of the sphenoid bone frequently make part of the palate bones, and are only an enlargement of the posterior face of the palatine process; the bone, wedged in between the pterygoid process of the sphenoid bone and the body of the superior maxillary bone, forms or completes with it the *pterygo-palatine fossa* (*F. pterygo-palatina*); 5th, with the posterior extremity of the lower turbinated bone, by the lower transverse eminence; 6th, finally, with the posterior extremity of the lower edge of the vomer, by the palatine crest.

§ 591. At first, the palate bone is situated very low, so that its perpendicular portion is shorter than its horizontal portion, and considerably large, particularly from before backward, in proportion to its other dimensions. We have found it in the fetus of three months, composed of a single nucleus of bone, which appeared as a curved plate.

§ 592. The anomalies it offers consist in the separation of the two palatine portions, existing either alone or attended with a similar division of the upper maxillary bones. This anomaly seems to be sometimes although rarely occasioned, and sometimes compensated for, by the extension of the palatine process of the maxillary bones backward, which is extremely remarkable.

III. OF THE MALAR BONES.

§ 593. The *malar* or the *cheek bones* (*ossa jugalia, zygomatica, malaria, malæ*) have an irregular quadrilateral form; they are convex externally and concave internally. They are composed of two pieces united at a right angle, the upper, smaller and internal; the lower, larger, perpendicular and external. The first is very much grooved upward and forward, and forms the anterior part of the anterior wall of the orbit. The second is situated outwardly under the skin of the cheeks, and forms, by its projection, the broadest region of the face.

§ 594. The *zygomatic canal* (*canalis zygomaticus*), which is generally single, sometimes double, or even multiple, passes through the malar bone. This canal commences by an upper orifice at the anterior face of the superior portion, and terminates, on one side, at the external face of the perpendicular portion, by the *external zygomatic foramen* (*foramen zygomaticum externum*); on the other, at the internal face of this same part, by another opening, called the *internal zygomatic foramen* (*foramen zygomaticum internum*).

§ 595. This bone articulates, 1st, with the malar process of the upper maxillary bone, by the anterior edge of its external portion, also by the internal edge of its superior portion, between which is a rough surface; 2d, by the posterior part of the inner rough edge of its horizontal face, with the edge formed outward by the union of the anterior and external faces of the large wing of the sphenoid bone; 3d, by its upper portion with the malar process of the frontal bone; 4th, by its inferior and posterior parts with the zygomatic process of the temporal bone. We call those prolongations by which this bone articulates with the sphenoid bone, the upper maxillary bone and the temporal bone, the sphenoidal, the maxillary, and the temporal processes.

The greater part of its posterior edge is free.

The articulation of this bone with the temporal bone forms a *bridge* (*zygoma, jugum*) above the temporal fossa (*fossa temporalis*) comprised between the anterior part of the squamous portion, the large wing of the sphenoid bone and the posterior face of the malar bone; this bridge varies in form, according to the races.

§ 596. The malar bone appears early, toward the commencement of the third month. We have always found it composed of a single nucleus of bone. The numerous observations and facts on this subject carefully collected, would lead us to doubt the assertion of Portal, that there are three points of ossification.

§ 597. This bone is sometimes entirely deficient ;(1) a striking resemblance with what is seen in several mammalia, as the tanrec, the

(1) Meckel, *Beytrage*, vol. i. p. ii. p. 54.—Dumeril, *Bull. de la soc. phil.* vol. iii. p. 122.

sloth, and the ant-eater. It is sometimes divided by a suture into two portions, an anterior and a posterior,(1) or even into three pieces.(2)

IV. OF THE NASAL BONES.

§ 598. The *nasal bones* (*ossa nasi*, *nasalia*, *nasi propria*) are small bones, of an oblong square form, thick at their upper part, thinner and broader downward, which form the upper and anterior walls of the bony frame of the nose. They are situated obliquely from above downward and from behind forward, between the frontal bone, the maxillary bone, and the perpendicular plate of the ethmoid bone. They describe a double curve, whence they are concave forward and convex backward in their upper part, while in their lower part they are convex forward and concave backward. Near their centre, we observe one or more foramina which pass entirely through them.

§ 599. They articulate, 1st, with each other by a rough and very broad surface, which is usually extended into a crest or spine, called the *nasal crest* or *spine* (*crista*, s. *spina nasalis*) ; 2d, with the ethmoid bone, directly, by the nasal spine, or indirectly, by a piece of bone interposed between them, which also represents a spine ; 3d, with the frontal bone (§ 568) by their upper and thickest edge ; 4th, finally, with the anterior edge of the nasal process of the upper maxillary bone, by their outer edge.

§ 600. Each of them is developed by a single nucleus of bone which begins to appear at the commencement of the third month.

§ 601. Both bones not unfrequently unite in their whole length, or only at their upper part, which deserves to be remarked as offering an analogy with the formation of several simiæ.

V. OF THE UNGUIFORM BONES.

§ 602. The *unguiform* or the *lachrymal bones* (*ossa lachrymalia*, s. *unguis*) are the smallest of the bones of the face. They are only thin plates of an oblong quadrangular form, situated in the inner angle of the eye between the maxillary, the frontal, and the ethmoid bones, and are frequently perforated.

Their outer face is divided by a longitudinal crest, to which a depression corresponds posteriorly, into two parts, an anterior and a posterior, the proportional extent of which varies much. The posterior part is sometimes very small, and then the papyraceous plate of the ethmoid bone is rather extensive. When, on the contrary, the anterior is narrower, it is made up by the greater breadth of the nasal process of the upper maxillary bone. The anterior part is always much thinner than the posterior, concave externally and convex internally. It forms the posterior wall of the *nasal channel* (*sulcus canalis nasalis*), the anterior of which belongs to the posterior part of the external face of the nasal process of the upper maxillary bone (§ 581).

(1) Sandifort, *Obs. anat. pathol.*, b. iii. p. 113, iv. p. 134.
(2) Spix, *Cephalogenesis*, p. 19.

§ 603. The unguiform bone articulates, 1st, by its upper edge with the orbital portion of the frontal bone; 2d, by its posterior edge, with the anterior edge of the os planum; 3d, downward, by its inferior edge, with the anterior part of the inner edge of the body of the upper maxillary bone; 4th, forward, by its anterior edge, with the posterior edge of the nasal process of this bone. All these edges are thin and smooth. The posterior face of the unguiform bone closes the anterior ethmoidal cells.

§ 604. The ossification of the unguiform bone begins in the fifth or sixth month.

§ 605. The unguiform bone is not unfrequently extremely small or entirely deficient. It is then supplied by the cribriform plate of the ethmoid bone, or more frequently by the ascending branch of the upper maxillary bone, which becomes broader, or finally by both these at once.

VI. OF THE INFERIOR TURBINATED BONES.

§ 606. The *inferior turbinated bones* (*conchæ, conchæ inferiores, ossa turbinata* s. *spongiosa*), thus called to distinguish them from the superior and middle turbinated portions of the ethmoid bone, form a very great part of the base of the olfactory organ.

In form and structure they resemble the ethmoidal turbinated bones, but are larger than them, and are convex externally. They are elongated from before backward, higher in the centre than in the other parts, straight, very thin and smooth in their upper portion, bulging in the lower portion, and terminate downward by a rounded edge, which is reflected from below upward. Their inferior portion is rough, and on its external face are tubercles, and small blind depressions on its internal.

§ 607. Near the centre, the upper edge, which is sharp, is reflected outward and downward, to produce the broad *unciform maxillary process* (*processus maxillaris*), by which it is joined to the lower edge of the maxillary sinus. In front of this process we perceive another, which varies in length,—the *nasal* or *lachrymal process* (*processus lachrymalis* s. *nasalis*), the direction of which is from below upward; it articulates with the lower extremity of the unguiform bones. Between these two eminences, we sometimes see the *ethmoidal processes* (*processus ethmoidales*), which go to the large and small processes of the ethmoid bone (§ 574).

The anterior and blunter extremity of the bone articulates, 4th, with the lower transverse eminence of the upper maxillary bone (§ 585), and the posterior with the corresponding eminence of the palate bone (§ 590).

§ 608. Ossification appears first in the fifth month, at its centre, where there is only one nucleus. We have never found several.

VII. OF THE VOMER.

§ 609. The *ploughshare* (*vomer*) is an irregularly quadrilateral bone, situated on the median line to which it imperfectly corresponds, and downward and backward divides the nasal cavity into two portions. Its upper edge, which is the thickest and also the shortest, is divided into two lateral processes, called the *wings* (*alæ vomeri*), between which is a furrow. These wings embrace the spine of the sphenoid bone, and are covered by the vaginal processes of this bone. The upper and anterior edge, the longest of all, is also cleft, but much thinner; it is articulated posteriorly with the posterior edge of the perpendicular plate of the ethmoid bone, and forward with the inferior edge of the cartilaginous septum of the nasal fossæ. The inferior, which is the third in extent, articulates with the palatine crest (§ 585). The posterior is free. Thus the vomer articulates with the ethmoid bone, the sphenoid bone, the upper maxillary bones and the palate bones.

§ 610. In the fetus of four months, there is already formed only a single bone, which is much lower, in proportion to its length, than in the adult, and is composed of two plates, of equal thickness in every part, separated in almost all their height, and united only at their lower part, loose around the cartilage of the septum of the nasal fossæ, and having the appearance of a single plate reflected on itself. It is then proportionally and absolutely much broader than in the adult. This form is found even in the full grown fetus, where the lateral plates are no where turned outwardly. We have never found several points of ossification, which Portal asserts exist.

§ 611. When the nose is not completely developed, the vomer is some times deficient, or is perforated by an opening.

VIII. OF THE LOWER MAXILLARY BONE.

§ 612. The *lower maxillary bone* (*maxilla*, s. *mandibula inferior*, *os maxillare inferius*) is situated opposite the upper. It has a parabolical form, resembling a horse-shoe. We may, for the convenience of study, divide it into the *central*, *alveolar*, or *horizontal portion* (*pars alveolaris, ramus horizontalis*), and the *articular*, *lateral* or *ascending parts* (*partes articulares, rami perpendiculares*).

§ 613. These three parts are marked with muscular impressions, which render the surface uneven. In the centre of the anterior and posterior faces of the central portion are two longitudinal eminences, called the *external* and the *internal mental crests* (*crista mentalis externa et interna*). At some distance on this crest, equally on both faces, we perceive on each side a line, the direction of which is almost the same as that of the upper edge: these are called the *external* and *internal oblique lines* (*linea obliqua externa et interna*). This line extends from before backward, to the second small molar tooth.

Below this same tooth, about the centre of the bone, is the *mental* or *anterior maxillary foramen* (*foramen maxillare anticum*, s. *mentale*).

§ 614. The ascending branch is divided upward into two processes, of which the anterior, called the *coronoid process* (*processus coronoideus*), is greater, thinner, and more elevated than the posterior, flattened from without inward, and pointed. The second, called the *condyloid procsss* (*processus condyloideus*), is broader from one side to the other than from before backward. Its direction is a little oblique from without inward and from before backward, so that the the two articular surfaces converge toward each other backward. Its upper face is rounded, and usually divided, by a transverse line, into an anterior and a posterior part.

This process, which is the broadest part of the lower maxillary bone, is about six lines broad from one side to the other; its height and thickness are about three lines. The thick and contracted part which comes after it is its *neck.* The *sigmoid notch* (*incisura semilunaris*, s. *sigmoidea*) is that part of the upper edge which is found between the two processes and the *angle of the jaw* (*angulus maxillaris*) is the place where the posterior and inferior edges are united with each other. A little above the middle of the internal face is a large opening, the *posterior maxillary foramen* (*foramen maxillare posterius*), which leads into the *maxillary canal* (*canalis maxillaris*). This last penetrates into the bone nearer its lower than its upper edge, opens externally by the mental hole, but still continues as far as the median line, and furnishes, at its upper part, some small canals which go to the roots of the teeth. A small fissure proceeds from this posterior maxillary foramen along the internal face, which is called the *mylo-hyoid fissure* (*sulcus maxillæ inferioris*, s. *mylo-hyoideus*). Sometimes, but rarely, this fissure is converted into a real canal, either at its origin or in one or several parts of its course: more rarely still, it divides into two branches at the moment of its origin.

§ 615. The lower maxillary bone does not articulate, except with the temporal bones, on which it moves.

§ 616. We have found this bone formed, in the earliest periods, of but two lateral pieces, united on the median line by a cartilaginous substance. In fact, Autenreith pretends that it developes itself by three or four points of ossification, belonging to the condyle, to the coronoid process, to the horizontal portion, and to the angle.(1) Even before him, Kerkring said he had found the coronoid process at least, developed separately.(2) Very recently still, Spix(3) has admitted not only the osseous nuclei pointed out by Autenreith, but has also described and figured a fifth, a plate which closes the alveolar edge internally, and which, according to him, remains separate and distinct until the fourth month. But, however carefully we may have examined even the youngest fetuses, we have never found, either during or after pre-

(1) Wiedemann, *Archiv für Zoologie und Zootomie*, vol. i. pt. i. p. 39.
(2) *Opp. omn. anat.* p. 233.
(3) *Cephalogenesis*, p. 20.

paration, more than a single plate in each portion of the lower maxillary bone. It is true that the alveolar edge is not closed at first internally by the osseous substance; but there is no special nucleus of bone formed in this part: there is developed a process, the direction of which is from before backward, which becomes an anterior portion of the bone, and is at first separated from it by a small posterior fissure. When it has arrived at the region of the ascending branch, it unites to its internal face by a bridge, and forms the posterior maxillary foramen. In the commencement, the maxillary canal is not yet closed at its upper part, and is connected with the dental edge.

We always find, even in the full-grown fetus, two openings at least, in the place of the posterior maxillary foramen; one much more ample, leads to a furrow which exists at the bottom of the posterior alveolar process, and which ceases at its anterior extremity. The other, smaller and inferior, leads to a canal which passes under the alveolar process, and which goes to the internal extremity of the half of the jaw. The furrow and the canal communicate by several openings, and all lead to the anterior maxillary foramen; but the furrow more directly.

A pretended line of demarkation, pointed out by Spix, between the plate and the rest of the lower maxillary bone, is only the mylo-hyoid fissure (§ 614), which is extensive in the fetus, because of the great development of the mylo-hyoid branch of the fifth pair of nerves.

We shall speak of the development of the alveolar edge, when treating of the teeth.

The two lateral parts are straighter and nearer to each other, in proportion to the youth of the bone. The ascending branch, especially the articular process, is more depressed, so that the alveolar edge does not project in the fourth month of pregnancy. There is less difference between the direction of the posterior edge of the ascending branch, and the inferior edge of the horizontal portion; and, also between the anterior edge of the first and the upper edge of the second: and, fourthly, the articular process is contracted from right to left.

In the full-grown fetus, the lower maxillary bone does not resemble the formation which distinguishes it in the adult, except in regard to the fourth condition. As to the first, the bone, in the early periods of the fetal state, differs more than the lower maxillary bone of the adult, since its form is then rounder. This, it is true, depends partly on the greater projection of the alveoli; but this circumstance is not the only cause. The maxillary bone, however, is still much flattened at this period; its edges are very round, and the whole bone is very broad. Finally, it is perfectly developed very early, since, in the fetus of three months even, it is the largest bone in the whole body.

The union of the two lateral portions commences in the first months after birth. Generally, however, in the course of the second year we observe always at the upper edge a small fissure, the direction of which is from above downward, whence the fusion takes place from below upward. This peculiarity is very remarkable, because the bones situated below the lower maxillary bone, the sternum, and the hyoid bone, also often unite in the median line, while those found above it, the upper maxillary bone and the other accessory bones of the face, remain separate during life; and the lower parts of the two pieces of the frontal bone are also the last in which this fusion takes place.

Sometimes the two portions are already united in the full-grown fetus; this union, in certain cases, seems to take place at the expense of the formation of the other bones of the head.

Sometimes, also, there is developed between these two halves, either a single bone or two small bones, a right and a left, which unite on the median line: not long since, we observed this anomaly in a child three months old; or, this horizontal branch is divided still farther back into two large halves: a striking analogy with the development of the upper maxillary bone, and with the constant arrangement of the lower maxillary bone in birds, in reptiles, and in the mammalia.

§ 617. The two portions of the inferior maxillary bone do not, to our knowledge, ever continue separated, although this arrangement exists, in the normal state, in many animals, and is a very frequent anomaly in the superior maxillary bone.

An unfrequent anomaly is the union of the articular process with the temporal bone. This prevents mastication (1).

IX. OF THE HYOID BONE.

§ 618. The *hyoid bones* or the *hyoid bone* (*ossa hyoidea*, s. *os hyoides*)(2), forms an arch which is convex forward. It is situated behind and below the lower maxillary bone, at the root of the tongue and at the upper part of the neck. It is generally considered a single bone, and is divided into a central portion or body, and four horns, two on each side. But, as these parts remain distinct through life, it is better to admit five distinct hyoid bones, a middle and four lateral bones.

1. OF THE CENTRAL HYOID BONE.

§ 619. The *central hyoid* bone, or the body (*os hyoides medium*, s. *basis*), the largest of all, is situated transversely.

Its anterior face is slightly convex, and the posterior very deeply grooved.

The anterior face is divided into a larger inferior ascending and uniformly convex portion, and a smaller superior portion which is also arched from right to left, but more or less grooved from above downward, which is also divided into two lateral portions by a small eminence between.

(1) Sandifort, *Obs. Anat. Patho.* vol. 1, p. 102. tab. vi. vol. ii. p. 117.

(2) See, on the hyoid bone considered in all vertebrated animals, the memoir on the anterior bones of the chest, by G. F. St. Hilaire, (*Philosophie Anatomique*, p. 139). He admits seven pieces in the hyoid bone of the mammalia, and refers to it also, the styloid processes of the temporal bones. F. T.

The upper and lower edges are sharp, the two lateral are somewhat broader.

At the end of the upper part of the anterior face, there is on each side a small plain articular surface covered with cartilage.

II. OF THE INFERIOR HYOID BONE.

§ 620. The *inferior hyoid bone*, called also the *inferior horns*, *the large horns of the hyoid bone* (*ossa hyoidea lateratia inferiora*, *cornua inferiora*, s. *magna*), is the direct continuation of the preceding, and forms the largest posterior part of a horizontal arch. Each of the two pieces of which it is composed, is longer than the central hyoid bone, but it is much weaker. Their anterior part is the broadest. They then gradually contract, and terminate backward by a rounded bulging edge. These two pieces usually diverge from before backward, but they rarely incline a little toward each other posteriorly.

Their anterior broader edge is slightly concave and covered with cartilage. The inner end of the upper part of their anterior face has also an articular facet, which is smooth and covered with cartilage.

They often, in the same subject, vary considerably in form and size on the different sides.

They articulate with the central piece by a fibro-cartilaginous mass, and sometimes unite in the later periods of life in one bone.

III. OF THE SUPERIOR HYOID BONE.

§ 621. The two pieces of the *superior hyoid bone*, called also the *superior* or *small horns of the hyoid bone* (*ossa hyoidea*, s. *cornua superiora* s. *minima*), have a more or less rounded and oblong form. They gradually grow thin from one extremity to the other; are oblique from below upward, and from within outward; and are situated in the place where the middle and inferior bones unite, being connected with them by a loose capsular ligament.

They are always very thin, and usually much shorter, but sometimes also much longer, than the inferior bones. Their length varies from two lines to an inch and a half. In the latter case, it often but not always happens, that each is composed of two separate pieces.

Of all bones, these present the greatest differences in respect to form and length, not only in different individuals, but also in both sides of the body in the same individual. We not unfrequently find them twice as long on one side as on the other, and this side is almost always the left, at least according to our observations. We have never found this to be the case on the right side, although we have examined many hyoid bones (1).

§ 622. The hyoid bones articulate with one another at the places pointed out (§ 619, 620, 621), and farther upward, with the styloid

(1) The remark, that this arrangement is constant, is more probable, because Duvernoy has made the same remark.—(*Comm. Petrop.*, vol. vii. p. 216.)

process of the temporal bone, downward with the centre of the upper edge and the superior horns of the thyroid cartilage.

§ 623. They begin to ossify about the end of pregnancy, and sooner in the lower lateral hyoid bones than in the central bone. The upper lateral hyoid bones do not ossify till several months after birth.

§ 624. These bones continue on the neck, the chain of bones formed in the head by the lower maxillary bone; in the chest, by the ribs and sternum; in the pelvis, by the symphysis pubis. We may then consider them as corresponding to the ribs and sternum, and call the central part the *bone of the neck*, and the lateral parts the *cervical ribs.*

CHAPTER III.

GENERAL REMARKS ON THE BONES OF THE HEAD.

§ 625. The bones of the head (*ossa capitis*), taken collectively, may be considered, 1st, in regard to the general form of the whole, and the differences in respect to age, sexes, and races; 2d, as regards the characteristics of certain parts of the head, to produce which, several bones concur, having regard principally to the relations between these parts and the other organic systems.

I. REMARKS ON THE GENERAL FORM OF THE HEAD.

§ 626. The head has, as a whole, a rounded form. This however is more evident in the skull than in the face; for this last resembles, properly speaking, an irregular square, furnished however with numerous depressions and elevations, of which we see but slight traces, so long as the portions of the other organic systems which cover them are not removed. Further, the skull itself is not round and regular. Its anterior, superior, posterior, and lateral portions, are, it is true, plain and smooth, except a few inconsiderable asperities; but its lower part, or the *base* (*basis cranii*), is extremely irregular, because of numerous muscular impressions, and large or small holes, through which pass vessels or nerves, of which we find but slight traces in its other regions.

The skull contains a cavity, generally inclosed with very thin walls, which is convex externally and concave internally in the different regions which have been mentioned. The internal face corresponds with tolerable exactness to the external. On the contrary, not only its lower part is not uniformly concave internally, and convex externally, but the external and internal faces do not correspond.

The general differences between the external and the internal faces of the skull depend on their relations with the organs with which both are connected.

1st. The greater part of the internal face, especially the anterior part of the base, presents numerous digital depressions and mammillary eminences (§ 526).

2d. On the internal face of the lateral and superior parts, numerous fissures (*sulci meningei*) arise from the middle part of the base, in which are situated the cerebral arteries.

3d. This same face presents other fissures for the veins (*sulci venosi*), which are broader, and are situated in the upper part of the skull on the median line; and in the lower part, on both sides of this line, they are the traces of the sinuses of the dura mater.

4th. The internal wall of the base presents several depressions, which are the largest of any, and which correspond to the different divisions of the encephalon.

The elevations and projections which render the internal face uneven, serve partly for the attachment of the dura mater. Others circumscribe several of the depressions which we have mentioned; and others still, as the petrous portion of the temporal bone, possess an independent existence.

§ 627. The form of the skull is not exactly round. If cut perpendicularly and horizontally, it represents ellipses, of which the greater diameter is backward, the smaller forward. The skull is much longer from before backward, than from right to left and from above downward. The proportion between its greatest length from the glabella of the frontal bone to the spine of the occipital bone, its greatest breadth from the squamous portion of one temporal bone to that of the other, and its greatest height, is nearly : : 3.3 : 2.3.

If we examine the interior of the skull, we perceive that this cavity, uniform in parts, divides, especially downward, into three portions situated successively from before backward, the *anterior*, the *middle*, and the *posterior*.

The *anterior*, which is the smallest in every dimension, occupies the most elevated region. Its sides are formed by the orbital portions of the frontal bone; its centre by the central part of the ethmoid bone, and its posterior part by the small wings of the sphenoid bone. Forwaɹd, and on the sides, it is imperceptibly continuous by a rounded edge with the lateral faces of the skull; while backward it is separated from its central part by a sharp and grooved edge. Its form is then almost semicircular. Downward, on both sides, where it forms the roof of the orbits, it is strongly bulging, and projects into the cavity of the skull, while it presents a considerable depression in almost all its central portion, which is formed forward principally by the cribriform plate of the ethmoid bone. The crista galli process (§ 571) arises from its centre; before this, the internal frontal crest arises (§ 564), between which and the process is the *foramen cæcum* (§ 566).

The anterior extremities of the anterior lobes of the cerebrum and the olfactory nerves, the threads of which pass through the holes of the cribriform plate, rest upon this portion. To the crista galli process and to the frontal ridge is attached the lower anterior extremity of the large falx of the dura mater.

The central portion, which deserves this name both from its situation and from its extent, has the form of a figure 8 placed transversely (∞), for it is much narrower in the centre than on the two sides. It is formed by the body the large wings and the posterior and inferior portions of the small wings of the sphenoid bone, and by the squamous and the large anterior part of the temporal bones. Its anterior edge, formed by the small wings of the sphenoid bone, consists in two large lateral arches and a central arch which is smaller: the lateral is insensibly continuous with the lateral face of the cranium; the posterior is composed of a central, smaller, and straight portion, the upper edge of the sloping part of the sphenoid bone, and of two much more extensive, sharp, and almost straight edges, which proceed from within outward and from before backward, the upper angles of the petrous portion of the temporal bone. This portion is grooved, but its central part, the sella turcica, is much more elevated than the lateral portions, which are more extensve than it.

In its centre is situated the pituitary gland, and on the two sides the anterior part of the posterior lobes of the brain.

The posterior portion, which is the largest of all, has an almost circular form. It is for the most part composed of the occipital portion of the basilar bone, forward and on the sides by a small part of the temporal and of the sphenoid bones. The posterior edge of the second portion separates it from the last forward. In every other direction it is gradually continuous with the other walls of the skull.

It lodges the cerebellum, the medulla oblongata, and the inferior part of the venous sinuses of the cerebrum. The anterior edge of the tentorium is attached to its anterior and sharp edge.

§ 628. The base of the skull, considered in regard to its external and its internal faces, ascends from its posterior to its anterior portion, which is the larger. The first is formed by the posterior and inferior part of the squamous portion of the occipital bone. The occipital foramen is situated almost horizontally a little behind the centre. After leaving this point, the body of the sphenoid bone suddenly rises, then curves forward above the sella turcica: this last is almost horizontal. From thence the internal face of the base of the skull divides into an upper and inner and an outer and lower portion. The first elevates itself again, but slightly, before the anterior edge of the sella turcica; the second, which comprises the wings of the sphenoid bone and the lower part of the ethmoid bone, turns perpendicularly downward, to assist in forming the nasal fossæ.

§ 629. The facial portion of the head represents a very irregular square or triangle, which is much higher forward than backward, and is situated below the anterior half of the cranium, extending a little in front of it. Of the fourteen bones which compose it, thirteen are firmly united, either with each other or with the adjacent bones of the skull, by broad dentated surfaces, by sutures, or by smooth, sharp edges. One alone, the lower maxillary bone, is movably articulated with the temporal bones.

Instead of a single large cavity, like that of the skull, the bones of the face, form (not however alone, but with those of the skull) other and more open cavities and depressions, which are connected with the radiations of the nervous system the organs of sense, or with the movable organs of mastication.

The cavities of the first kind are situated forward; those of the second are found on the side, and are farther backward. The first are the cavities of the orbits, the nasal fossæ, and the cavity of the mouth; the second are the temporal fossæ.

I. OF THE ORBITS.

§ 630. The *orbits* (*orbitæ*) have the form of truncated, short pyramids with unequal faces, of which the very broad and almost perpendicular base looks forward, and is directed a little from before backward and from within outward, while the summit corresponds to the posterior extremity. Both orbits converge very much backward, so that they are for the most part, if not entirely, turned forward and a little outward.

The outer and lower faces are straight. The internal and the upper, especially the latter, on the contrary, are very concave.

The upper face, called the *vault of the orbit* (*lacunar orbitæ*), is formed, in most of its anterior part, by the orbitar portion of the frontal bone. We observe, in a small part of its posterior portion, the inferior face of the small wing of the sphenoid bone. It is insensibly continuous, by a rounded edge, with the internal and the external walls of the orbits.

The external wall in the direction of length is oblique from without inward and from before backward, in that of height it is directed from without inward and from above downward, and its length exceeds its height very much. Its anterior and smaller part is formed by the malar bone, and the posterior and larger portion by the large wing of the sphenoid bone; it is separated backward and upward from the upper by the superior sphenoid fissure, backward and downward by the inferior sphenoid fissure.

The lower face is irregularly triangular, and mostly formed by the upper face of the body of the upper maxillary bone, forward by the malar bone, and inward by the orbital portion of the palate bone. It descends a little from behind forward and from within outward.

The inner face is formed at its central part, which is the most extensive, by the lateral plate of the ethmoid bone, forward by the lacrymal bone, and backward in a small portion by the body of the sphenoid bone. Its direction is a little from before backward and from within outward, and it descends obliquely downward and outward.

The nasal canal commences at its anterior extremity.

The anterior opening of the cavity of the orbit is almost quadrilateral; its breadth however exceeds its height, and it is circumscribed by rounded, grooved edges, which are insensibly continuous with each other.

This cavity is connected with the *cavity of the skull*, with the *nasal cavity*, with the *pterygoid fossa*, and with the *anterior part of the face*.

1st. With the cavity of the skull, by the optic foramen, which is found at its posterior extremity, always a little within its axis (§ 541); more anteriorly, by the superior sphenoid fissure (§ 541); forward, by the anterior and posterior ethmoid foramina (*foramina ethmoidalia anteriora et posteriora*), situated between the orbital part of the frontal bone and the upper edge of the os planum of the ethmoid bone.

2d. With the nasal fossa, by the anterior ethmoid foramina and the nasal canal.

3d. With the pterygoid fossa, by the inferior sphenoidal fissure.

4th. With the anterior part of the face, by its large anterior opening, the infra-orbital canal, and the foramina of the malar bone.

§ 631. Seven bones concur in its formation, viz. the frontal bone, the sphenoid bone, the upper maxillary bone, the malar bone, the palate bone, the ethmoid bone, and the unguiform bone.

§ 632. In youth the orbits are proportionally deeper, and their walls are more concave; the internal, which does not even exist in the fetus, is much lower; the inferior is concave and almost straight, or less oblique from above downward and from behind forward; finally, the anterior opening is more or less transversely elongated. Considered as a whole, the breadth of the orbital fossa exceeds its height very much. Its external edge, formed in a great part by the malar bone, projects very much from above downward and from behind forward, while afterward it descends almost perpendicularly. These remarkable differences are greater in proportion as the fetus is younger. They depend on the fact that the face is at first low, and lengthens gradually.

II. OF THE NASAL FOSSÆ.

§ 633. The *nasal fossa* (*cavum nasi, nares internæ*)(1) is situated below and between the two cavities of the orbits (§ 624—629); but it extends also above them, by some of its prolongations. It has a very irregular form; it is however on the whole quadrangular, and similar to the form of the face. A *perpendicular septum* (*septum narium*), directed from before backward, divides it in its broadest part into two halves, a right and a left. We may divide it into the *proper nasal fossa*, and into *secondary* or *accessory cavities*.

§ 634. In the *proper nasal fossa* we distinguish an anterior and a posterior opening, the floor, the upper wall or the vault, and the lateral walls. The accessory cavities comprehend the three nasal sinuses.

The *anterior opening* (*apertura narium anterior*, s. *faciei pyriformis*) is elongated and pyriform. It terminates in a point at its upper part, enlarges downward, but again contracts toward its inferior extremity. It is single, because the bony septum does not extend entirely forward. The lines which circumscribe it are always arched externally. It is

(1) Ziervogel, *Diss. de naribus internis*, Upsal, 1760.

not exactly perpendicular, but, regarded from above downward, it projects a little backward. At its lower part, it projects a little from without inward, and from behind forward, and in the middle of the inferior edge we see the *anterior nasal spine* (*spina nasalis anterior*). It is formed above by the inferior edge of the nasal bones, and in almost all its lower part by the nasal process and the body of the upper maxillary bone.

The *posterior aperture* (*apertura nasalis posterior*) is lower, but much broader than the anterior. It represents a somewhat regular square, and is always double, because the septum, which terminates by an oblique and serrated edge, extends to the posterior extremity of the nasal fossa. It is formed by the inner plate of the pterygoid processes of the sphenoid bone, the vomer, and the horizontal portion of the palate bone.

The *floor* of the nasal fossa is almost straight, and slightly concave, for it is a little elevated on each side, internally and externally, toward the septum and the lateral walls. It terminates forward in a triangular edge, and backward in another edge semicircular on both sides, having two deep notches. We observe in the centre of the first the anterior nasal spine, and in the centre of the second the posterior nasal spine. The floor is formed by the horizontal part of the upper maxillary and palate bones.

The upper wall, which is the smallest, is formed upward by the cribriform plate of the ethmoid bone, downward by the frontal bone and the nasal bones.

The posterior wall exists only at the summit of the nasal fossa, and is formed by the sphenoid bone.

The lateral walls of the nasal cavity are very irregular. They elevate themselves in an almost straight direction, but generally are a little convex externally, and present on their internal portion considerable projections, which render the surface very uneven, and also openings which lead into the accessory cavities.

The direction of the eminences projecting internally is from before backward. They are convex internally, concave externally, and are situated one above the other. Their upper edges are attached, and their lower edges are free. We usually count three: 1st, the *upper*; 2d, the *middle turbinated portion of the ethmoid bone* (§ 572); 3d, the *inferior turbinated bone* (§ 606). We usually remark, besides, a smaller process, situated at the upper and posterior part,—the *upper turbinated portion of the ethmoid bone*.

The depressions or semi-canals between these projections, which are directed from before backward, and always ascend from behind forward, are the *superior*, the *middle*, and the *inferior* meatuses of the nose, which extend equal distances backward, but not forward.

The *superior meatus* is generally found between the upper and the middle turbinated bones. It is the least elevated, the narrowest, and the shortest, for it does not project forward nearly as far as the two others. The sphenoidal sinuses open into its posterior part; the cellules of the ethmoid bone, of the palate bone, and of the upper maxillary bone, in its central part.

The *middle meatus* is much higher, and is the most uniform of the three in its height. It extends between the middle and the inferior turbinated bones, projects much farther forward than the upper, and receives in its anterior portion the frontal sinuses, and in its centre the maxillary sinuses.

The *inferior meatus*, the longest of all, is higher in its anterior part, but much lower in its posterior part than the middle meatus, and is situated between the inferior turbinated bone and the floor of the nasal cavity. It communicates with no accessory cavity; the lachrymal duct, however, opens in its anterior extremity.

Besides these three channels, we always remark a fourth longitudinal depression, between the superior turbinated bone and the whole internal wall of the labyrinth and of the cribriform plate; this depression extends much farther forward than the superior meatus. Finally, we usually discover a fifth, which is much smaller, the most superficial and the shortest of all, between the most superior and the upper turbinated portions of the ethmoid bone.

§ 635. The nasal fossa sends upward, on the two sides and backward several *processes*, *prolongations*, or *accessory cavities* (*sinus*, *antra*).

1st. The upper prolongations are the *frontal sinuses* (§ 564), which open into the middle meatus by an orifice, which gradually narrows, and the direction of which is from before backward and from above downward.

2d. The lateral prolongations are the *maxillary sinuses* (§ 534), the largest; they open by a very narrow orifice, in about the centre of the middle meatus.

3d. The posterior are the *sphenoidal sinuses* (§ 536), which also open by a narrow orifice into the posterior part of the superior meatus.

§ 636. The nasal cavities communicate upward with the orbits and the cavity of the skull by the orbital holes, and with the cranium by openings in the cribriform plate; backward, with the pharynx, by their posterior openings; forward, with the cartilaginous nasal fossæ, by their anterior openings; downward, with the oral cavity, by the anterior palatine foramen.

§ 637. They are formed by nine different bones: 1st, the upper maxillary bones; 2d, the palate bones; 3d, the sphenoid bone; 4th, the ethmoid bone; 5th, the inferior turbinated bone; 6th, the vomer; 7th, the nasal bones; 8th, the unguiform bones; and 9th, the frontal bone. Of all these, the upper maxillary bones contribute the most to their formation, as they form most of the floor and of the lateral walls. The ethmoid bone belongs to them entirely, forming their upper wall. The palate bones complete their floor, and contribute to form their lateral walls. The unguiform bones form part of their lateral walls, as does also the inferior turbinated bone. The sphenoid bone concurs to form the posterior part of the posterior wall and the lateral walls, by its pterygoid processes and its sinuses. The frontal bone and the nasal bones terminate their upper wall forward. Finally, the vomer forms the inferior and posterior part of the septum of the nose, while its upper wall is composed of the perpendicular plate of the ethmoid bone and of the spine of the sphenoid bone.

§ 638. The nasal fossæ are much less spacious, proportionally speaking, in the early periods of life. From the smallness of the whole face, they are much lower and narrower, so that their anterior and posterior openings are proportionally much broader and lower; for the height of the posterior is one half greater than its breadth, the anterior in the full grown fetus is not more than one half as broad as it is high, and its shape is not pyriform, but irregularly quadrilateral; and again, the ethmoid cellules and the accessory cavities are not entirely developed at first, but acquire their normal size only at puberty.

In the early periods of life, and at the commencement of the third month of fetal existence, the nasal fossæ are not entirely separated from the oral cavity at their lower part, for the floor gradually develops itself from without inward.

III. OF THE ORAL CAVITY.

§ 639. The bony *oral cavity* is a parabolic space, convex forward, terminated posteriorly by a straight edge, and situated below the nasal fossæ, from which it is separated by their floor (§ 631). The lower face of this last forms what is called its *roof* or the *bony palate* (*palatum osseum*, s. *stabile*), which is slightly concave and almost quadrangular. The anterior and lateral parts of the walls of the oral cavity, which are insensibly continuous with it, are formed upward by the alveolar edge of the upper maxillary bone, a small part of their posterior portion by the broader extremity of the pterygoid processes, and downward, by the whole inferior maxillary bone. A posterior and inferior wall does not exist, so that the bony cavity of the mouth is entirely open in this direction. The lateral walls are separated by a large hollow, which divides them into an upper and a lower part; for the lower maxillary bone is not united to the other bones of the head, but is movably articulated with the temporal bone (§ 533, 615), so that the oral cavity may open and close at different degrees in front, and it may vary considerably in height in all its extent. This peculiarity distinguishes it from all the other cavities of the head.

§ 640. This cavity is formed by four bones, the upper and lower maxillary bones, the palate bone, and the sphenoid bone. It is connected posteriorly with the pharynx, anteriorly with the anterior part of the face, by the mouth; finally upward with the nasal fossæ, by the anterior palatine foramen, and with the pterygoid fossa by the posterior.

§ 641. Like the nasal fossæ it is lower the younger the subject is, as the teeth are not yet developed, and from the shortness of the ascending process of the upper maxillary bone it is proportionally shorter and broader.

IV. OF THE TEMPORAL FOSSA.

§ 642. The *temporal fossa* (*fossa temporalis, jugalis, zygomatica*) is the inferior and anterior somewhat contracted part of the lateral surface of the skull and the face.

It is open on all parts upward, backward, and downward, and also outward in most of its extent, and even on this point it is but imperfectly closed near the centre of its height by an almost transverse eminence, the direction of which is from before backward and slightly arched outward, which passes over it like a bridge. This is the *zygomatic arch* (*zygoma, arcus zygomaticus, jugalis*) which extends from the temporal bone to the face, or, to speak more precisely, to the upper maxillary bone.

It is much flatter at its upper than at its lower part, where it is depressed inward. Its internal wall descends at first a little obliquely from without inward, but in its lower portion it is perpendicular. The anterior is almost straight and very slightly grooved. The zygomatic arch anteriorly is broader than it is posteriorly.

§ 643. The temporal fossa is formed from four bones, viz. 1st, the sphenoid bone; 2d, the temporal bone; 3d, the upper maxillary bone; and 4th, the malar bone. The larger and under wing of the sphenoid bone constitutes almost all of its inner wall; the upper and posterior part, which is less extensive than the rest, is formed from the anterior part of the squamous portion of the temporal bone. The zygomatic arch is formed by the zygomatic process of the temporal bone, and by the malar bone. This last and the upper maxillary bone form the anterior wall of the fossa.

§ 644. The temporal fossa communicates with the orbit by the inferior sphenoidal fissure, with the pterygoid fossa by the pterygo-palatine channel, and with the oral cavity by the posterior palatine foramen.

§ 645. The temporal fossa, from the greater breadth of the skull and the lowness of the face in the early periods of life, is much lower, planer, and narrower from above downward and from within outward, but longer on the contrary from before backward than in the adult.

II. COMPARISON OF THE BONES OF THE HEAD WITH EACH OTHER, AND WITH THE OTHER BONES.

§ 646. The bones of the head differ very much from each other, and from the other bones of the body, in regard to their forms; there are however great traits of analogy between them and the latter. Certain bones of the skull, considered separately, or several together, more or less evidently resemble the vertebræ.(1)

(1) J. P. Frank first recognized the analogy between the skull and the vertebræ (*Sammlung auserlesener Abhandlungen*, vol. xv. p. 267; *Epit. de curandis hom. morbis*, b. ii. p. 42); he deduced it from the relation between the brain and the spinal marrow. Burdin (*Cours d'études médicales*, Paris, 1803, vol. i. p, 16) also thought that the head is only a vertebra more complicated than the others. This was also the

We must regard the occipital portion of the basilar bone considered as one bone, the sphenoid portion united to the frontal bone, and the two temporal bones taken collectively with the parietal bones, as forming three systems, each corresponding to a vertebra, so that the skull is composed very evidently of three vertebræ, placed one after another from behind forward. It is easy to demonstrate the justice of

opinion of Keilmeyer (A. L. Ulrich, *Annotationes quædam de sensu ac significatione ossium capitis*, Berlin, 1816, p. 4). But as J. F. St. Hilaire remarks it was necessary to have had as clear an idea of this analogy as we now possess to discover it in the midst of a series of foreign ideas, among which it was thrown as if by accident. Duméril has developed this idea still farther (*Considérations générales sur l'analogie qui existe entre tous les os et les muscles du tronc dans les animaux*; in the *Magasin Encyclopédique*, 1808, vol. iii). Having attended to the articular surfaces to which the muscles of the spine were attached in man and the mammalia, he thought he could perceive that the posterior parts of their skull presented eminences, processes, depressions, and cavities like the posterior parts of the vertebræ, whence he concluded, in his public essay, that the head is a vertebra immense in its dimensions. He established that the occipital hole corresponds to the spinal canal, of which it is the origin; that the basilar process, and very often the body of the sphenoid bone, correspond, in their structure and uses, to the bodies of the vertebræ; that the condyles represent their articular facets; that the occipital protuberance and the spaces below it are analogous to the spinous processes and their bony plates; finally, that the mastoid processes are exactly like the transverse processes. Thus Duméril presented his *theory of analogies*; but the exact resemblance which he had perceived was scarcely remarked or at least appeared but trifling, doubtless because it did not coincide with the exact and consequently too confined meaning attached to the word *vertebra*. At the same time, the German anatomists were led to the same views by comparative anatomy. The celebrated Goethe conceived the idea that the head contained several vertebræ (*Zur Naturwissenschaft*, vol. i. p. 250); he admitted six of them, three of which, the occipital, the anterior and the posterior sphenoid vertebræ envelop the brain, and the other three, the palatine, the superior maxillary, and the intermaxillary vertebræ, comprise that portion of the face in which the organs of sense are situated. Oken (*Ueber die Bedeutung der Schädelknochen*, Jéna, 1817) admits three cephalic vertebræ, the *auricular*, composed of the occipital bone, to which is attached the petrous portion of the temporal bone, the styloid process of which corresponds to the sacrum, and the hyoid, which represents the pelvis; the *maxillary*, of which the posterior sphenoid forms the body and also the transverse and oblique processes, and the parietal bones the spinous process, which also represents the upper and lower extremities, since the squamous portion stands in the place of the scapula and the iliac bone, the pterygoid process, of the clavicle, the malar bone, of the arm and the fore-arm, the upper maxillary bone, of the hand and fingers, the inter-maxillary bone, of the thumb, the maxillary condyle, of the femur, the coronoid process, of the leg, and the anterior part of the bone, of the foot. The *ocular*, composed of the anterior sphenoid; its spinous process is the frontal bone; while the vomer, the ethmoid bone, the inferior turbinated bones, the palate bones, and the nasal bones unite to represent the thorax. These ideas have been brought forward and modified by Oken (*Isis*, 1820, No. 6, p. 552; *Esquisse d'un système d'anatomie, de physiologie et d'histoire naturelle*, Paris, 1821, p. 41). In this last treatise the author increases the number of the cephalic vertebræ to four, viz. 1st, the *auricular* vertebra, which has for its body the basilar process, for transverse processes the lateral occipital, and for a spinous process the upper occipital process; 2d, the *lingual* vertebra, having for a body the posterior sphenoid, and for a spinous process the parietal bones; 3d, the *ocular* vertebra, having for a body the anterior sphenoid, for transverse processes the small wings of the sphenoid bone, bone, and for a spinous process the frontal bone; 4th, the *nasal* vertebra, having for a body the vomer, for transverse processes the ethmoid bone, and for a spinous process the nasal bones. According to him, the extremities may also be traced in the head, to wit, the arms in the upper maxillary bones, and the feet in the lower maxillary bone. All these views have been adopted and the last especially fully developed by J. B. Spix (*Cephalogenesis, seu capitis ossei structura, formatio et significatio per omnes animalium classes, familias, genera et ætates digesta*, Munich, 1815). Spix, not content with calling the cranium a prolongation of the vertebral system, conthis analogy in regarding the forms, the mode of development, and the functions of these pieces of bones.

1st. The analogy is no where more evident than in the occipital portion of the basilar bone. This bone forms, like every vertebra, a ring, of which the central part is thick and spungy, while the lateral

siders it a second formation representing all its parts, so that according to him, the being is formed by two complete sections, the one anterior and restrained in its development, the head; the other posterior, and uninterruptedly developed, the trunk: and as the latter has its extremities, the limbs, so the skull has similar extremities, the component parts of the face. Farther, he admits but three cephalic vertebræ, called the *occipital*, the *parietal*, and the *frontal* vertebræ, from the parts which predominate, or the *cranial*, the *thoracic*, and the *abdominal* vertebræ, from the parts of the trunk to which he supposes they correspond, or finally, the *anterior*, the *central*, and the *posterior* vertebræ, also from the analogies which he admits between the different parts of the head and trunk; so that reserving the face, he avails himself of three corresponding sections, the *anterior*, the *central*, and the *posterior*, to form the appendages or the extremities of the cephalic portion of the animal. According to him the first cephalic vertebra, the *occipital*, presents all the parts of the pelvis in the temporal bones; and all those of the inferior limbs in the lower maxillary bone; the squamous portion of the temporal bone is the ilium, the small bones of the ear are the pubis, and the ring of the tympanum is the ischium; the maxillary condyle corresponds to the femur, the coronoid process to the tibia, the angle to the fibula, the tubercle above the posterior dental canal to the tarsus, the internal oblique line to the metatarsus, the alveolar process to the phalanges, and the teeth to the nails. In the second cephalic vertebra, the nasal bone corresponds to the sternum, the malar bone to the scapula and to the clavicle, and the upper maxillary bone contains all the parts of the upper extremity; finally, in the third, the ethmoid bone represents the cricoid cartilage, the unguiform bone the thyroid cartilage, the palate bone and the internal wing of the pterygoid process the hyoid bone. Ulrich (*Loc. cit.*) continues these researches, but does not compare the jaws except to the upper limbs, and does not trace the inferior extremities in the head.

Cuvier (*Règne animal*, vol. i. p. 73) adopts the principle of the analogy between the head and the spine, neglecting always the term vertebræ, and admitting but three vertebræ, or, to use his own expression, *rings* (*ceintures*), of the skull, the *anterior* of which is formed by the two frontal bones and the ethmoid bone, the *central* by the parietal bones and the sphenoid bone, the *posterior* by the occipital bone. Blainville also recognizes this principle of analogy (*Bulletin de la soc. phil.*, 1816, p. 111, and 1817), and declares himself in favor even of the accessory comparisons established by Oken and Spix, at least as far as we can judge from the vague manner in which he expresses himself. Carus gave a new support to the doctrine of the three cranial vertebræ, by dividing the brain itself into three distinct portions and endeavoring to determine the bones belonging to each of them in the vertebrated animals. His work also is one of the most extensive which has been published on this subject (*Lehrbuch der Zootomie*, Leipsic, 1818, p. 164). Meckel (*Beytræge zur vergleichenden Anatomie*, vol. ii. p. 74–82), proposes to consider the whole sphenoid bone as a second vertebra, to make the third in the ethmoid bone and the frontal bone, and to regard the temporal bone as a vertebra cut in two. Schultz (*De primordiis systematis ossium et de evolutione spinæ dorsi in animalibus*, Halle, 1818, p. 13) refuses to admit any analogy between the bones of the face and the vertebræ. Bojanus (*Isis*, 1818, p. 501; 1819, p. 1364), admits four cephalic vertebræ, the first or the *auricular*, the second or the *gustative*, the third or the *ocular*, and the fourth or the *olfactory*, the body of which he formed in the vomer, the axis in the ethmoid bone, and the spinous process in the nasal bones. At the same time, he considers the hyoid bones as the ribs of the first, the pterygoid processes as those of the second, the external wings of these same processes as those of the third, and the bones of the palate as those of the fourth. Finally, he traces the upper extremities in the mastoid, the tympanal, the squamous, the malar, and the upper maxillary bones, and the lower extremities in the lower jaw. Burdach (*Vierter Bericht von der anatomischen Anstalt zu Kœnigsberg*, Leipsic, 1821) endeavors to prove there are but three cephalic vertebræ, and that the other bones of the head are only secondary parts of vertebræ. Finally, J. F. St. Hilaire, wishing to settle so many uncertainties, asserted that we ought to begin by determining strictly the characters and the conditions of a vertebra. Neglecting the conditions founded on adults and assuming and posterior portions are thin and extended in processes; a rounded opening exists in it through which a portion of the central mass of the nervous system passes.

Its squamous portion and its condyloid parts correspond perfectly to the semi-arches, and the basilar process to the body of the vertebra, in

higher considerations, he demonstrated, that a vertebra is not simply a transverse section placed against other transverse sections, thus producing an accumulation of parts to which as a whole the term column is applied; in a word, that it is not a single bone, but an osseous system formed of nine elements, which may or may not be united, and essentially continue the same (*Considérations générales sur la vertèbre;* in the *Mémoires du Muséum*, vol. ix. p. 89.—*Sur le système intra-vertébral des insectes*, in the *Annales de la médecine physiologique*, vol. ii. p. 233). These elements are an unmated and central nucleus, the *cycléal*, to which are adapted two rings, an upper and a lower, which contain the first a section of the medullary system, and the second one of the sanguineous system. Each of these rings is composed of four pieces, namely, the upper of two *périal* and two *épial*, and the inferior of two *paraal* and two *cataal*. In general, one of the two increases always at the expense of the other, and when the excess is extreme, the elements of the smaller ring appear as very small processes. Like the difference between the two extremities of the central axis of the nervous system, one of which is attenuated, the other, on the contrary, increased and enlarged like a ball, this difference not only requires an increase in the surface of the principal pieces, but also, and with equal influence, the concurrence of all of them which must then combine uniformly, without any dismemberment of external parts or projections, that is, simply become pieces of the external septum. J. F. St. Hilaire thus explains the defect of projections and processes, which forms one of the distinctive characters of the largest skulls. The osseous system having then only to inclose a medullary mass, it maintains as few external relations as possible, while farther on, having to protect only a very small mass, the spinal marrow, it becomes rough externally, and all its superficial points are formed of strong processes for each muscular part. Leaving these general ideas, to which it was necessary to arrive to determine this question, and to deduce true philosophical conclusions in regard to the cephalic bones, J. F. St. Hilaire concludes (*Composition de la tête osseuse de l'homme et des animaux*, in the *Annales des sciences naturelles*, vol. iii. p. 173) to consider the head, leaving out the lower jaw, as formed of seven vertebræ, which are named and composed as follows: 1st, the *cerebelloid* (*cérébelleuse*) *vertebra* comprising the *basi-sphenal* (the posterior segment of the basilar bone), two *super-occipital* (the upper occipital bones), two *stapedial* (the stapes), two *ex-occipital* (the lateral occipital bones), and two *incudal* pieces (the incudes); 2d, the *auricular vertebra*, comprising the *otosphenal* (anterior section of the basilar bone), two *parietal*, (the parietal bones), two *tympanal* (the rings of the tympanum), two *petrous* (the petrous portion of the temporal bones), and two *malleolar* (the mallei); 3d, the *optic* or *quadrijumal vertebra*, comprising the *hyposphenal* (the posterior body of the sphenoid bone), two *cotyleal*, two *pterygoid* (the large wings of the sphenoid bone), two *temporal* (the squamous portion of the temporal bone), two *serrial* (the large portions of the tympanum); 4th, the *cerebral vertebra*, comprising the *ento-sphenal* (the anterior body of the sphenoid bone), two *ingrassial* (the wings of Ingrassias), two *ad-orbital* (the orbital portions of the maxillary bone), two *jugal* (the malar bones), two *herisseal* (the internal pterygoid processes); 5th, the *ocular vertebra*, comprising the *ethmosphenal* (the body of the ethmoid bone), two *frontal* (the frontal bone), two *ad-gustal* (the external pterygoid processes), two *palpebral* (the tarsal cartilages), and two *ethmophysal* (the upper turbinated bones); 6th, the *nasal vertebra*, comprising the *rhinosphenal* (the plate of the ethmoid bone), two *nasal* (the bones of the nose), two *palatal* (the palate bones), two *lachrymal* (the unguiform bones), two *rhinophysal* (the inferior turbinated bones); 7th, the *labial vertebra* comprising the *protosphenal*, two *ad-nasal* (the intermaxillary bone), two *vomeral* (the vomer), two *addental* (the dental parts of the maxillary bone,) and two *protophysal* (the cartilage of the nose. As to the lower jaw J. F. St. Hilaire says, independently of the seven cephalic vertebræ, admits in each of these branches seven pieces at most, viz. the *subdental*, the *sublachrymal*, the *subpalpébral*, the *subjugal*, the *subtemporal*, the *subrupéal*, and the *sub-occipital*. Thus, according to him, the head is composed of seventy-seven bones, the skull and face of sixty-three pairs, and seven which are unmated, and the lower jaw of seven pairs. F. T.

regard to form and situation. The squamous part represents the spinous process, and the condyloid portions are analogous to the transverse and articular processes.

The different parts of which it is composed are developed like those of the vertebræ; the squamous and the condyloid portions appear before the body, and the different pieces which form the posterior and lateral portions fuse together before they unite to the body.

The body unites with the central portion of the sphenoid bone forward, and its lateral parts articulate with the cervical vertebra backward, in the same manner as do the analogous portions of the vertebræ with each other.

Similar muscles are attached to the occipital bone and the different vertebræ. So too this bone contains like each vertebra a part of the central portion of the nervous system. Between it the first vertebra backward and the temporal bone forward we find the same foramina as between the other vertebræ, and these holes give passage to he same nerves and vessels.

As the bodies of the other vertebræ most generally fuse with each other in some parts at an advanced age, so the bodies of the occipital and the sphenoid bones always unite in a single bone. Their fusion however takes place sooner. Finally, as the last lumbar vertebra often unites to the sacrum, so the occipital bone tends very much to unite in different ways with the first cervical vertebra.

2d. The sphenoid portion of the basilar bone and the frontal bone taken together, represent the second of the anterior vertebræ composing the skull. We may also consider them as composed of several imperfect vertebræ.

In regarding them in the first point of view, the body of the sphenoid portion corresponds to that of the vertebra. Its two wings and the frontal bone represent its lateral portion. Most of the frontal bone and the large wing of the sphenoid bone are in fact analogous to the posterior and superior part of the semi-arches, as the malar process of the frontal bone and the inferior pterygoid process correspond to the articular and the transverse processes of the vertebræ. We must consider the frontal bone as belonging to the anterior vertebra of the skull, because the lateral parts of the sphenoid portion alone do not curve to meet one another, and do not unite with the body to form a ring inclosing the anterior part of the brain, while this ring is produced by the assistance of the frontal bone.

The very complicated ossification of this vertebra occurs according to the same laws as that of the vertebræ of the trunk.Those pieces which correspond to the lateral parts ossify long before the body of the sphenoid portion; and it is a normal condition, that the two lateral halves of the largest portion of the arch of the frontal bone unite in the same manner as the semi-arches of the vertebræ. If the lower part of these lateral pieces unites earlier with the body of the sphenoid portion, thus differing from what occurs in the vertebræ, this difference is made up by another circumstance, viz. that the body of the sphenoid portion does not completely develop itself, or does not acquire its sinuses, until the pieces of the frontal bone are fused.

Several smaller vertebræ may be demonstrated in this large anterior vertebra of the skull. In fact, we can imagine the sphenoid portion formed of two vertebræ; a posterior, which is larger, and represented by the body and the large wings, and an anterior, which is smaller, and formed by the small wings; and we can suppose the frontal bone either as a portion of this anterior vertebra, which would then be much larger than the posterior, or as the arch of a vertebra of which the body is not developed, since the arches of the true vertebræ are always formed before their bodies.

The central vertebra of the skull is formed by the temporal and the parietal bones. The temporal bones represent a vertebra divided at its lower portion into two parts by the basilar bone. The parietal bones and the squamous portion with the zygomatic and the mastoid processes of the temporal bone, represent the semi-arches and processes; while the petrous portion of the temporal bone corresponds to the body of the vertebra. But we may also, as in the anterior vertebra of the skull, consider the parietal bone only as the rudiment of a particular vertebra, and regard the temporal bones as two halves of vertebræ, entirely distinct from each other.

Here also the parts of the arches are developed sooner than that of the body, and it is remarkable that of all the sutures, the sagittal suture is most frequently and the soonest effaced; so that the semi-arches unite on the median line before they blend with the other portions.

The ethmoid bone differs so strikingly from all the other bones of the skull, that at first view we cannot perceive the least relation between them. We may, however, represent it as a fourth anterior and inferior vertebra of the skull, which, pressed in between the others, would not be developed in a ring, and would be flattened from one side to the other. We may, however, consider its perpendicular plate as the body, and its lateral portions as the semi-arches.

Here, as in the rest, the lateral portions ossify before the central part.

§ 647. In the bones of the face, the analogy with the vertebræ is less easily demonstrated. One great point of resemblance is here deficient, viz., the relation with the central part of the nervous system. We may, however, consider, in some measure, the upper maxillary bone as a large facial vertebra, of which the other bones of the face are a compliment. We may also compare the lower maxillary bone with the upper part of the sternum and the upper ribs, and the styloid processes and the hyoid apparatus with the lower part of the sternum and the lower ribs; for their semicircular form, their convexity forward, their concavity backward, their movable articulation with the skull, and their situation before it, establish a general correspondence with the sternum and with the ribs, in regard to form and connections; and more so, because the upper ribs are united with the upper part of the sternum more intimately than the lower ribs are with the lower part of this bone; precisely the same as the lower maxillary bone constitutes a single bone, while the hyoid bones and the styloid processes always form several distinct pieces.

We may also add, in favor of this analogy, that as the lower maxillary bone and the ribs are among the bones which are developed the first, and as the ribs form long before the sternum, so, too, the lower maxillary bone generally corresponds to the ribs fused together, and is composed only of two halves, the intermediate cartilage being gradually effaced. When two special nuclei are formed in this cartilage, as sometimes but rarely happens, the analogy is still greater; since these nuclei, which correspond to the pieces of the sternum, arise long after the lateral portions.(1)

§ 648. Finally, we may compare the whole bony head to a large vertebra, composed of several, which are smaller and immovably articulated with each other, and accompanied by some rudiments of ribs fused together. This method of considering it is much more admissible, because the bones of the skull and some of those of the face tend to unite in a single piece; and even in young subjects, we not unfrequently find all the sutures effaced, and then the head is composed of three bones only, which move on one another,—the lower maxillary bone and the hyoid bones anteriorly, and the collection of the bones of the skull and face posteriorly.

§ 649. The differences of the head at different periods of life are very great.(2)

They regard principally 1st, *form;* 2d, *mass;* 3d, *number;* 4th, *the mode of union of the bones;* 5th, *the form of the whole;* 6th, *the proportion between the skull and the face.*

1st. The *form.* The bones of the head are much less rough and uneven, and their eminences project less, the younger the organism is. But those of the skull, or at least the occipital bone, the parietal bone, and the frontal bone, differ at different periods of life, inasmuch as from the fourth month of pregnancy to the end of the first year of existence, they are much less uniformly bulging than at anterior and subsequent periods; but they project considerably at their central part, where the point of ossification develops itself; so that the upper and lower portions there unite at an almost right angle. Before the fourth month, the bones of the skull are much flatter than in the rest of life, and more so as they are smaller.

2d. The *mass.* The bones of the head increase in extent, thickness, and weight, from the commencement till the termination of their development in the adult age; but after this time, and till old age, they always diminish in these three relations. Hence, in advanced life they are thinner, often perforated in several parts, especially where they are

(1) It seems less proper to compare the jaws to limbs, and the hyoid bones to the pelvis, as Oken has done; although it is not difficult to trace the cavity of the chest in the nasal fossæ, and that of the abdomen in the oral cavity. It is perhaps from the considerable development of the cephalic vertebræ and brain, that the other bones of the head can become only the rudiments of the ribs and sternum fused together.

(2) *Recherches sur le crâne humain*, by Tenon; in *Mém. de l'Instit. sc. phys. et math.*, vol. i. p. 221-233.—Spix, *Cephalogenesis*, Munich, 1815.

naturally thin, as the external and anterior part of the large wing of the sphenoid bone, and the orbital portion of the malar bone: from this cause, the malar bone is frequently separated from the sphenoid bone in this place; the sphenoidal fissure is often very extensive; the maxillary bones are narrower by the entire height of the alveolar edges; and finally, the skull becomes lighter and smaller.

The difference of weight between the skulls of old men and those in mature age is much greater than that of volume. The skull of a female seventy years old, now before us, weighs fourteen ounces, and that of a girl twenty years of age weighs twenty-four ounces; the first is nearly one half lighter than the second.

3d. The *number* of the bones of the head differs at different periods of life. At first the number is smaller, because ossification does not commence in all parts at the same time. Next, the bones are more numerous, because some bones are developed by several points of ossification, whence result separate pieces, which gradually unite.

4th. The *connection* of the bones of the head is much looser the younger the subject is; because the bony pieces are less extensive and are separated by larger intermediate cartilages. In very old persons, the bones which are united, during the greater part of life, by a simple immovable cartilaginous substance, almost always fuse together. This is the case particularly with the parietal bones which unite with each other, or with the frontal and the occipital bones, and it is true also of the ethmoid bone which joins with the inferior turbinated bone, while the latter is fused with the upper maxillary bone.

5th. In the early periods of life, the *whole form* of the head is much rounder than at an advanced age, which is particularly owing to the small development of the face which the skull overreaches in every direction, and which is proportionally much smaller the younger the fetus is. In fact, the difference between the greatest length and breadth of the head is much greater the younger the fetus is, but it bulges more in all parts of its circumference, which makes its general form more round. We remark especially, during the early periods of uterine existence, that the skull is much broader and less compact in the region of the temples than it is afterward, and that the frontal bone, the parietal bone, and the occipital bone, are much more bulging. In a later period the bones sink remarkably.

The more rounded form of the skull during the early periods of pregnancy also results from the slight development of its base. In fact, this is shorter and narrower, and forms with the lateral and posterior faces a more obtuse angle.

§ 650. The form of the bones of the head, and consequently of the whole bony cavity, varies very considerably in the different races.(1) The differences in this point of view are more or less evident in all directions and in all regions. Hence the facial angle of Camper (§ 51)

(1) Blumenbach, *Decades collectionis suæ craniorum diversarum gentium illustratæ*, Gottingen, 1790-1814.

will not measure them exactly, since it indicates only the direction of the anterior part of the skull and face, and gives only a general idea of the profile. We must then, at the same time, employ other means to determine it. Thus, on the one hand, we practice the method recommended by Blumenbach,(1) that is, we embrace as much as possible all the peculiarities with a single glance, looking from behind forward, while the head rests on the lower maxillary bone, so that the malar bones may be horizontal; 2d, we follow Cuvier's method, which consists in looking at the head from above downward and from before backward, to judge of the relations of capacity between the skull and the face.

We have already mentioned (§ 34) the results of these measurements, which furnish the principal distinctive characteristics of the human races.

The difference between the skull and the face in the relation of their respective capacities, is most important. The difference is most favorable to the skull in the European race; and most unfavorable to it in the Ethiopian. Thus, the skull of a negro, compared with thirty-six skulls of Europeans, contained less water than any of them (2).

Besides these differences of races, there are others which establish a difference more or less remarkable in the skulls of different people belonging to the same race.

The nations of the south, in whom we see the purity of the Caucasian race, or those which are most allied to it, as the Greeks and Turks, differ from all other nations belonging to this race by their very round heads.(3)

CHAPTER IV.

I. GENERAL REMARKS ON THE ANOMALIES OF THE BONES OF THE HEAD.

I. OF THE CONGENITAL DEVIATIONS OF FORMATION.

§ 651. The congenital deviations in the formation of the bones of the head, affect their *number*, *form*, *connection*, and *size*, and are for the most part more or less dependent on their mode of development. These four conditions are almost always united. We can, however, refer to one or another of them, only the essence of every deviation of formation of a bone of the head, since the number of these last never increases, like those of the trunk and extremities, by the formation of new pieces, but by the division of the primitive bones into several, so that we remark proportional differences in the form, connections, and size of the bones, the division of which has increased the whole number.

(1) *De variet. gen. hum. nat.*, Gottingen, 1794, p. 203.
(2) Saumarez, *Principles of Physiology*, London, 1798, p. 163.
(2) For other differences which are less constant, see the work by Blumenbach already cited, and Soemmering's Osteology.

I. ABSENCE AND SMALLNESS.

§ 652. The bones of the head are entirely deficient in *acephalia vera*. In those cases of acephalia which are somewhat more perfectly developed, we rarely find a slight rudiment of a head composed of several bones.(1)

After this state, comes, as regards its external form, the *acephalia falsa*, in which the base of the skull and the face are generally regularly developed; but in which also the bones, or the portions of the bones which form the vault of the skull, are entirely deficient, or are very small.

Next comes that state of the bones of the skull which exists in *encephalocele*, when several of these bones, or one only, (generally the occipital bone,) is but slightly developed; and a portion of the brain, or serum collected between it and its envelops, projects through the opening.

Next follows the arrangement of the bones of the skull in *hydrocephalus*, where they are more or less distant from one another, and are often separated by unossified spaces.

The next state is the permanence of the *fontanelles*, which sometimes remain, in one or several parts, during life.

The state which is the least abnormal, although usually attended with some degree of imperfection in the intellectual faculties, on account of the corresponding state of the brain, is the smallness of the head, characterized by the flatness of the anterior portion of the skull, and by its narrowness in the transverse direction: this is principally seen in ideots(2).

I. SEPARATION OF THE BONES OF THE HEAD.

§ 653. The best name for the abnormal bones, resulting from this division is, that of *bones of the sutures* (*ossa suturarum*).(3) This in fact is the only general character we can assign to them, since they are not developed, except at the circumference of the concave bones; and never, or at least but very rarely, within them. When the latter is the case, the abnormal bones form only between those parts of bone which are transiently separated, as between the different pieces of the occipital bone; and usually unite when the development is finished. The terms *triangular bones* (*ossa triquetra*) and *wormian bones* (4)

(1) Curtius, *De monstro humano*, Leyden, 1762.—Meckel, *Handbuch der pathologischen Anatomie*, vol. i. p. 151.

(2) Greding, in Ludwig, *Adv. med. pract.*, vol. ii. and iii.

(3) Bertin, *Traité d'ostéologie*, vol. ii. p. 470.—Bose, *De suturis cranii*, Leipsic, 1763.—Monro, *A skull uncommon for the number and size of the ossa triquetra*, in the *Edin. med. essays*, vol. v. no. 16.—Van Doeveren, *Spec. obs. acad.*, ch. viii.—Sandifort, *De ossiculis suturarum*, in *Obs. anat. path.* book iii. chap. ix. and book iv. chap. x. p. 136-141.

(4) These bones have been called also *intercalia* or *epactalia*. One of them occurs frequently in the posterior fontanelle; it is the proper epactal bone, the *triangular bone* of Blaes, the *os epactale*, s. *gœthianum* of Fischer. (G. Fischer, *Observata quædam de os epactali sen Goëthiano palmigradorum*, Moscow, 1811.—*Adversar.*

(*ossa wormiana*), are less suitable when considered generally. The first term, however, is not perfectly appropriate, as the division of the frontal bone into two lateral portions also enters into this anomaly, although the relations of this bone with those around it are not changed.

These bones are remarkable in several respects. In fact, 1st, their formation is governed by very precise laws; 2d, they depend, in great part, on the normal development of the bones; 3d, for the most part they establish striking analogies with animals.

1st. These bones are formed according to constant laws. The following circumstances prove it:.

a. They are usually arranged more or less symmetrically, so that we rarely find them on one side of the body only; and when unmated, they usually extend as much on one side as on the other.

b. They occur more particularly in the cranium, and much more rarely in the face.

c. They are not equally common in all parts of the skull. They are observed most frequently between the occipital bone on one side, and the parietal and the temporal bones on the other. They are most generally situated in the lambdoid suture, more rarely in the mastoid suture. The parts in which they are next most frequent, are the squamous suture, especially at its anterior extremity, between the large wing of the sphenoid bone, the squamous portion of the temporal bone, and the frontal and the parietal bones. They are more rare in the sagittal suture, where they are seen principally between the two parietal and the frontal bones, consequently at the anterior extremity of this suture. They are least common between the sphenoid bone and the adjacent bones.

In the face, the bones of the sutures are met with principally between the os planun of the ethmoid bone and the frontal, the unguiform and the upper maxillary bones, and also between the latter and the unguiform bones. They are more rare between the two upper maxillary bones. It is equally unusual to find the lower maxillary bone or the malar bones composed of two parts.

d. We may state as a general rule, that they are developed most frequently in the places where large cavities are to be filled. They are very frequent in the fontanelles, and are most common in the posterior, and next in the anterior lateral, middle lateral and the posterior lateral fontanelles.

e. They vary much in size. Sometimes they are only small pieces of bone, and sometimes the whole bone is divided into two equal parts. Thus, the occipital bone is sometimes divided into an upper and a lower portion, and the frontal bone is formed of two lateral portions of equal size. There are numerous degrees intermediate between these two extremes.

anatomica, Moscow, 1819. Another, almost as common, is situated in the temporal fossa. Beclard proposes to call it the *crotophal* bone. The others occupy the occipito-parietal suture, the place of the posterior and inferior fontanelle and the parietal suture. F. T.

f. The cause of the abnormal want of union between the parts of bone, is not always manifest. Although the anomaly is usually attended with an accumulation of serum within the skull (*hydrocephalus*), and with the distention of the ossifying surfaces ; we cannot, however, say it is owing to this distention, and suppose, with Blumenbach(1) that the fetus has been affected with hydrocephalus, which has been cured.

2d. The formation of these pieces of bone depends, in great part, on the normal development of the bones of the head. In fact,

a. The separation of the frontal bone into two portions is normal from the origin of this bone till the first year of life.

b. The occipital portion of the basilar bone forms gradually by the union of eleven pieces (§ 543), and these are the pieces which are abnormally separated.

c. The temporal bone is also formed by four nuclei (§ 554) ; and these are the nuclei which remain more or less sensibly distinct.

d. The small bones of the sutures are most usually formed by the natural development of the bones of the head, since new nuclei always form on the circumference of the primitive germs of bone, which are smaller and more distinct, and which unite with them in one mass when the development proceeds regularly.

All the bones of the sutures however, do not depend upon the abnormal division of the separate pieces of bone, which form only one piece in the normal state ; and we cannot consider them all as resulting from an imperfect development. In fact, those in the large and the anterior lateral fontanelles, and in the squamous suture, and also the division of the squamous portion of the temporal bone and of the frontal bone into two parts situated one above the other, are not normal, but are distinct and special formations.

3d. It is generally very easy to trace the analogy between these abnormal bones and the structure of animals.

a. In most animals the frontal bone is composed of two lateral halves.

b. The separation of the occipital bone in different osseous pieces is also an arrangement which remains in many animals during life, and in others until birth. In many reptiles this bone is divided during life into a basilar, an articular, and a squamous portion, and this last itself into an upper and a lower portion. It is true that the first three parts and the squamous portion unite in a single piece in the mammalia ; but in many animals, as also in the fishes, the squamous portion is divided into two parts.

c. The mastoid portion of the temporal bone forms a distinct bone in the mole.

d. The primitive arrangement, that is, the insulation of the different nuclei of bone, remains during life in the gecko.(2)

(1) Knochenlehre, p. 180.
(2) Carus, *Anatomie und Physiologie des Nervensystems*, Leipsic, 1821.

However, the other bones of the sutures, which constitute positive anomalies, do not appear in animals.

From what precedes, it follows that our views upon the origin of these bones are more extensive than certain anatomists have thought,(1) since we can say, that most of them are produced by a development deficient in energy.

§ 654. The development of these bones forms an unusual number of sutures, since its essence consists in increasing the number of pieces of bone at the expense of the normal bones.

The slightest deviation from the normal state is the existence of a suture called the *frontal suture* (*sutura frontalis*) between the disunited portions of the frontal bone, which sometimes extends through the whole bone, and sometimes exists only at its upper or lower part, more frequently in the former. As this suture is continuous with the sagittal suture, and cuts the coronal suture at a right angle, those heads which have them are termed *capita cruciata*. The other supernumerary sutures arising from the same source are usually small and imperfect, and do not extend the whole breadth or height of the bone. Sometimes, however, we find the occipital bone and more rarely the parietal bone entirely divided by a transverse suture into an upper and a lower half.

We must remark, in regard to this, that the division is most frequent in the frontal bone; it is more rare in the squamous portion of the occipital bone, and still less frequent in the parietal bones; so that its degree of frequency is in direct ratio with the time during which the bone remains in its primitive form, or, more particularly, with the occurrence of deviations of formation in the primitive pieces.

If the number and situation of the bones of the sutures be such as to form along one of the usual sutures a chain corresponding to the normal form of the corresponding edges of the bones, which are wedged in between them, we then have *double sutures* (*suturæ duplices*), which are generally seen between several bones of the same skull, since these bones are usually developed in several regions of the skull in the same subject, but not in the same number.

The unusual distance between the bones of the skull, which is caused by hydrocephalus, is allied to the abnormal development of separate bones formed at the expense of the normal bones. Then we have developed not only a greater or less number of bones of the sutures, but these are also separated by large unossified spaces.

Finally, we must arrange here the want of union between the palate-bone and upper maxillary bone on the median line, which essentially constitutes *hare-lip*. Another anomaly allied to this, and dependent on the same proximate cause, is the imperfect ossification of the skull-bones, which present from space to space hollows filled with cartilaginous substance only. This anomaly is also seen in hydrocephalus, and is sometimes primitive and sometimes consecutive.

(1) Hildebrandt, *Lehrbuch der Anatomie*, vol. i. p. 216.

III. OF THE ABNORMAL UNION OF BONES OF THE HEAD.

§ 655. The state opposite to that which we have examined supervenes usually at an advanced age; but it is not rare in young people, and is frequently seen in hydrocephalus, in consequence of the disappearance of the cartilaginous layer interposed between the adjacent bones.

These anomalies are also subject to certain laws:

a. The pieces of bone which remain separate and distinct beyond the proper periods usually fuse with the adjacent bones sooner than these unite with one another.

b. Of all the bones of the skull, the parietal bones unite soonest and most frequently: their union commences generally, but not always, in the centre of the sagittal suture. The temporal bones and the occipital bone unite less frequently, and the frontal bone still less so; in regard to which we must observe that the central portion of the coronal suture is usually the first to disappear. The union of the frontal and the temporal bones, of these latter with the sphenoid bone, and of the ethmoid bone with the adjoining bones, is more rare.

In the face, the inferior and the middle turbinated bones fuse with the upper maxillary bone, the vomer unites with the sphenoid bone, and the two nasal bones with each other.

§ 656. The bones of the skull sometimes become unusually large. This state generally attends hydrocephalus, and the anomaly becomes very striking when we regard the base of the skull at the same time, since we there see more or less sensible marks of the compression caused by a mechanical power acting from within outward.

§ 657. The bones of the skull vary also in thickness. In advanced age they are thinner than during the early periods of life. The same thing is seen in hydrocephalus. However, at the end of life they become thicker, but also very spungy. They are also thicker in ideots;(1) although then the relation of causality between this state of the skull and that of the brain probably is not always the same, since the excessive development of the bones from within may be a primitive anomaly, and cause a compression of the brain which is injurious, or their unusual increase may depend upon a want of nutrition and on the shrinking of the brain. Besides, the thickening of the bones of the skull is attended sometimes with an increase and sometimes with a diminution in the density of their tissue.

§ 658. The bones of the skull are sometimes abnormal by a defect in symmetry, so that they, and consequently the whole head, appear *oblique*. This state depends perhaps upon a primitive congestion of serum in the skull, and upon the unequal pressure exercised by the fluid. It sometimes attends mental derangement.

(1) Greding, in Ludwig, *Adv. med. pract.*, vol. ii. p. 456, vol. iii. p. 600.

The bones of the skull present other anomalies, especially in *cretinism*.(1) Although the form of the head in cretins is not always exactly the same, the skull however is generally low, less bulging particularly in the frontal and the occipital regions, and on the contrary unusually broad from side to side; the base from before backward is short and somewhat compressed; the sutures are more or less completely effaced, and filled with numerous *bones of the sutures*. In regard to particular bones, the basilar bone differs most from the normal state: it is small, flat and even concave at its upper part, while its articular parts and the occipital foramen are more or less oblique and sometimes almost perpendicular, so that the articular portions look directly forward, and the basilar process and the body of the sphenoid bone are straight and very elevated.

It often happens also that the skull is more or less oblique, especially in the moderate degrees of cretinism, which obliquity seems to depend upon the existence of the anomalies on one side only.

§ 659. The consecutive or accidental deviations of formation in the bones of the head are,

1st. The *solutions of continuity*. Sometimes these are *fissures* (*fissuræ*), which are often extremely small, and are then termed *capillary openings*. They differ from the normal or abnormal sutures in being straighter, in the periosteum not adhering with as much force as usual, in not having cartilage upon their edges, and in being seen in the places upon which the wounding cause has acted. We call these *counter-fissures* (*contra-fissuræ*) when they supervene on the side opposite to that on which the blow has been struck. Both extend from one bone to another, passing over the sutures. Sometimes there are *depressions* (*depressiones*), when there is no solution of continuity, but a piece, wholly or partly detached, is pressed in. Depressions can take place without a fracture in youth, because of the thinness and the elasticity of the bones of the head.

2d. The separation of the connections of the bone (*diastasis*), which, if the sutures are perfectly developed, can be caused only by a very violent mechanical action.

SECTION III.

OF THE BONES OF THE EXTREMITIES.

§ 660. The bones of the upper and lower extremities correspond not only on the right and left sides, but also upward and downward; so that the lower limbs are a repetition of the upper, in respect to number

(1) J. F. Ackermann, *Ueber die Kretinen, eine besondere Menschenabart in den Alpen*, Gotha, 1790.—Foderé, *Essai sur le goître et le crétinage*, Turin, 1792.—Michaelis, *Ueber die Kretinen im Salzburgischen*, in Blumenbach, *Med. Bibl.*, vol. iii. p. 658.—Joseph and Charles Wenzel, *Ueber den Kretinismus*, Vienna, 1802.—H. Reeve, *Some account of cretinism*, in the *Edin. med. journ.*, vol. v. 1809, p. 31-36.—Iphofen, *Der Cretinismus, philosophisch und medicinisch untersucht*, Dresden, 1817.

and form, and the mutual relations of the different sections of which each limb is composed.

§ 661. Each is composed of four grand sections: the first is formed principally by one large bone; this is the *scapular portion* (*Portio scapularis*) in the upper limb, and the *iliac portion* (*P. iliaca*) in the lower; the second includes one cylindrical bone, the *humerus* in the upper extremity and the *femur* in the lower; in both, the longest and the next section is composed essentially of two bones, which are the *radius* and the *ulna* in the fore-arm, and the *tibia* and the *fibula* in the leg; the fourth comprises, in the upper extremity, the bones of the hand, and below, those of the foot, which correspond with each other almost perfectly in number, form, and divisions.

CHAPTER I.

OF THE BONES OF THE UPPER EXTREMITIES.

ARTICLE FIRST.

OF THE BONES OF THE SHOULDER.

§ 662. We find on each side two bones in the region of the shoulder: the larger is flat, situated backward and a little on the side; the smaller is cylindrical and is situated at the anterior and superior part of the shoulder: the former is termed the *scapula*, the latter the *clavicle*.

I. OF THE SCAPULA.

§ 663. The *scapula* (*omoplata*) has in general the form of an equilateral triangle, the base of which looks upward, and it extends, when all the muscles which unite the bones of the trunk and those of the superior extremities are inactive, from the second to about the seventh rib, and its internal edge is nearly an inch distant from the lateral portion of the spinal column.

§ 664. It has three edges; the internal is longer than the external, and hence is called the *base* (*basis scapulæ*). In its upper fourth, its direction is from above downward and from without inward, and it is more or less convex. After leaving this point, it proceeds almost directly downward and outward, and is parallel to the external. The latter, which unites to it at an acute angle, is most prominent at its lower part, where it is straight and very thin, while it is slightly concave and much thicker at its upper portion; so that the anterior and posterior faces of the scapula, particularly the latter, pass much beyond it. The upper extremity of this edge enlarges still more, to form a superficial oblong cavity, which is narrower upward, and is called the *glenoid cavity* (*cavitas glenoidea*), and which projects very far outward. The upper edge is oblique from within outward and from above downward, and it is slightly concave at its upper part. Toward its internal extremity, we see a semicircular grove (*incisura semilunaris, lunula*), which is more or less distinct, but always distinguished from the rest of the concavity by a greater depth. This fissure is sometimes changed into a foramen by a slip of bone.

Where the superior and external edges unite, the scapula extends into a process curved upward and forward, the *coracoid process* (*processus coracoideus*). The upper face of this process is turned inward and its lower face outward.

§ 665. The posterior and external face of the scapula is divided into two portions by an eminence which extends obliquely from the internal to the external edge, and is called the *spine of the scapula* (*spina scapulæ*); the upper is smaller, and is termed the *fossa supra-spinata*; the inferior portion is much larger, and is termed the *fossa infra-spinata.* The whole external face of the scapula is a little convex backward, particularly in the *fossa supra-spinata.* The spine itself begins near the internal edge, by a small, triangular, broad elevation, which inclines downward very much, and gradually enlarges from within outward. It does not go directly backward, but is inclined at the same time from below upward and from before backward, so that it makes an acute angle with the supra-spinal portion, and an obtuse angle with the infra-spinal portion.

It does not extend as far as the external edge, but stops at some distance from the posterior edge of the articular surface; so that an interval exists between this and the last, which is the *neck of the scapula* (*collum scapulæ*). The direction of the spine now changes, and it enlarges very much from without inward. This part, which is found about an inch distant from the glenoid cavity, and which projects upward and inward, is called the *acromion* process; it is the highest point of the scapula. It confines the motions of the head of the humerus inward and upward, as the coracoid process limits them forward and upward. Its posterior edge presents, immediately behind this upper extremity, a small straight surface which is covered with cartilage.

§ 666. The anterior face is more uniform. It presents only a slight depression, which corresponds to the spine; and we can distinguish on it also a supra-spinal and an infra-spinal portion. This latter usually presents three small ridges, which ascend upward and outward from the base, and which unite nearly in the centre, and between which are superficial depressions. All the anterior face is slightly concave.

§ 667. The infra-spinal portion of the scapula is the thinnest. The bone becomes thicker toward its edges, but principally toward the internal, and on the side of the articular eminence. It is a little thinner in the coracoid process, and still more so in the spine, although this is thicker than the fossæ.

§ 668. The scapula first appears toward the end of the second month of pregnancy, as a flat and irregularly quadrilateral bone, on the surface of which the spine is not yet visible; this is developed at the third month of pregnancy, and extends from its origin beyond the upper edge.

In the full grown fetus the processes appear, but are still almost entirely cartilaginous. The spine never develops itself by a single point of ossification, but appears as a prolongation backward of the posterior face. Gradually, however, we see a distinct germ of bone for the coracoid process, which exists even in the full grown fetus, or at least appears in the first year. It is, however, usually united with the rest of the scapula in subjects fifteen years old. At the point of union, and about the period when it is finished, there is developed, above and at the base of the coracoid process, a rounded nucleus of bone, which remains separate and distinct longer than the other processes. Afterward, when the coracoid process is united, we see also special nuclei of bone for the upper part of the acromion process, for the lower angle, and for the base: these do not unite to the principal portion until the growth of the subject is matured. The size of the osseous nucleus of the acromion process varies much; for sometimes it is only a narrow band, and sometimes forms most of this process.

§ 669. The deviations of formation in the scapula are particularly its continuance in an early stage of development. Thus, sometimes the portion of the acromion process remains separated during life, being united to the rest of the bone only by cartilage.

Sometimes the process of ossification is not perfect in other points, so that a greater or less portion of the *fossa infra-spinata* remains cartilaginous, which is singularly analogous with what is observed in many mammalia, especially the *pachydermata*.

II. OF THE CLAVICLE.

§ 670. The *clavicle* (*clavicula*, *clavis*, *os juguli*, *furcula*, *ligula*) is situated on the line of separation between the neck and the chest, between the sternum and the scapula. It extends a little obliquely from before backward, from below upward and from within outward. It is turned like an italic *S*, so that the outer half is convex backward and concave forward, while the inner half is concave backward and convex forward.

We distinguish in this bone a *body*, a *sternal extremity*, and a *scapular extremity*.

The *body* is contracted from above downward. It, however, presents more or less distinctly three faces; a posterior, smooth and concave from above downward; an upper, oblique from above downward, and from behind forward, and very rough; finally, a lower, straight or slightly concave, smooth or slightly rough. Among the angles, the upper, which forms at the same time the upper edge, is the only one which is seen distinctly. It is also rounded. We usually find one and sometimes two foramina of nutrition on its posterior face.

The *anterior* or *sternal portion* (*pars sternalis*) is the thickest, and most evidently triangular portion of the clavicle; it terminates by a mostly triangular, cartilaginous, but uneven surface, the base of which looks upward, and sometimes has a more irregular and rounded form. At the beginning of this sternal portion, we often find on its anterior face a considerable and rough depression, and further outward a rough elevation.

The *posterior* or *scapular portion* (*pars scapularis*) is the broadest portion of the bone, and the flattest from above downward: on its upper face are muscular impressions; on the lower, are asperities to which the ligaments are attached: and at its external extremity is a larger or smaller cartilaginous articular surface.

§ 671. The clavicle is very remarkable in the history of the development of the organism, because it is one of those parts most proper to demonstrate the great difference which is presented in the form, and particularly in the proportional volume of one and the same organ at different periods of life. Notwithstanding its smallness, it appears very early, if it is not the first of the bones which develops itself. Towards the middle of the second month of pregnancy, its length is about three lines, and it is four times as large as the humerus and the femur. At the third month of fetal existence, it is nearly twice as long as these bones; and at the end of the month it continues larger than them. The humerus is larger in the fourth month; in the full-grown fetus it is only one-fourth longer, while it is twice as long in the adult. The division of the clavicle into a body, a sternal and a scapular extremity is founded solely on the different dimensions of these regions, and on their relations with the adjacent parts, but not on their mode of development: for the clavicle arises by a single point of ossification, excepting always a very thin nucleus of bone, which forms very late on the anterior face of its sternal extremity.

§ 672. This bone is also one of those in which the sexual differences of the skeleton are most manifest. It is generally straighter, and proportionally smaller in the female than in the male. Its greater straightness depends particularly on the lesser curve of its external portion, while in man it extends far backward and then comes forward The internal anterior half presents nearly the same curve in both sexes. The clavicle of the female is rounder than that of the male: we however find clavicles of females perfectly like those of males, and vice versa. Sometimes of the two clavicles in the same body, one is constructed in the type of the male, and the other in that of the female. These two anomalies are a slight degree of hermaphrodism.

§ 673. The clavicle is articulated by its anterior extremity with the handle of the sternum, by its posterior extremity with the acromion process of the scapula, and also with the scapula and with the first rib by fibrous ligaments

§ 674. Sometimes a portion of the clavicle, particularly the external, is deficient, even when the upper extremity is otherwise normally developed; and it is then replaced by a process of the scapula, which however is always thinner(1).

(1) Martin, *Déplacement naturel de la clavicule:* in *Roux*, *Journal de Med.*, vol. xxiii., p. 458.

ARTICLE SECOND.

OF THE HUMERUS.

A. NORMAL STATE.

§ 675. The *arm-bone* or the *humerus* (*os humeri*, *os brachii*) the third in size of the round bones, forms alone the bony foundation of the arm. Its body is slightly twisted; it gradually becomes thinner from above downward, but is broader at its lower extremity. Its three faces are more marked at the lower than at the upper part, which is rounded rather than triangular. These faces are, when the arm is extended along the body, an *anterior*, a *posterior*, and an *external*. The first two are almost straight; the upper part of the posterior face alone is convex, and its lower part is straight. The internal edge, which terminates the anterior and posterior faces, is very rough in the upper part of the bone where the anterior and posterior edges are hardly perceptible, while they are very distinct in the inferior portion, and become more so when examined still lower. The upper extremity of the body enlarges considerably, particularly inward and backward. The foramen of nutrition, which is single, is found at the commencement of the lower third, on the anterior face near the internal edge, sometimes even on this or on the posterior edge.

It is extended into an upper process, the direction of which varies a little inward and backward from that of the body. Its greater posterior, inner, and upper portion forms a semi-spherical *head* (*caput humeri*), covered with cartilage, which is surrounded with a slight and somewhat rough depression. On the outer and anterior circuit of this upper process, are two eminences for the insertion of the muscles, the *tuberosities* (*tubercula*) of the humerus, one of which is three times as large as the other, is situated outward and forward, and is called the *external*, *anterior*, or *larger tubercle* (*tuberculum majus*, *anterius*, *externum*); while the other, smaller but more projecting, is called the *smaller*, *posterior*, or *internal tubercle* (*T. minus*, *posterius*, *internum*). From each of them proceeds a rough line, of which that of the large tubercle (*spina tuberculi majoris*) terminates in the internal edge, and that of the small tubercle (*spina tuberculi minoris*) is not more than a third or a fourth as long as the body of the humerus, and disappears at this height. A groove, which varies in depth, exists between the tubercles; this goes downward, forward, and outward, and soon disappears on the upper extremity of the internal face of the body; this is the *bicipital groove*.

The lower extremity is more complex than the upper. The bone is here a little broader, but is much thinner than at its upper end; and is consequently flat. It terminates downward by an oblong, round, and cartilaginous projection, the surface of which is very uneven from several eminences and depressions. Its anterior or external portion is rounded, and extends much higher on the anterior or internal side of the bone, than on the posterior or external: it is the *inferior head* (*eminentia capitata*). The posterior or internal part is much larger, extends as high backward as forward, and is composed of two semicircular eminences, of which the external or anterior, situated at the side of the former, and separated from it by a fissure, is much smaller than the internal or posterior, which is also separated by a considerable depression. These two eminences form the *pulley* (*trochlea ossis humeri*). We observe over the inferior head a slight depression, called the *small anterior fossa* (*fossa anterior minor*); above the pulley and forward, another deeper depression called the *great anterior fossa* (*fossa anterior major*); finally backward, and also above the pulley a third depression, deeper than the other two, called the *largest* or the *posterior fossa* (*sinus maximus*, s. *fossa posterior*). The last two cavities not unfrequently communicate by a large opening in the bone, which generally exists upon both sides of the body. The bone, too, is sometimes perforated with a large rounded opening over these articular eminences.

Besides these articular processes in which the lower extremity of the humerus terminates, its anterior and posterior edges present two eminences which are not so deep, but serve as attachments to muscles: these are the *condyles* (*condyli*). The anterior and outer condyle is much smaller, and is termed also the *epicondyle* (*condylus flexorus*). Most of the flexor muscles of the hand are inserted in it, and also in that part of the anterior face of the humerus over it. The *posterior* and *internal condyle* or *epitrochleus*, (*condylus extensorius*), which is three times as large, gives attachment to the extensor muscles of the hand.

§ 676. The humerus begins to form about the middle of the second month of pregnancy. Toward the end of this month it is still small, only about a line long, and flat. Perhaps it develops itself by two points of ossification, situated one at the side of the other, which grow together rapidly; for in young fetuses we have seen a fissure extending from its upper extremity to its central portion. Even till the last month of fetal existence, the body only is ossified; but at this period ossification commences also in the extremities, and first in the inferior.

This presents at birth only one nucleus of bone, which is not situated in its centre, but in the small head. Sometimes, and most generally, the body gradually extends into the pulley, or a single nucleus of bone is developed in the pulley, which fuses first with the head, then with the body. Some months after birth, we see an osseous germ in the upper extremity or in the place of the head, with which a second, in the large tubercle, unites afterward, and usually at the end of the first year: these two nuclei fuse together before the whole extremity joins the body. Still later, the internal or posterior condyle develops itself by one point of ossification, which fuses sometimes with the body and sometimes also with the rest of the inferior extremity. This last unites with the body sooner, long before the subject is perfectly grown, while the upper remains distinct and separate until after this period. The internal tubercle fuses with the body much sooner than the upper, but much later than the lower.(1)

§ 677. The humerus forms, by its head, with the glenoid cavity of the scapula, an arthrodia: its lower extremity is united with the two bones of the fore-arm.

B. ABNORMAL STATE.

§ 678. The humerus is sometimes entirely deficient, from a primitive deviation of formation, or in a greater or less portion when the upper limbs are more or less imperfectly developed. The degrees of this anomaly are very various; for sometimes a very small stump only appears; sometimes, when the development is more advanced and the fore-arm and hand only are deficient, the humerus becomes thin at its lower extremity, and terminates in one or two processes.(2)

We have already mentioned (§ 678) the union of the larger anterior and posterior fossæ. 5

ARTICLE THIRD.

OF THE BONES OF THE FORE-ARM.

A. NORMAL STATE.

§ 679. The bones of the *fore-arm* are two, the *radius* and the *cubitus* or *ulna*, which are nearly equal in size, are situated on the same plane, and are both articulated with the humerus; but which are capable of executing very different motions, on account of the forms of their articular surfaces.

I. OF THE ULNA.

§ 680. The *ulna* (*ulna* s. *cubitus*, *canna major*, *focile majus*) is longer than the radius, and this extra length extends above it. It deserves then to be examined first, partly on this account and partly because being less movable, it forms the basis of the bony frame of the fore-arm.

Its body gradually diminishes in thickness from above downward, and it is slightly curved in the form of an S; for near the centre it approaches the radius, then separates from it, and again approaches it at its lower extremity. Its upper portion, which is the longest, presents very distinctly three faces: these are, when the fore-arm is at rest, a posterior, an anterior, and an internal face; but they disappear at its lower portion, where the bone becomes rounder. The posterior and the anterior faces are almost straight: sometimes however the anterior is

(1) Albinus has pointed out, but very imperfectly, the order in which the nuclei of ossification are developed and united.

(2) Bonn, *Thes. oss. morb. Hov.*, Amsterdam, 1783, p. 120.

divided by a longitudinal eminence into two broad furrows. The internal face is always slightly grooved. The anterior edge, which limits the external and the anterior faces, and which looks toward the radius, projects the most and is called the *crest of the ulna* (*crista ulnæ*). At the upper extremity of the anterior face is a large eminence, which gives attachment to certain muscles, and is called the *tubercle*, or *head of the ulna* (*tuber ulnæ*).

The foramen of nutrition is usually situated a little above the centre of the bone, at the side of the crest, on the anterior or on the internal face. The upper extremity has the form of a hook, is the largest part of the bone, and is much thicker than the lower part. The upper and posterior part of this hook, the *olecranon process* (*olecranon, processus anconæus*), is directed perpendicularly from below upward; it is slightly rough, and convex at its upper and posterior part, and its anterior portion is concave and faced with cartilage. Where the upper face is continuous with the lower, is formed the *tuberosity of the olecranon* (*tuber olecranii*). The anterior part of the hook, the *coronoid process* (*processus coronoideus*), has a horizontal direction and is much lower. It presents an upper cartilaginous and concave surface, which is continuous at a right angle with the anterior face of the olecranon process, and is separated from it by a transverse fissure, which backward and inward usually presents no cartilage. These two cartilaginous surfaces form by their union a very deep cavity, called the *large sigmoid cavity* (*cavitas semi-lunaris, sinus sigmoideus, sinus lunatus major*), which is divided in its whole extent by a prominent line into two portions, of which the posterior is broader. Next to the anterior horizontal portion of this articular cavity, and joined to it at a right angle, we find, on the anterior face of the upper end of the ulna, the *small semilunar cavity* (*cavitas semilunaris, sinus sigmoideus, sinus lunatus minor*), which is much flatter, transverse, and also covered with cartilage.

The lower and rounded extremity of the bone swells out a little, and hence is called the *head* (*capitulum ulnæ*). Its inner and anterior part is covered with cartilage; the external is extended into a small rounded process, separated from the rest of the surface forward and backward by a groove, which is called the *styloid process* (*processus styloideus*). The inferior face of the head is slightly channeled.

§ 681. The ulna appears as early as the humerus (§ 676), or shortly after it. In the full grown fetus it is composed of a single uucleus of bone, which comprises all the upper process. Later, and rarely before the sixth year, nuclei of bone are developed above and below it. We first see the nucleus of the lower extremity which forms the base of the head, with the lateral faces and the styloid process. A little later, there are are developed in the upper end the three nuclei of the olecranon process. Two of these are situated inward, one at the side of the other, and extend transversely from before backward; the posterior is much larger than the anterior; the third, which is the largest of all, is found externally, and very much resembles the patella, both in situation and in its round form; these three nuclei concur but slightly to form the upper extremity of the ulna. They are not united with the body even at puberty; the upper unite with it much sooner than the lower, which remains separate until the subject has attained its growth.

§ 682. The ulna articulates at its upper extremity with the posterior part of the articulating surface of the lower end of the humerus, or the pulley, the elevations and depressions of which correspond perfectly to those of the large sigmoid cavity. In a state of extreme flexion, the anterior and most projecting part of the internal edge of the coronoid process engages itself in the larger anterior fossa of the humerus: when the fore-arm is extended, the olecranon process is received into the posterior fossa of this same bone (§ 675). The small lateral fissure of the upper extremity receives the commencement of the head of the radius, the inferior extremity of which turns around the convex and cartilaginous portion of the head of the ulna.

II. OF THE RADIUS.

§ 683. The *radius* (*radius, focile minus*) is much shorter than the ulna, and differs from it in being much thicker in its lower than in its upper part. It occupies the anterior region of the arm when in a state of repose along the body, and the external region when this limb is turned outward. It is considerably curved; for its central part is convex forward and concave backward, while the upper and lower portions are almost straight.

We distinguish in the body three faces and three edges. The internal face is the broadest, slightly concave upward, and convex downward; the foramen of nutrition is situated a little above the centre of the bone. The anterior face is very concave, the external is almost straight. The posterior edge, or the *crest of the radius* (*crista radii*), projects considerably, especially at its central part; the anterior and external edges are very round, so that the inner face is insensibly continuous with the anterior, and this with the external, while there is a well defined limit between the external and internal faces. Near the upper extremity of the bone, we see on the internal face the *tuberosity of the radius* (*tuberositas radii*), a considerable rounded, oblong eminence, which gives attachment to certain muscles and in which the posterior and the anterior edges unite. Above this point the bone slightly contracts, becomes round, and forms a *neck* (*collum*), which is rather long, and follows a similar direction. The neck enlarges at its upper extremity, and with it is connected the *head* (*caput radii*), which is round, slightly concave above, and covered with cartilage in every part.

The body gradually increases while descending, and finally becomes very thick. It spreads especially from before backward, and supports the lower triangular process, the base of which is turned backward, and the summit forward. The summit projects a little beyond the inferior face, and this forms a small prominence, called the *styloid process* (*processus styloideus*). The lower cartilaginous face is divided, by a small eminence, the direction of which is from within outward, into a posterior portion, which is square, and an anterior and triangular part. The posterior lateral face is also covered with cartilage, slightly excavated, and forms the *semilunar notch* (*incisura semilunaris*). The anterior is almost straight. The external is convex, and has a large projection in its centre. On both sides of this projection is a considerable tendinous groove, which extends from above downward, and which contains another smaller.

§ 684. The radius appears at the same time as the ulna. It is already developed in the full-grown fetus, but is composed of only one part, the body. At this time its lower part does not much exceed that of the ulna in size, because this lást is much thicker proportionally than it is afterwards. The osseous nucleus of the inferior process appears in its anterior portions first, but rarely before the end of the second year. The upper extremity does not begin to develop itself till towards the age of seven years; it however fuses with the body long before the subject is fully grown, while the lower remains separate even after this period.

§ 685. The radius articulates by the upper face of its head with the small head on the lower articular surface of the humerus; by the lateral face of this head, which is covered with cartilage, with the small semilunar cavity of the ulna; by the semilunar notch of its lower extremity with the cartilaginous surface of the head of the ulna; finally, by its inferior face, forward with the scaphoid bone, and backward with the semilunar bone of the wrist.

§ 686. By the arrangement of the corresponding articular surfaces, the radius possesses the motions of flexion and extension with the ulna, but can also partially turn on its axis, while the ulna changes its position very slightly. It is so connected with the wrist, that the hand follows all its motions. If the radius turns from before backward and inward, crossing the ulna obliquely, the posterior edge being directed outward and the internal face backward, the back of the hand is carried forward and the palm backward, the arm hanging beside the body: this is called *pronation* (*pronatio*). The opposite motion, which brings the radius and the ulna on the same plane, carries the back of the hand backward and brings the palm forward, is called *supination* (*supinatio*). In both cases the upper and lower extremities of the radius turn on the corresponding lateral faces of the ulna, which are faced with cartilage.

B. ANOMALIES.

§ 687. Sometimes one of the bones of the fore-arm is deficient, sometimes both. In the latter case, the hand is generally deficient; in the former, the hand is often well formed.

ARTICLE FOURTH.

OF THE BONES OF THE HAND.

A. NORMAL STATE.

§ 688. The hand comprises three regions, the *carpus*, the *metacarpus*, and the *fingers*. That face which looks outward when the arm is hanging down is called the *back* (*dorsum manus*), and the opposite face the *palm* (*palma, vola*) : the former is convex, the latter slightly concave. The edge turned forward in the same posture of the arm is called the *radial* edge (*margo radialis*), and the opposite edge is the *ulnar* (*M. cubitalis*). The faces of the different bones of the hand are then distinguished into *dorsal*, *palmar*, *radial*, and *ulnar*.

I. OF THE BONES OF THE WRIST.

§ 689. The *wrist* (*carpus*) is the uppermost and the shortest region. It is composed of eight, sometimes of nine bones, which are very irregular, do not ossify till after birth, are very closely united with each other, and articulate with the bones of the metacarpus. Beside the four regions which it has in common with all the bones of the hand, we distinguish in it a *brachial face* (*facies brachialis*) and a *digital face* (*F. digitalis*). The bones which form it are arranged in two rows, a *posterior* or *upper*, and an *anterior* or *lower*.

I. OF THE BONES OF THE FIRST CARPAL RANGE.

§ 690. The *posterior range of the carpal bones* comprises four, which are, counting from before backward, or from the radial to the ulnar side, the *scaphoid* bone, the *semilunar* bone, the *pyramidal* bone, and the *pisiform* bone.

I. OF THE SCAPHOID BONE.

§ 691. The *scaphoid* bone (*os naviculare, s. scaphoideum*) does not perfectly deserve this name, for its form is very irregular. In fact it is boat-shaped in its upper and posterior portion ; but forward is a large projection, which makes almost one half of its mass. It is composed of two parts, which are separated by a narrower portion, and it may be compared to the figure 8. Its upper posterior part is broader but flatter than the inferior anterior portion. Its brachial face is convex and covered with cartilage. The digital face is concave and divided by a rounded projection into two semicircular portions, a posterior, smaller and plane, and an anterior, which is larger and very concave. The first may be considered the ulnar face ; the second extends to the anterior part. The brachial and palmar faces of this part are not covered with cartilage, although the radial and digital faces form a triangular surface covered with a cartilage, which is divided by an eminence, the direction of which is from before backward, into two parts, the one longer and triangular, which is found outward, the other smaller, in form an oblong square, and turned downward.

§ 692. Although the scaphoid bone is one of the largest of the carpal bones, it does not begin to ossify till several years after birth.

§ 693. The scaphoid bone articulates, by its upper and cartilaginous face, with the anterior triangular portion of the lower face of the radius (§ 685); by its ulnar face, with the semilunar bone (§ 696); by the posterior digital face, with the os magnum (§ 709); by its radial face, with the trapezium; finally, by the anterior portion of its digital face, with the trapezoides (§ 704).

II. OF THE SEMILUNAR BONE.

§ 694. The *semilunar bone* (*os lunatum* s. *semilunare*) has a convex brachial face, which is covered with cartilage. This face is insensibly continuous with the convex palmar face, which has no cartilage, and with the straight dorsal face. The radial face is semicircular and entirely covered with cartilage. The ulnar face has the same form; it is destitute of cartilage except on its upper, posterior, square portion. These last faces are straight. On the digital face is a deep cavity, which is covered with cartilage.

§ 695. Ossification commences as late as in the scaphoid bone.

§ 696. The semilunar bone articulates, by its brachial face, with the posterior square portion of the lower cartilaginous face of the radius (§ 685); by its radial face, with the scaphoid bone (§ 693); by its ulnar face, with the pyramidal bone (§ 699); and by its digital face, with the os magnum.

III. OF THE PYRAMIDAL BONE.

§ 697. The *pyramidal bone* (*os triquetrum*, *triangulare*, *cuneiforme*) has its base forward and its summit backward. The internal and anterior smaller portion of its brachial face is covered with cartilage in a triangular space; its radial face is straight and plane, and is every where covered with cartilage; most of the digital face is a little concave, and also mostly covered with cartilage; lastly, the palmar face is rough and slightly concave in its inner half; its outer half is straight and covered with cartilage.

§ 698. Its ossification advances equally with that of the two preceding.

§ 699. It articulates by the cartilaginous portion of its brachial face with the triangular intermediate cartilage, by its radial face with the semilunar bone (§ 696), by its digital face with the unciform bone (§ 714), and by the cartilaginous part of the palmar face with the pisiform bone (§ 700).

IV. OF THE PISIFORM BONE.

§ 700. The *pisiform bone* (*os pisiforme, articulare, subrotundum*) is the smallest bone in the wrist. Its form is rounded and oblong, and it is situated entirely above the palmar face of the other bones in the posterior range, which are almost all on the same level except the anterior part of the scaphoid bone, which also projects considerably into the palm of the hand. The dorsal face of this bone is straight and covered with cartilage, and is the articulating surface, uniting it with the pyramidal bone (§ 699). It does not begin to ossify till after the age of six years. It forms with the scaphoid bone (§ 690) the *upper eminences of the carpus.*

II. OF THE BONES OF THE SECOND, THE INFERIOR OR ANTERIOR, CARPAL RANGE.

§ 701. The *second carpal range* includes the largest and most irregular bones of this region. The first three bones of the upper range, however, are larger than the two anterior of the second. The bones of the latter, counting from before backward, are the *trapezium*, the *trapezoides*, the *os magnum*, and the *os unciforme.*

I. OF THE TRAPEZIUM.

§ 702. The *trapezium* (*os multangulum, majus trapezoides, trapezium, rhomboides*) has a very irregular quadrilateral form. Its quadrilateral, transverse, brachial face is divided by a sharp ridge, which extends from the palm of the hand to the palmar edge, into two slightly concave surfaces, having the form of an irregular square, situated one at the side of the other, and covered with cartilage. The digital edge is transverse, concave from behind forward, slightly convex from the back of the hand to the palm, and also covered with cartilage. The dorsal, palmar, and radial faces are very uneven and rough.

§ 703. This bone is still entirely cartilaginous at the age of six years.

§ 704. It articulates by the anterior part of its brachial face with the scaphoid bone (§ 693), by the posterior with the trapezoides (§ 706), by its ulnar face with the metacarpal bone of the index finger, by the digital face with the metacarpal bone of the thumb.

II. OF THE TRAPEZOIDES.

§ 705. The *trapezoides* (*os multangulum*, s. *trapezium minus*, s. *pyramidale*) represents a short and irregular pyramid, the base of which is toward the back of the hand and the summit toward the palm. The dorsal and palmar faces are rough, destitute of cartilage, and slightly concave.

§ 706. Ossification always begins in it later than in the trapezium.

§ 707. It articulates by its brachial face, which is but slightly concave, with the scaphoid bone (§ 693); by the radial edge which is a little convex, with the trapezium (§ 704); by its digital face, which is triangular, convex from before backward, and concave from above downward, with the metacarpal bone of the index finger, and by its convex ulnar face with the os magnum (§ 710).

III. OF THE OS MAGNUM.

§ 708. The *os magnum* (*os magnum* s. *capitatum*) is the largest of the carpal bones. Its form is pyramidal, and it is so situated that its greatest diameter extends from its brachial to its digital face, the latter representing its base and the former its summit. Its brachial face is covered with cartilage, is rounded, and very convex. Its radial face is also covered with cartilage, and divided by two eminences, which extend from the back of the hand to the palm, into three parts, of which the posterior, larger than the other two, is convex and rounded; the central is also a little convex and square; finally, the anterior, the highest, is concave. The anterior face is triangular and a little concave and is also covered with cartilage. The ulnar face is rough in its anterior part, and its posterior is almost straight and covered with cartilage. The dorsal and palmar faces are slightly concave and have no cartilage.

§ 709. In the full grown fetus this bone is ossified in its centre, but not very perceptibly; most of it is cartilage. Its ossification is not completed till the tenth year.

§ 710. It articulates by its brachial face with the semilunar bone (§ 696), by the upper part of its radial face with the scaphoid bone (§ 693), by its central portion with the trapezoides (§ 707), by its anterior face with the metacarpal bone of the third finger, by the cartilaginous portion of its ulnar face with the os unciforme (§ 714).

§ 711. A ninth carpal bone sometimes exists between this bone and the preceding,(1) a curious analogy with the formation of apes, in which we find, between the trapezium and the os magnum, a ninth bone, which seems to arise from the division of the trapezoides into two portions.

IV. OF THE OS UNCIFORME.

§ 712. The *unciform bone* (*os hamatum*, s. *os unciforme*) has an irregular triangular form, the base being turned toward the back of the hand and the summit toward the palm. The latter portion, which is flat from one side to the other, forms the hook. The unciform process causes this bone to project very much inward beyond the central two, as the trapezium does outward, and produces, with the latter, the

(1) Salzmann, *Decas. obs. illustr. anat.*, Strasburg, 1725, p. 3.

inferior eminences of the carpus, which, united to the superior (§ 700), form the walls of a groove, through which pass the tendons of the flexor muscles of the hand and fingers.

The brachial face of the unciform bone is covered with cartilage, and is oblique, convex, and oblong. The external portion of the radial face is plain, and covered with cartilage; the internal is rough. The digital faces are slightly concave from without inward, a little convex from before backward, and divided by a slight ridge, which extends from the unciform process to the palmar side, into a small anterior and a larger posterior portion. The dorsal face is a little convex and rough. The palmar face, which is almost destitute of cartilage, is continuous by its external edge with the unciform process.

§ 713. We discover also in this bone, in the full grown fetus, an osseous nucleus, situated near the centre, larger than that of the os magnum, although the unciform bone itself is smaller than this bone. Ossification is completed at the same time as in the preceding bone.(1)

§ 714. The unciform bone articulates by its brachial face with the pyramidal bone (§ 699), by its radial portion with the os magnum (§ 710), by its digital portion with the metacarpal bones of the fourth and fifth fingers.

II. OF THE METACARPAL BONES.

§ 715. The *metacarpus* is composed of five cylindrical bones, which vary in length, but are all formed after the same model. The *bodies* are rounded, or slightly triangular, convex on the dorsal side, concave on the palmar face, and a little broader toward the anterior end than near the posterior extremity. We distinguish in them three faces and three edges, which, except in the first metacarpal bone, in the anterior and posterior halves are situated differently. In fact the anterior or inferior portion presents a dorsal, a radial, and an ulnar face; also an internal, inferior, or palmar edge, a radial, and an ulnar edge, of which the first is more prominent. The posterior or upper half, on the contrary, presents two lateral faces, but not a superior, which is replaced by an inferior or palmar face; no palmar edge, but a dorsal, external, or upper edge; because the two lateral edges unite at the central part of the bone, and after leaving this point, a sharp edge extends on the back of the latter to its posterior extremity.

The *posterior extremity* or the *base* (*basis*) is triangular or irregularly quadrangular, and covered with cartilage at its posterior portion, which is generally plain. The lateral parts are also mostly covered with cartilage. Before and between the cartilaginous points of the lateral faces, are very considerable rough depressions, which are

(1) Albinus, followed by all the anatomists, says: "*Singula carpi ossa cartilaginea in fœtu sunt, nec nisi diu post nativitatem os inchoant;*" which is incorrect, according to our numerous examinations of full grown fetal skeletons. We always find nuclei of bone in the semilunar and unciform bones: they are more imperfect than those of the tarsal bones, proportionally smaller, and not infiltrated with blood, but yellowish.

succeeded by similar projecting eminences: these are the vestiges of the connections of the metacarpal bones with each other and with those of the carpus, in such a manner as to admit of but very slight motion on account of the arrangement of their articular surfaces, of the number of means of union, and of the substance which forms them.

The *anterior extremity* is rounded, almost entirely covered with cartilage, and from its form is called the head (*capitulum*). It is a little compressed from one side to the other, and terminates backward on each side, both on the dorsal and palmar faces by two *tubercles* (*tubercula*), between which, on each side, is a large *depression* (*sinus*). These depressions and tubercles trace the insertion of the ligaments.

§ 716. Ossification of the metacarpal bones commences at the third month of pregnancy. They do not all appear at once: we see the second, then the third, and then the others appear. Towards the end of the third month each contains an oblong nucleus of bone. In the full-grown fetus, the body only is ossified, and the two extremities are still entirely cartilaginous. They do not begin to ossify till very late; we see only one nucleus of bone in the head towards the end of the second year. This nucleus remains separate from the body for a long time, sometimes until the subject is fully grown. We have never seen it in the posterior extremity, except in the metacarpal bone of the thumb, which seems to have none in its head, at least we have never been able to see it in this part. The posterior or upper nucleus of the first metacarpal bone remains separated from the body as long as the anterior nuclei in the other four.

§ 717. The metacarpal bones articulate by their posterior cartilaginous faces, with the anterior range of the carpal bones: by the cartilaginous parts of the lateral wall of their bases, partly with these bones, and partly with each other; by their heads with the corresponding bones of the posterior phalanges.

I. OF THE FIRST METACARPAL BONE.

§ 718. The *first bone of the metacarpus*, or *the metacarpal bone of the thumb* (*os metacarpi pollicis*), varies from the others in size and in form. It is much shorter, but thicker and broader than the others, and relatively and absolutely flatter, while the latter are compressed, that is, are narrower from one side to the other, than from above downward. The dorsal face, the broadest of all, extends the whole length of the bone. The two lateral faces, of which the ulnar is the most extensive, unite at an angle much more obtuse than in the other metacarpal bones. The base is more broad than high, and has no cartilage on its two sides. Its posterior face is covered with cartilage, slightly concave from the radial to the ulnar side, a little convex from the dorsal to the palmar face, open on the two sides, and bounded only upward and downward by a slight projection. These particulars, and the extreme looseness of the capsular ligament, allow this bone much more motion than the other bones of the metacarpus. The head also is broader, but lower than in the others.

§ 719. The first metacarpal bone is one of those which is developed the last. In the fifth month of pregnancy, it is still, in proportion to the others, much shorter than it is afterward, since it is not more than one half shorter than the fifth, which, when the body is perfectly developed is only one-seventh longer. Its mode of ossification differs from that of the others in a peculiarity mentioned above (§ 716).

§ 720. This bone articulates with the trapezium (§ 704).

II. OF THE SECOND METACARPAL BONE.

§ 721. The *second bone of the metacarpus*, or the *metacarpal bone of the index finger*, is generally the longest of all, and extends backward farther than the others. The next one is seldom as long: the second is thinner than the third. Its posterior extremity has a triangular articular face mostly faced with cartilage, which is very concave, and corresponds exactly to the convex digital face of the trapezoides (§ 707). On its radial face upward and backward, is a small plain cartilaginous surface. The ulnar face has another which is larger, occupying all the height of the bone, and divided by a slight projection into a smaller posterior portion, and an anterior part which is larger. This bone articulates by the cartilaginous part of its radial face, with the trapezium; by the posterior part of that of its ulnar face with the os magnum (§ 710); and by the anterior part with the third metacarpal bone.

III. OF THE THIRD METACARPAL BONE.

§ 722. The *third bone of the metacarpus* articulates with the os magnum (§ 710) by its posterior face, which is irregularly quadrilateral, broader above than below, convex from above downward, and covered with cartilage; with the second metacarpal bone, by the radial face of its base, which is covered with cartilage at its posterior part: finally, with the fourth, by two flattened cartilaginous surfaces, situated one above the other, as is seen in the ulnar side of the same part.

IV. OF THE FOURTH METACARPAL BONE.

§ 723. The *fourth bone of the metacarpus* is much shorter and thinner than the third. Its posterior articular surface is narrow, irregularly quadrilateral, straight, and covered with cartilage, and corresponds to the anterior portion of the digital face of the unciform bone. Two small plane surfaces, which are covered with cartilage, and situated one above the other on the radial side of the base, are fitted to the corresponding surfaces of the ulnar side of the third metacarpal bone (§ 722). Another narrow surface, extending as high as the bone, is found on the ulnar side, and corresponds to a similar one on the radial side of the fifth metacarpal bone (§ 724).

V. OF THE FIFTH METACARPAL BONE.

§ 724. The *fifth metacarpal bone* is shorter, but thicker than the fourth. The articular face of its posterior extremity is quadrangular, convex, and covered with cartilage, and articulates with the anterior portion of the unciform bone. It articulates, by a small cartilaginous portion of its radial face, with the ulnar face of the fourth metacarpal bone (§ 723). The upper articular face presents, on the ulnar side, a blunt and rough tubercle.

III. OF THE BONES OF THE FINGERS.

§ 725. The fingers contain fourteen bones; each one, except the thumb, has three *phalanges* (*phalanges, articuli, internodia*). All the bones of the fingers are elongated, flattened from their dorsal to their palmar face; consequently more broad than high, convex from before backward on their dorsal face, concave on their palmar face, broader and stronger at their posterior than at their anterior extremity; and presenting, at least in the former, a slightly concave and cartilaginous articular surface.

§ 726. Ossification begins in the bodies of these bones later than in the metacarpal bones, and not until towards the end of the third month of pregnancy. The osseous nuclei of the first and third phalanges appear before those of the second. All these bones are developed by two points of ossification only; a larger for the body, and the other for the posterior extremity. This last begins to ossify about the age of five years; it remains separated from the body a long time, often even until the subject is perfectly developed. No special nucleus of bone exists in the anterior extremity.(1)

I. OF THE PHALANGES OF THE FIRST RANGE.

§ 727. The phalanges of the first range are the longest and strongest. The dorsal face of their bodies is very convex from one side to the other; the interior or palmar face is less so, but presents, in its centre, especially in the bones of the three middle fingers, a radial and an ulnar edge, which project very much into the centre of the hand, and are turned upon themselves. This projection is seen only in the first phalanx of the thumb. The posterior extremity presents a rounded articular process which is almost plain and covered with cartilage, and which articulates by arthrodia with the heads of the metacarpal bones. On the lateral parts, and below them, is on each side a very projecting edge. The upper face is rounded and triangular, and covered with cartilage, having in its centre a longitudinal furrow which gives it the form of a pulley. On each side we observe a depression (*sinus*), behind which is a slight tuberosity.

(1) Albinus says that the two pieces of bone fuse directly with each other. (*Ic. oss. fœt.*, p. 120.) We have never observed a fact to support this proposition. Loder is likewise mistaken (*Anatomie*, p. 264) in saying that the anterior extremity also develops itself by a single osseous germ. Albinus had already given a correct description of the progress of ossification.

Of these five bones that of the middle finger is the longest; those of the second and fourth fingers are nearly equal in length, and so too of the first and fifth; the latter however is a little longer than the other. That of the thumb is proportionally the broadest and flattest, which serves to distinguish it from that of the little finger.

II. OF THE BONES OF THE SECOND PHALANX.

§ 728. The *bones in the second phalanx* very much resemble those in the first, but they are flatter and broader in proportion to their length, especially in their posterior portion. The edges project very much in the central part of the second, third, and fourth, but less so than in the first phalanx. The posterior articular face fits into the pulley of the first phalanx; it is also divided by a projecting line into two small and slightly concave lateral facets; the interior has slightly the form of a pulley. In this range of bones that of the middle finger is the longest and the strongest; next come those of the fourth and second fingers, the shortest is that of the fifth finger.

III. OF THE BONES OF THE THIRD PHALANX.

§ 729. The third phalanx differs from the others, as its bones present an articular surface faced with cartilage only in their posterior parts. This face is much broader in proportion than their anterior extremity. The latter is less bulging, rough, rounded, and terminated by a tubercular edge. Besides, the bones in the third phalanx are much shorter than those of the other two ranges. Their posterior face is concave, and by a slight edge hollowed into two lateral cavities. The upper face is smooth, the inferior very rough, especially near the extremities. The phalangœal bone of the thumb in this range is much longer and thicker than the rest, which are smaller and nearly equal in length, but of different thicknesses; that of the little finger is much smaller than the rest.

B. OF THE ANOMALIES IN THE BONES OF THE HAND.

§ 730. The *bones of the hand* are sometimes partly or wholly deficient, which results from an imperfect development. In the former case, there are sometimes whole parts of which we can discover no traces, sometimes only portions of these parts are deficient, as for instance one or several bones of the phalanges.

So too the number of the bones is sometimes increased by one or more; this increase takes place in the number of the fingers, or of the other parts of the hand.

Sometimes the bones of two or more fingers are fused together.

A disease, which does not belong exclusively to the bones of the fingers, but which very often attacks them, is a swelling, with a diminution in the density of their substance. This disease results from inflammation, and is called *pædarthrocase*, because observed most frequently in children, particularly those whose constitutions are feeble.

CHAPTER II.

OF THE BONES OF THE LOWER EXTREMITIES.

ARTICLE FIRST.

OF THE ILIAC BONES.

A. GENERAL REMARKS ON THE ILIAC BONES.

§ **731**. The *iliac* or *coxal bones* (*ossa coxarum*, s. *pelvis lateralia*, s. *innominata*) correspond in form and situation to the shoulder-bones of the upper extremity. 1st. In form; being composed generally of two parts, one elongated and smaller, the other broader and larger. 2d. In their situation; they are placed between the abdominal extremities and the lower part of the vertebral column, in the same manner as the bones of the shoulder are, between the second section of the pectoral limbs and the upper part of the vertebral column; their broad portion is situated backward and on the side, and their long portion forward, where the bones of the two sides meet, while the arrangement in the posterior face of the trunk is different. Comparative anatomy and the history of ossification place this analogy in a still stronger light.

§ **732**. The iliac bone is divided into three parts, the *ilium* (*os ilium*), the *ischium* (*os ischii*), and the *pubis* (*os pubis*).

I. OF THE ILIUM.

§ **733**. The *ilium* is the largest of these three portions. It corresponds to the scapula since it constitutes the broadest, the most posterior and the most superior part of the whole bone. Its form is irregular, more however like a triangle than any other figure. Its upper edge is convex; the anterior is usually straight and is grooved below; it is continuous with the ischium and the pubis by the anterior part of the latter.

§ **734**. The upper convex edge is the largest and the broadest, especially forward and backward. It is called, from its form, the *crest of the ilium* (*crista ossis ilii*). We distinguish in it an external and an internal lip, and a middle portion. It terminates forward by a small eminence which projects above the anterior edge, and is called the *anterior* and *superior iliac spine* (*spina ossis ilii anterior superior*); backward, by two other projections, called the upper and lower *posterior iliac spines*, which are separated from each other by a small *semi-lunar notch* (*incisura semi-lunaris*).

The anterior edge, oblique from above downward, and from behind forward, presents two superficial notches which are separated by an eminence, the *anterior* and *inferior iliac spine* (*spina anterior inferior*).

In the inferior edge is a large notch; it forms the posterior and superior part of the *iliac notch* (*incisura iliaca*, s. *ilica superior*).

§ 735. The external and the internal faces are slightly concave, because the bone becomes thicker at its circumference; the internal however is more concave than the other. The upper part of the inner face is smooth, the posterior and inferior is very rough. The anterior and smaller portion of this rough part is faced with cartilage, elongated, convex forward and concave backward; it is called the *auricular surface* (*facies auricularis*). The posterior is more uneven and is destitute of cartilage.

The lower and by far the smallest part of the plane portion of this face, curves on the upper at an obtuse angle, and follows an almost perpendicular direction, while the upper extends obliquely from above downward and from without inward.

The angle which separates them forms, at the posterior part both upward and downward, between the smooth and the rough portions of the internal face, the *curved line* (*linea arcuata*). It is continuous forward with the posterior and projecting edge of the upper face of the horizontal branch of the pubis, thus producing all around the iliac bone a ridge, called the *linea innominata*. Immediately above this crest is found a large foramen through which the artery of nutrition passes to the bone.

The external face is smooth in every part, and divided by two semicircular lines, which project slightly, being concave upward and backward, into two portions, the anterior of which is much greater than the posterior.

§ 736. The ilium is thickest downward and forward, where the inferior and anterior edges meet; forward and outward it presents a deep fissure, which forms the upper and external smaller portion of the *cotyloid cavity* (*acetabulum*). Some anatomists term this part of the bone the *body*.

II. OF THE ISCHIUM.

§ 737. The *ischium* (*os ischii*) forms the inferior central part of the iliac bone. It descends almost perpendicularly from the anterior part of the lower edge of the latter, but goes however a little from above downward and from without inward, following the same direction as the lower part of the internal face of the ilium. In this place its internal face is slightly convex backward and very concave forward. The upper part is the broadest and thickest, and has also been called the *body*. The anterior portion of its external face forms the larger and lower part of the cotyloid cavity.

The posterior edge of the body is sharp; it forms the anterior part of the iliac notch, and runs backward and inward into the *sciatic spine* (*spina ossis ischii*).

The *descending branch* (*ramus descendens*) begins in this place. This branch is slightly compressed, but is very thick, and swells downward into the *sciatic tuberosity* (*tuber ischiadicum*), which is covered with cartilage. A deep furrow is found externally between this tuberosity and the lower edge of the cotyloid cavity. We remark also between it and the spine, on the internal face and posterior edge, the *inferior iliac* or *ischiatic notch* (*incisura iliaca inferior*, s. *ischiadica*).

The ascending branch leaves the tubercle, and goes inward, forward and upward. This branch is much shorter and weaker than the descending, and is compressed from before backward and from without inward.

III. OF THE PUBIS.

§ 738. The *pubis* (*os pubis*, s. *pectinis*) resembles the ischium in form, being also composed of two branches united at an angle. The *upper* or *horizontal branch* (*ramus horizontalis*) begins with the bulging external extremity of the *body*, by means of which it forms the upper and internal part of the cotyloid cavity; and then contracting, it also forms in its centre and at its origin a triangle. Toward its inferior extremity, it becomes considerably broad from within outward, becomes thinner from before backward, and thus produces its *descending branch* (*ramus descendens*), which goes downward and outward, gradually becomes narrow, and finally unites with the ascending branch of the ischium.

The inferior face of the horizontal branch is concave from behind forward and from without inward. The anterior edge, situated between the upper and anterior faces, is blunt. The upper, placed between the posterior and superior faces, forms the *crest of the pubis* (*pecten*, s. *crista*). Both unite, beyond the internal extremity of the horizontal branch and on the anterior face, in the *tubercle of the pubis* (*tuberculum ossis pubis*).

§ 739. The ischium and the pubis united represent an irregular ring, which surrounds an opening, closed in great part by a membrane, and called the *obturator* or *oval foramen* (*foramen obturatorium*, s. *ovale*). This foramen is, however, triangular or irregularly quadrilateral. It has an external, an upper, and an internal edge.

The external edge, formed by the inner edge of the descending branch of the ischium and the outer part of the horizontal branch of the pubis, is longest, and is often divided into two portions, an inferior, which is the smaller, and a superior. The upper part is always very broad, and forms a channel, the direction of which is from without inward and from behind forward, through which the obturator nerves and vessels pass from the pelvis. The abdominal viscera sometimes pass out through this opening, forming a hernia through the foramen ovale.

The upper edge, which is oblique from above downward, from behind forward, and from without inward, is formed by the inferior edge of all the inner part of the horizontal branch of the pubis, and unites at an obtuse angle with the internal.

The latter, oblique from above downward and from without inward, is formed by the upper edge of the descending branch of the pubis and of the ascending branch of the ischium, and it unites at an acute angle with the external.

§ 740. The *cotyloid cavity* (*acetabulum*) is situated on the external face of the iliac bone, in the place where the three pieces which form it meet. Its largest inferior portion is formed by the body of the ischium, its smallest anterior portion by that of the pubis, and its posterior part by that of the ilium, that is, by the thickest portion of the iliac bone. It is round, rather deep, and surrounded by a sharp edge (*supercilium acetabuli*), which presents forward and downward, toward the foramen ovale, a considerable space, called the *cotyloid fissure* (*incisura acetabuli*). Its central and anterior part, the *sinus* (*fovea*), terminates anteriorly by a notch, and is uneven and rough, is grooved in several places, particularly in the upper and anterior region, and is destitute of cartilage. The upper and posterior, on the contrary, which is called the *semilunar face* (*facies lunata*), is smooth and covered with cartilage; it extends forward, and forms two *horns* (*cornua*) which surround the notch, so that the superior does not always descend entirely to it. The inferior is much more prominent, and forms with it a channel.

§ 741. The iliac bone is developed by three nuclei of ossification, which correspond exactly to the three parts we have described. These three parts are not however formed at the same time. First, the nucleus of the ilium appears in the fourth month, next that of the ischium and lastly that of the pubis. Those parts which are most distant from the median line and from the anterior face are always developed first; so that they enlarge from without toward the median line. In the full grown fetus, these three pieces are not only entirely distinct, but the ascending branch of the ischium and the descending branch of the pubis are but slightly ossified; so that there is more than half an inch of cartilage between them. At two years of age they touch, but the cartilage exists till the seventh year. About this period they unite with one another, although the three pieces of the iliac bone are still perfectly distinct, in the cotyloid cavity, in subjects of fourteen years of age. In the sixteenth year there is developed, in the cartilage which joins them in this place, a bone formed like a Y, which unites with the rest to form but a single bone. The formation however is not yet completed; for afterward, a single oblong nucleus of bone appears in the crest of the ilium, and a second along the inferior edge of the ischium. These do not unite till the age of twenty, and it is then only that the iliac bone is perfectly developed.

§ 742. The iliac bones articulate with the sacrum, with the coccyx, and with each other; viz. the ilium by its auricular surface and the rough portion behind it, with the sacrum, by synchondrosis; the ischium, with the sacrum the coccyx, and ilium by the two sacro-sciatic ligaments; the two descending branches of the pubis articulate together at their upper part by the intermediate fibro-cartilage.

§ 743. From the description given, the iliac bone differs from the scapula in certain respects; but the analogy is greater than the differences, and the latter may be easily explained (§ 731). In the imperfect state the analogy is more striking, as is always the case: the broad part and the thin part do not make one, as in the adult, but they are separated; and it is still more remarkable in this respect, that although the pubis and the ischium form after the ilium, they however unite with each other before they join the last; so that taken together they represent the clavicle. Although the clavicle develops itself before the scapula, while the ischium and the pubis are formed after the ilium, yet this difference is of little importance. So too the difference in the manner in which these bones are articulated with each other and with the vertebral column, as also in the form of this articulation, which always continues, does not deserve notice.(1)

If we place a scapula and an iliac bone side by side, so that the internal edge of the former and the crest of the latter are directed upward, we recognise, without difficulty, that the inner, the anterior, and the outer edges of the scapula correspond to the crest, to the anterior edge, and to the iliac notch of the iliac bone; the glenoid cavity of the former, to the cotyloid cavity of the latter; the coracoid process, to the body of the pubis: finally, the spine of the scapula, to the body and descending branch of the ischium: the rest of the pubis and of the ischium represents the clavicle.

The horizontal portion of the pubis may also correspond to the clavicle, and the descending branch of the ischium to the coracoid process; since the ascending branch of the latter and the descending branch of the pubis are the costal cartilages ossified, and the fibro-cartilaginous mass between the descending branches of the pubis may be compared to the sternum in its unossified state.

B. OF THE ILIAC BONES ARTICULATED WITH EACH OTHER AND WITH THE LOWER BONES OF THE TRUNK, OR OF THE PELVIS.

I. NORMAL STATE.

§ 744. The *pelvis*(1) is a bony cavity situated at the lower extremity, forming a part of the trunk, and it is composed of the sacrum (§ 491), and the coccyx which form it posteriorly, and by the two iliac bones (§ 731), which circumscribe it in the rest of its extent. The form of this cavity is very irregular, being much broader from one side to the other than from before backward, while it is much higher on the sides and backward than it is forward.

(1) See on this subject our *Beytræge*, vol. ii. p. 2. Comparative anatomy also demonstrates how unimportant is this difference.

(2) Ed. Sandifort, *De pelvi ejusque in partu dilatatione diss.*, Leyden, 1753.—J. Ripping, *Diss. sys. quasdam de pelvi animadversiones*, Leyden, 1776.—C. C. Creve, *Vom Baue des weiblichen Bechens*, Leipsick, 1794.—J. J. Watt, *Anatomico-chirurgical view of the male and female pelvis*, London, 1817.—G. Termanini, *Della figura, ampiezza, altezza, situazione ed osse della cavita del pelvi*, in *Opusculi. scient. di Bologna*, vol. i. 1817.

§ 745. It is divided into the *large* and *upper pelvis*, and the *small* or *lower pelvis*. The large pelvis is the space circumscribed on both sides by the upper part of the iliac bones, backward by the upper face of the sacrum, and forward by the upper edge of the pubis, so that it is open forward and downward. It is separated from the lower pelvis by the *linea innominata*, or more properly the *linea terminalis*, the *terminal*, *marginal*, or *peripheric line*, which follows the anterior edge of the upper face of the sacrum, and by the promontory (§ 495), the boundary between the upper and lower parts of the iliac bones, and by the crest of the pubis. The surface comprised by this line is called the upper *opening* or *strait* of the *small pelvis* (*introitus* s. *apertura pelvis superior*). The large pelvis is much broader across than from above downward, or from before backward, especially at its upper opening; for after leaving this point, its lateral walls which are slightly concave, proceed obliquely downward and inward towards the inferior opening.

We distinguish in the large pelvis an *anterior* and a *posterior transverse diameter* (*diameter transversa posterior et anterior*), indicating the first, the greatest distance between the two iliac crests, and the second, the distance between the anterior and posterior iliac spines.

§ 746. The *small* or *lower pelvis* is more rounded and more elevated than the large. Although broader from one side to the other than in any other direction, it is however much narrower than the latter; more surrounded than it by bony walls in all its circumference. Its walls are formed by the greater part of the sacrum, of the coccyx, of the ischia, and the pubes and the lower part of the ilia. The hollows in the walls of the small pelvis are filled by muscles and ligaments.

We observe in the small pelvis, the *entrance* or *superior strait* (§ 745), the *outlet* or *inferior strait* (*exitus*, s. *apertura inferior*), and the *cavity* (*cavum*), the space comprised between the two straits.

The upper strait has a rounded and oblong or elliptical form, and has a small process forward at its central part. We distinguish in it four diameters, an *antero-posterior* or *sacropubic*, the *conjugate diameter* (*diameter antero-posterior*), which is measured from the centre of the promontory to the centre of the symphysis pubis; the *transverse* or *iliac* (*D. transversa*), which extends from one side to the other, falling on the centre of the two sides of the *linea innominata;* the two *oblique diameters* (*D. obliquæ*, s. *diagonales*), which extend from the sacro-iliac symphysis of one side to the union of the pubis and ilium of the opposite side, and are distinguished into right and left. The oblique and transverse diameters are longer than the conjugate diameter.

The walls of the cavity of the pelvis are a little oblique from above downward. We distinguish in this cavity a *straight* diameter, a *transverse* and two *oblique* diameters. The first reaches from the union of the second and third sacral vertebræ to the centre of the symphysis pubis. The transverse diameter extends from the centre of one cotyloid cavity to the same point in the opposite cotyloid cavity. The oblique is measured from the inferior extremity of the sacro-iliac symphysis to the centre of the foramen ovale of the opposite side: they are the longest, and the straight diameter is longer than the transverse.

The *inferior strait*, or the *outlet*, is narrower than the other regions, but it can enlarge an inch, as the bones of the coccyx are movable. It is formed by the lower edge of the coccyx, the two sacro-sciatic ligaments, the ascending branch of the ischium and the descending branch of the pubis; so that is composed of three large arches, viz. two lateral, situated between the coccyx and the sciatic tuberosities, and an anterior, which is larger, and is found between the two latter tuberosities. We distinguish in it only two diameters, a straight and a transverse. The *straight* or *cocci-pubic* diameter extends from the centre of the lower extremity of the coccyx to that of the lower edge of the symphysis pubis; the second or ischiatic, is measured from the centre of the lower edge of one sciatic tuberosity to the corresponding point of the other. When the coccyx is pushed back the straight diameter increases in breadth, so that it becomes greater than the transverse; but otherwise, in the normal state, they are equally long.

Besides these imaginary lines, we admit also an *axis* (*axis, linea directionis pelvis*), (1) that is, a line passing through the centre of the pelvis from above downward, but which, from the irregular form of this cavity, is not exactly parallel to its walls. This line is convex backward, and concave forward. We may suppose it produced by two or three straight lines, which unite at an obtuse angle in the centre of the straight diameter of the cavity of the pelvis: the upper line is the axis of the superior strait, the lower, that of the inferior strait, and the central one, of the cavity of the pelvis. They are directed, the first from above downward, and from before backward; the other two from before backward, and from behind forward.

The axis of the pelvis has not the same direction as that of the body, and the angle it forms with this last is not the same in all its extent, for this angle gradually contracts from above downward; so that it may be estimated about thirty degrees upward, twenty-five in the centre, and eighteen downward.

The surface, near the centre of which these lines are supposed to pass, is called the *surface of inclination;* and the difference between the direction of the pelvis and that of the trunk is termed the *inclination* (*inclinatio*) *of the pelvis*.(2)

§ 747. The pelvis is undoubtedly that part of the body which varies the most in the two sexes on account of its relations with the function of generation. The differences it offers in this respect, are then very important, and deserve to be examined particularly.

The general characters of the female pelvis are its breadth and depth; those of the male pelvis are its narrowness and height.

The lateral walls of the superior pelvis in the female have a more oblique direction downward: they are less deeply grooved from before

(1) J. G. Rœderer, *De axi pelvis programma*, Gottingen, 1751.—Sommer, *Dei Axe des weiblichen Beckens*, Brunswick, 1781.

(2) G. G. Stein, *De pelvis situ ejusque inclinatione diss.*, Marburg, 1797.

backward, or from above downward, separate very much from behind forward, and are much broader in this direction than in the male, which makes them appear lower.

The small pelvis is more spacious, less elevated, and more uniformly broad, than in the male, especially in the transverse direction. The circumference of the female pelvis is more rounded and elliptical, while in the male it is heart-shaped, because its walls first separate a little from each other from behind forward, they then converge and approach insensibly, before uniting forward. The upper part of the sacrum in the male projects much more inward than in the female, a difference depending principally on what is observed in the form of this bone (§ 496) and on the greater breadth of the central part of the pubis in the female.

In the female the iliac bones where their upper and lower portions unite, project very much beyond the sacro-iliac symphysis, while in the male they go almost directly forward. In the female the horizontal portion of the pubis extends almost in a straight line from without inward, after leaving the anterior edge of the cotyloid cavity; instead of which, in the male, it goes directly forward. Hence it follows that the superior strait of the small pelvis in the female is broader, and its transverse and oblique diameters particularly are proportionally larger than the straight diameter.

The small pelvis has nearly the same breadth in every part in the female; that of the male, on the contrary, becomes much narrower from above downward, because in the female pelvis the ilium and the ischium descend almost in a straight line, while in the male they approach each other very much while descending; and also because the sacrum is much straighter in the female, not projecting so far backward in its centre, nor so much inward in its lower portion; hence the sciatic tuberosities are much nearer each other in the male.

In the same manner, these bones and the pubis, and consequently all the small pelvis in the male is much higher than in the female.

The foramen ovale is much higher and narrower in the male, less elevated and broader in the female; it is more oval in the former and more triangular in the latter.

Finally, the outlet in the male is much narrower than in the female. The distance between the two sciatic tuberosities being much greater, the ascending branches of the ischia and the descending branches of the pubes meet in the female only after describing a large arch (*arcus ossium pubis*), while they unite at an acute angle (*angulus ossium pubis*) in the male. Besides in the male the descending branches of the pubes are turned, so that one of their faces looks more forward and the other more backward, while in the female the arch they describe causes their anterior face to look more outward and the posterior more inward, an arrangement which renders the difference in the form of the inferior strait still more evident. Thirdly, the branches of the pubes being much thinner in the female, the inferior strait of the pelvis is broader.

The most essential difference then between the male pelvis and that of the female in respect to breadth and form arises principally from the lower strait, which in the male is not only narrower but also heart-shaped and terminated forward in a point, while in the female it is rounder.

§ 748. The important differences in the form and breadth of the pelvis in the two sexes will be more evident from a table of the comparative measurements of the diameters of the cavity of the pelvis, taken from subjects of the same height.(1)

	MALE PELVIS.		FEMALE PELVIS.	
Transverse diameter of the large pelvis.	inches.	lines.	inches.	lines.
1st. Between the anterior and superior iliac spines	7	8	8	6
2d. Greatest distance	8	3	9	4
Transverse diameter } of the superior strait	4	6	5	0
Oblique do. } of the superior strait . . .	4	5	4	5
Straight do. } of the superior strait	4	0	4	4
Transverse do. } of the cavity	4	0	4	8
Oblique do. } of the cavity	5	0	5	4
Straight do. } of the cavity	5	0	4	8
Anterior transverse diameter } of the outlet	3	0	4	5
Posterior do. do. } of the outlet . . .	3	0	4	6
Straight do. do. } of the outlet	3	3	4 and sometimes 5 in.	4

II. OF THE ANOMALIES OF THE PELVIS.

§ 749. The anomalies peculiar to the female pelvis(2) are principally deviations of formation, which are congenital or accidental, and which affect the bones themselves, or their connections. All these deviations are very important as they exert a pernicious influence upon the functions of generation, especially upon parturition.

§ 750. 1st. The anomalies of these bones are seen in the variations presented in their form and situation, or in their continuity.

a. Anomalies in form. The slightest abberration consists generally in an *increase* or a *diminution* of *capacity*, which causes a general

(1) The calculations forming the basis of this table differ a little from those of Chaussier. See Mad. Boivin, *Mém de l'art des accouchemens*, p. 26–29.

(2) C. C. Creve, *Von den Krankheiten des weiblichen Beckens*, Berlin, 1795.—Mad. Boivin, *Mém. de l'art des accouch.* p. 31–34.

largeness or narrowness of the pelvis. These two states however, more particularly the second, when existing in a certain extent, are more rare than anomalies in the form of one or more bones, whence the figure of the whole pelvis varies more or less from the ordinary proportions either because only one of these regions is deformed, or because, even when the anomaly extends to the whole pelvis, a single diameter is shortened, so that the cavity is contracted in only one direction. These different kinds of anomalies are by no means equally common.

Most usually the antero-posterior or conjugate diameter of the upper and lower opening of the pelvis is narrower, because the sacrum describes too great a curve, whence its upper and lower extremities project too much inward. At the same time the pelvis is almost always oblique, which renders the oblique diameters unequal. The transverse diameter generally preserves its proper proportions, but is sometimes unusually broad. As to the straight diameter of the cavity,it is often unusually and uselessly long, from the great concavity of the sacrum.

The shortening of this straight diameter however may result also from an anomaly in the form of the iliac bones, they being either too short, or because, although large as usual, they describe an arch which is too convex.

The effect is the same also when the pubes are not properly arched externally, but go directly inward after leaving the ilium. A narrow space is then formed forward which does not assist the passage of the fetus, although the straight diameters are not really shortened.

Sometimes only the conjugate diameter of the outlet of the pelvis is shortened by the ossification of the ligaments of the coccyx. The shortening of the transverse diameter of the superior strait is rare, but that of the inferior strait, especially backward, is common, from the bending inward of the sciatic tuberosities.

Curvatures of the vertebral column, although extensive, have no effect upon the form of the pelvis, when not resulting from a general disease, as particularly rachitis. We have satisfied ourselves of this by a careful examination of a great many skeletons of hunch-backs.

b. Anomalies in situation. They cause a change in the direction or in the inclination of the pelvis. This cavity is inclined farther forward, and its distance from the horizontal line is greater as its axis is more perpendicular. On the contrary, it slopes very much more backward, and is more oblique as its axis is more horizontal.

c. Anomalies in the continuity of the bones. These consist in fractures which are not impossible as has sometimes been thought, but are observed in the pelvis even more frequently than in the other parts of the trunk. The part of the walls of the pelvis most frequently broken is the ilium, and the fracture is either transverse or longitudinal; a fracture of the descending branch of the ischium is most unfrequent. The horizontal and descending branches of the pubis and the ascending branch of the ischium almost always break together. Fractures of the sacrum are for the most part transverse; they are seldom seen except in the body of this bone.

§ 751. 2d. Anomalies in the arrangement of the connections of the bones of the pelvis consist in too loose or too firm a union.

a. Looseness in connection is primitive or accidental. The primitive is seen almost exclusively in the symphysis pubis. It is rarely met with alone,(1) and is most generally attended with an analogous anomaly in the bladder, a fissure of this organ. The bones are then always very imperfectly united by a fibrous ligament, which renders the gait unsteady, and the more as the pubes are generally separated some inches.

Accidental separation results either from external violence or disease, as inflammation and suppuration, by which the ligaments are torn or destroyed. External violence fractures the bone sooner than it destroys the ligaments, excepting always the pieces of the coccyx, which are movably articulated with the sacrum and with each other.

b. Too great solidity of the connections, the fusion of the bones, is caused by the ossification of their fibro-cartilages or of their fibrous ligaments.

This is seen most frequently in the sacro-iliac articulation, especially in that of the right side, which depends probably on the greater compression of this joint, from the support afforded to the body by the lower extremity of the right side.

It is less common to find a fusion either of a few, more particularly the lower of coccygœal bones, or of all, or finally of the first coccygœal bone with the sacrum. This anomaly is more frequent in males, especially equestrians, than in females.

The ossification of the sacro-sciatic ligaments is still more rare. That of the symphysis pubis is still more so.(2) It generally but not always results from inflammation and destruction of the cartilage, while that of the other joints supervenes without inflammation, and solely from the gradual change of their proper substance, and of the fibrous tissues which surround them.

ARTICLE SECOND.

OF THE FEMUR.

§ 752. The *femur* (*os femoris*) is not only the largest of all the cylindrical bones, but the greatest bone in the body. It is stronger than any other round bone, and so curved at its upper part, that it is convex forward and concave backward. Its upper extremity differs much from that of the body; for the almost spherical head which terminates it

(1) Walter mentions one case in his work, *Von der Spaltung der Schambeine*, Berlin, 1782.

(2) E. Sandifort, *De ancylosi ossium pubis*, in the *Obs. anat. pathol.*, book i. chap. vi. p. 115-125, tab. viii.

joins to this last at nearly a right angle, by a short but very manifest neck. Near the centre of the cartilaginous surface of this head, but rather downward than upward, is a considerable depression, which marks the insertion of the round ligament- The neck is slightly compressed from before backward. At the place of its union with the body we remark two large processes, called *trochanters* (*trochanteres*). The *large*, *upper*, or *outer trochanter* arises from the upper and outer extremity of the body, curves very much backward and downward, and presents on its internal face a considerable depression, called the *fossa of the large trochanter*. The *inner*, *smaller*, or *inferior trochanter* is situated lower than the preceding, and arises as a small truncated pyramid from the upper extremity of the internal face of the body, and inclines inward. Ridges extend from the large to the small trochanter on the anterior and posterior faces of the bone, and give attachments to certain muscles. These are called the *anterior* and *posterior intertrochanterian lines* (*linea intertrochanterica anterior et posterior*); the latter is by far the most distinct.

The anterior and external faces are so insensibly continuous with each other on the body, that we cannot trace the limit between them; and the bone is here round. The anterior and the internal faces are very distinct, and the external and the internal are still more so, as a very projecting ridge, called the *rough line of the thigh bone* (*linea aspera ossis femoris*), exists between them. This ridge arises by two roots from the large and small trochanters, is more or less evidently divided into two *lips* (*labia*) in almost the whole length of the femur, and terminates by two branches at the lower sixth of the bone. The base of the body is also divided into four faces; an anterior, a posterior, and two lateral faces which are the narrowest.

The inferior extremity of the body extends into an inferior process. This, the broadest and straightest part of the bone, has, generally considered, the form of a heart. We notice its two *condyles* (*condyli ossis femoris*), an *external* and an *internal*, the inferior, anterior, and posterior faces of which are insensibly continuous with each other, and thus form a broad surface, which is convex from before backward and from within outward, and is covered with cartilage. These two eminences are separated in every part by a fissure, which is very deep, especially in its posterior portion, where it is not covered with cartilage. This posterior part is the *posterior intercondyloid fossa* (*fovea intercondyloidea posterior*). The anterior is much flatter, is covered with cartilage, forms a part of the articular surface, and is called the *anterior intercondyloid fossa* (*fovea intercondyloidea anterior*). The two lateral faces of the condyles, which are destitute of cartilage, present elevations which serve for the attachment of the articular ligaments.

The *foramina of nutrition* (*foramina nutritia*), are found upon and at the side of the linea aspera, but at different heights. We usually observe two, one of which is larger than the other and is always situated higher. Sometimes also there is only one, which is then found near the centre of the femur.

§ 753. The femur appears first toward the end of the second month of pregnancy, at which time its length but slightly exceeds its breadth and thickness. From the third month, however, it not only becomes longer, but its two extremities are evidently broader than its central portion: it however remains straight till birth, and its curve is not apparent till toward the end of the first year, and afterwards gradually increases. In general it is larger in the male than in the female. Ossification does not commence in the lower extremity till the last month of pregnancy; a single rounded osseous nucleus then occupies the central portion, from whence it gradually extends to the two condyles. Some time after birth ossification begins also in the upper extremity, namely, in the head; but it is not till the third or fourth year that ossification begins first in the large and then in the small trochanter. The neck, which is simply the body prolonged, is indicated but very imperfectly in the full grown fetus, and only on the inside by the greater breadth of the upper part of the bone, as also by the projection of its upper extremity. These five osseous germs, that of the head, of the body, of the two trochanters, and of the condyles, remain separated a long time after puberty, and are not all fused, even when the subject is perfectly developed. The small trochanter first fuses with the body, next the head, then the large trochanter; the inferior extremity is fused the last.(1) This marked difference then exists between the ossification of the humerus and femur, that in the latter the lower, and in the former the upper extremity is the last to unite with the body.

§ 754. The femur articulates by its upper extremity with the iliac bone, and by the lower with the head of the tibia.

§ 755. The greatest anomaly presented by it is a great increase of its curve forward: this is seen principally in subjects affected with rachitis. More rarely the groove in the head for the insertion of the round ligament is deficient (§ 752). When the lower extremities are very imperfectly developed, this bone is sometimes wholly or at least in great part deficient.

ARTICLE THIRD.

OF THE BONES OF THE LEG.

§ 756. The leg, like the fore-arm, is composed of two bones, which differ in their relations with each other and with the adjacent bones, from those of the bones of the second section of the pectoral members. The larger is the *tibia*, the smaller the *fibula*.

I. OF THE TIBIA.

§ 757. The *tibia* (*focile majus*) forms the foundation of the leg, being five times as massive as the fibula. This bone is next in size to the

(1) Albinus mistakes in saying that the two trochanters fuse at the same time, and does not point out the order in which the different nuclei of bone are developed.

femur, and is longer even than the humerus. It is situated on the inside of the leg.

The direction of its body is almost straight; it is however slightly convex forward and a little concave backward. Its three faces are perfectly distinguished from each other by projecting edges. The anterior edge, which separates the internal from the external face and is directly under the skin, is sharp, and has hence been called the *crest of the tibia* (*crista tibiæ*); the external is acute; the smoothest and most rounded of the three is the internal. The external face is concave in its upper two thirds, and is called the *peronæal cavity* (*cavitas peronæa*) from the direction of its hollow. The internal and posterior face is slightly convex. Above its central part the body is a little compressed from within outward, but gradually enlarges in its lower fourth and becomes more rounded, because its edges disappear in this portion of it.

There is generally but one foramen of nutrition, situated at the inferior extremity of the first fourth of the posterior face, near the outer edge.

The upper extremity, the thickest and broadest part of the bone, terminates in the *condyles of the tibia* (*condyli tibiæ*), which correspond to those of the femur. Both present on their upper faces, which are faced with cartilage, a *superficial glenoid cavity* (*cavitates glenoideæ, externa et interna*). Their internal edge alone projects slightly, especially in the centre. Their internal articular face is a little longer from before backward, but narrower in the same proportion from within outward, than the external face. They unite inwardly and produce an unequal *elevation* (*acclivitas intercondyloidea*), the direction of which is from before backward, but which is not as extensive as they are. This elevation corresponds to the posterior intercondyloid fossa of the femur. Before and behind it we observe an anterior and a posterior depression (*fovea acclivitatis anterior et posterior*), which has no cartilage. At the posterior extremity of the lateral face of the external condyle of the tibia is a small, round, smooth articular surface (*facies articularis lateralis*, s. *peronea*), faced with cartilage, the direction of which is obliquely downward and backward, to which is fitted the corresponding facet of the upper extremity of the fibula. The anterior face of this upper extremity presents in its centre, at the place where it unites with the body, a considerable projection, call the *spine* or *tuberosity of the tibia* (*tuberositas tibiæ*), which is insensibly continuous with the crest.

The lower extremity forms in its lower convex portion a considerable triangular tuberosity, the angles of which are however rounded; this is called the *internal malleolus* (*malleolus internus*); on its posterior face is a groove, more or less deep, and the direction of which is from above downward and from without inward; it is the *internal malleolar groove* (*sulcus malleoli interni*). The external face of this extremity, on the contrary, is concave and receives the fibula. The lower face, which forms a right angle with the external face of the internal malleolus, is faced with cartilage, slightly concave from before backward to lodge the head of the astragalus, and is sometimes divided into two lateral portions by a slight eminence.

§ 758. The tibia developes itself by three points of ossification. The body appears toward the end of the second month of pregnancy. The osseous germ of the upper extremity does not appear till towards the last month, and then is seen in its centre. The inferior is wholly cartilaginous in the full-grown fetus, but begins to ossify immediately after birth. The fusion of these pieces of bone with the body is not completed till the subject is perfectly developed. The lower extremity fuses with the body before the upper extremity.(1)

§ 759. The tibia articulates by the upper faces of its condyles with those of the femur; by its lateral articular facet with the head of the fibula; and by its lower extremity with the astragalus.

§ 760. The anomalies of this bone are its entire or partial deficiency, which accompanies the imperfect development of the lower extremities, their curving inward (*valgi*) or outward (*vari*), or rarely forward in those affected with rachitis.

II. OF THE FIBULA.

§ 761. The *fibula* (*perone, focile minus cruris*) is the second, and the weaker of the bones of the leg, being situated on its outside. It is nearly as long as the tibia, but does not extend so high above, while it extends a little below the tibia. The body has an irregular form, and it is twisted on itself. We however distinguish in it three faces, which are very sensibly separated by as many edges. The anterior is not simply concave, but divided, in most of its extent, by a longitudinal crest into two parallel furrows. The external is concave in its upper part, and slightly concave downward. The internal is flatter, but in its upper part are prominent asperities for the attachments of some muscles. The anterior edge is the most acute, especially near the the central part of the bone, and hence it may be called the *crest of the fibula* (*crista fibulæ*). The body of the fibula is much thicker in its centre and towards its upper extremity than in the rest of its extent.

The foramen of nutrition, which is always single, is situated a little above the centre of the bone on its internal edge.

The upper extremity, the *head* of the fibula (*capitulum*), represents an irregular square, the upper face of which is directed obliquely from above downward, and from behind forward, and has on its posterior part an articular surface, which is cartilaginous and a little concave, which corresponds to the lateral articular facet of the tibia (§ 757). This surface presents asperities, more or less distinct, to which muscles are attached.

The lower extremity is triangular, and slightly compressed from right to left: it descends backward a little lower than forward, and forms the *external malleolus* (*malleolus externus*). The upper and

(1) Albinus has neglected to mention the order in which the nuclei of bone in the tibia are developed and fused.

interior portion of its internal face unites to the lower face of the inferior extremity of the tibia, at a right angle, to form the articular surface designed to receive the astragalus, and is covered with cartilage. The posterior and inferior half is rough, and very concave: it is called the *fossa of the external malleolus* (*fovea malleoli externi*). Above and behind this fossa, and also before and above the articular surface, are two tubercles, a posterior and an anterior (*tubercula malleolæ externæ posterius et anterius*), to which ligaments are attached. The posterior face of the external malleolus presents a groove (*sulcus malleoli externi*), which is perceptible with difficulty.

§ 762. The body of the fibula appears a little later than that of the tibia. In the fetus of ten weeks old, it is only about half as long as this last; and it is not till the end of the third month that both bones have the same length. On the contrary, even in the full-grown fetus and in the child, the tibia is thinner in proportion to the fibula than at a later period. The two single osseous nuclei of the extremities do not begin to appear till after birth, and fuse only when the subject is fully grown. The inferior unites to the body before the superior, and always sooner on its external than on its internal edge.

§ 763. The fibula articulates upward with the tibia (§ 759), and downward with the astragalus (§ 772).

§ 764. This bone is sometimes deficient when the lower extremities are not perfectly developed, although the tibia may exist; a curious analogy with some animals, resembling the fusion of the two bones into one as it is seen in several. Its lower part is then generally deficient; sometimes however, although the tibia and the foot exist, (the latter being very imperfect) the upper part of the fibula is deficient, and only a small portion of its lower part exists, which terminates upward in a point.

III. OF THE PATELLA.

§ 765. The *patella* or *rotula* is a shorter bone situated on the anterior face of the knee joint, between the femur and the tibia. It has an irregularly quadrilateral form. The angle produced by the union of its lower edges is the most acute, and that by the upper, the most obtuse. The anterior face is convex, and presents numerous foramina of nutrition; the posterior is covered with cartilage in all its upper portion, and is divided by a large projection into two slightly concave surfaces. This part is covered with cartilage, and is fitted to the anterior part of the articular surface of the lower extremity of the femur. The lateral fossæ receive the anterior parts of the condyles, and the central eminence is fitted into the anterior fossa.

The patella is situated in the substance of the tendon of the extensor muscles of the leg, which covers all its anterior face, but extends only upon those parts of its posterior face which have no cartilage. This tendon attaches it to the tuberosity of the tibia. It corresponds perfectly, both in its situation and in its connection with this tendon, to the olecranon process of the ulna; and hence the tibia has no process which may be compared with the olecranon. The patella increases the analogy between the bones of the leg and those of the fore-arm.

§ 766. Ossification of the patella does not commence till after birth. Portal is mistaken in saying that its posterior face is almost perfect in the full-grown fetus, and that it is developed by two points of ossification.(1) A nucleus of bone forms in the centre of the cartilage and gradually and slowly enlarges. We very rarely find several points of ossification; Rudolphi however mentions an instance.(2)

ARTICLE FOURTH.

OF THE BONES OF THE FOOT.

§ 767. The *foot* comprises three divisions, the *tarsus*, the *metatarsus*, and the *toes* (*digiti pedis*).

I. OF THE TARSUS.

§ 768. The *tarsus* is formed like the carpus of short and rounded bones very similar to the carpal bones, but differing from them in several respects, viz. in number: the bones of the tarsus are only seven; they are much larger and stronger, their mode of articulation with the bones of the leg differ, and they are arranged, not like the bones of the hand, in two rows, most commonly, but in three. On the other hand, the manner in which they articulate with each other, or with the metatarsal bones, is almost the same as that of the carpal bones, and it is much more exact to describe them as forming two rows.

I. OF THE POSTERIOR RANGE OF THE TARSAL BONES.

§ 769. The posterior range of the tarsal bones comprises the two largest, the *astragalus*, and the *os calcis*.

A. OF THE ASTRAGALUS.

§ 770. The *astragalus* (*talus*, *astragalus*, *os tesseræ*) has a quadrangular but very irregular form. We distinguish in it a *body*, a *head*, and a *neck*.

The body is quadrangular, and is the posterior and largest part of the bone. Its upper face is covered with cartilage, is convex from before backward, and slightly concave from within outward. The direction of the upper part of the external lateral face is obliquely from above downward and from within outward, and, like the smaller and

(1) *Anat. Méd.*, vol. i. p. 472.
(2) *Anat. physiol. Abh.*, p. 133.

upper part of the internal face, it is covered with cartilage. The inferior parts of these two faces which have no cartilage present numerous asperities for the attachment of ligaments. The small posterior face is also uneven, and extends outward into a small tubercle. The inferior is covered with cartilage, is directed a little obliquely from without inward and from before backward, and is very concave. The anterior is not free except in its inferior half, and to a small extent of the outside of the superior; it is continuous for the most part with the neck, which is short and very narrow upward, downward, and outward. The head is a little higher than the neck and extends much lower, but does not like the neck proceed outward as far as the body. Its upper face is rough. The anterior is convex from without inward and from above downward, is much more broad than high, and is covered with cartilage. The latter is usually divided into two portions by a slight eminence, the direction of which is oblique from before backward, and from without inward. Sometimes, but rarely, a portion which has no cartilage divides into two entirely distinct surfaces; these differences however do not depend on sex, nor is the arrangement on both sides of the same subject exactly the same.

§ 771. The rudiments of the astragalus appear first in the seventh month of pregnancy. In the full-grown fetus, it is a round nucleus of bone, the body and the head being then almost equal in size.

§ 772. The astragalus articulates, by the upper and lateral faces of the body, with the tibia (§ 759) and the fibula (§ 763), forming a ginglymus joint, which, besides the flexion and extension of the foot, admits only of a slight motion inward and outward. It articulates by the lower face of its body and its neck with the os calcis (§ 775), and by the anterior face of its neck with the scaphoid bone (§ 779).

B. OF THE OS CALCIS.

§ 773. The *os calcis* (*calcaneum*) is the largest of the tarsal and even of the short bones, and is more than double the size of the astragalus. It is situated below the astragalus and proceeds equally as far forward, but extends much farther backward. Its general form is irregularly quadrilateral. Its greatest diameter is from before backward, and the smallest from within outward.

We may distinguish in it a *body* and an *internal process*.

The *body* is compressed laterally. It bulges backward and forms a large *tuberosity* (*tuber calcanea*) to which the Achilles tendon is attached, and which terminates downward and forward in two eminences, the internal being larger than the external. The external face is rough; it usually presents forward two small tubercles which however are not constant, and seldom exist in both bones of the same subject. These tubercles, one of which is situated directly behind the other, form a species of groove. The outer face is generally smooth, the inner is a little concave from above downward and from before backward. The upper face forms two arches, the posterior of which is smaller and flatter, and extends from the upper extremity of the tubercle to the posterior extremity of the anterior arch. This latter is larger, and is composed at its anterior face of a cartilaginous convex articular surface, having a direction perpendicularly from behind forward, and of another portion situated forward, rough, very concave, and destitute of cartilage. In this place, the bone is much lower than in its posterior portion. Its anterior triangular face is slightly concave and covered with cartilage.

From the upper and internal edge of the anterior portion of the os calcis proceeds an oblong process, not broad, but very strong, which goes inward, and is called the *lateral process* (*processus lateralis, sustentaculum tali*), on which the head of the astragalus rests. This process is separated, backward and upward, from the body, by a deep groove (*sulcus sustentaculi tali inferior*). The upper face descends obliquely from before backward; it is covered with cartilage and is concave. Its anterior part is usually narrower than the posterior, and most generally there is at the commencement of the anterior third a greater or less contraction, which is sometimes converted into a deep furrow, destitute of cartilage, which seems to divide its single face into two parts. This face corresponds to the inferior face of the body of the astragalus. Its division into two is much more common than the same arrangement in the astragalus, and the lower face of the head of this bone is not usually divided, even in those subjects where the separation of the upper face of the lateral process of the os calcis is complete.

The assertion that this articular surface is entire only in the female is incorrect;(1) on the contrary, its division into an anterior and a posterior part is much more frequent in the female than in the male, where it is rare and less perfect. Farther, in both sexes we not unfrequently find the two arrangements in the two sides of the same subject, so that there are no peculiarities of sex.

§ 774. The os calcis is developed the first of all the tarsal bones. It begins to appear in the sixth month of pregnancy as a single nucleus in the centre of the cartilage. In the full grown fetus, this nucleus is nearly twice as large as that of the astragalus and goes farther forward but very little farther back than the latter, while in the adult the posterior forms almost half of the length of the bone. This difference arises from the fact that three-fourths of the os calcis at least, particularly all its posterior part, is still cartilaginous, and its osseous nucleus is situated directly below that of the astragalus. Afterward, that is from the eighth to the tenth year, there is developed in the tuberosity a single, flat, and rounded osseous germ which is much thicker downward than upward, and which increases from below upward. The lower part of this nucleus fuses with the body much sooner than the upper part. Sometimes also a third point of ossification forms in the upper part of the tuberosity. The perfect union of

(1) Sœmmering, *Knochenlehre*, p. 410.

this nucleus with the body takes place only when the subject is fully grown. The form of the os calcis, its slow development, and its connexions with the Achilles tendon, are circumstances worthy of remark, as establishing an analogy between it and the patella, and the olecranon process of the ulna.

§ 775. The os calcis unites to the bones of the leg but does not articulate with them, although attached by strong fibrous ligaments. It articulates by the upper articular surface of its body, with the body of the astragalus; by the upper articular surface of its process, with the head of the same bone (§ 772); and by the anterior face of its body, with the cuboid bone (§ 782).

II. OF THE ANTERIOR RANGE OF THE TARSAL BONES.

§ 776. The anterior range of the tarsal bones is formed of five bones, which are smaller than those of the posterior range, and of which four articulate with the latter by their posterior extremities, while the fifth is situated between the three internal bones of this range and the posterior range. Two of these bones, the scaphoid bone and the cuboid bone are usually considered as the second range of tarsal bones, because their posterior faces articulate with the astragalus and the calcaneum; but as the cuboid bone also extends as far forward as the other three which are usually considered as the third range, and as it articulates like the latter with the metatarsal bones, it is more proper to regard these five last as forming only one range.

A. OF THE SCAPHOID BONE.

§ 777. The *scaphoid bone* (*os naviculare*) is situated before the astragalus, behind the three cuneiform bones, and on the inside of the cuboid bone. It makes part of the posterior and internal portion of the anterior range of the tarsal bones. Its breadth exceeds its height very much, and its thickness still more. Its posterior cartilaginous face is concave and smooth; its anterior is larger and also covered with cartilage, convex, and divided by three eminences which extend from above downward, into four compartments, which diminish in extent from within outward. The upper and convex face is very rough. So too with the inferior which is straighter. At the place where these two faces meet, on the internal edge of the foot, the bone forms a projecting angle, called the *tuberosity* of the *scaphoid bone* (*tuberositas ossis navicularis*).

§ 778. Ossification of the scaphoid bone does not commence till after birth, and usually towards the end of the first year.

§ 779. This bone articulates by its posterior face with the anterior face of the head of the astragalus (§ 772), and by the four compartments of its anterior face with the three cuneiform bones (§ 784, 793), and also with the cuboid bone (§ 782).

B. OF THE CUBOID BONE.

§ 780. The *cuboid bone* (*os cuboideum*) derives its name from its form which is irregularly quadrilateral. It is longer from before backward than from one side to the other, and from above downward. Its posterior triangular face is covered with cartilage, and is slightly concave; the internal is rough in most of its extent; it is covered with cartilage at its central and upper portion: this cartilaginous surface is divided into two halves by a process which goes from above downward, of which the external half is the larger. The anterior face, situated on a short, slightly contracted eminence, is square, covered with cartilage, and also divided by a projection which goes from above downward into two halves, of which the external is the larger. The upper face is almost plane and slightly uneven. The external is the smallest, and in the place where it is continuous with the inferior, it forms a tuberosity which also extends across the whole breadth of the inferior face and which produces the *oblique eminence of the cuboid bone* (*eminentia obliqua ossis cuboidei*). Between this tuberosity and the anterior edge of the face, a deep furrow (*sulcus ossis cuboidei*) extends in an oblique direction. The portion of the external face situated behind the tuberosity is also concave and rough, but less so than the other.

§ 781. Ossification of the cuboid bone commences before birth, but not till towards the end of the eighth month of pregnancy, although it is far advanced in the full grown fetus.(1)

§ 782. This bone articulates by its posterior cartilaginous face, with the anterior face of the body of the calcaneum (§ 776); by the posterior half of the portion of its internal face which is covered with cartilage, with the most external and smallest compartment of the anterior face of the scaphoid bone (§ 779); by the anterior part of this same portion, with a part of the external face of the third cuneiform bone (§ 792); finally by its anterior face with the posterior extremities of the two external metatarsal bones.

C. OF THE CUNEIFORM BONES.

§ 783. The *three cuneiform bones* (*ossa cuneiformia*), which have received this name from their common resemblance to a wedge, are situated between the scaphoid, the cuboid, and the three inner metatarsal bones. They are all triangular, contracted from within outward, and much broader at one extremity than at the other, where they terminate by a more or less sharp edge. They are not equal in size.

(1) Albinus says *Maturo* (*fœtu*) *etiam nonnisi calceus et talus pertem ossĉam habent*, and every anatomist has followed him. But this is a mistake as may easily be seen by examining the skeleton of a full grown fetus.

a. Of the first cuneiform bone.

§ 784. The *first cuneiform* called also the *large* or *internal cuneiform bone* assists to form the internal edge of the sole of the foot. It is situated between the inner part of the scaphoid bone and the metatarsal bone of the large toe. It is very much larger than the other two and, from its position, the sharp edge is directed upward. Its free inner larger convex face is very rough. The external is a little concave, is still more rough. We remark along its upper and most of its posterior edge a straight band, which is covered with cartilage and divided forward by a small eminence in two parts; the anterior is smaller, and is directed a little obliquely from behind forward and from within outward. The inferior face is slightly convex and very rough. The anterior, almost plane, is in the form of an ear, that is, it is surrounded inward by a convex edge, and outward by a concave edge slightly grooved at its central part. The posterior is triangular, concave, and entirely covered with cartilage.

§ 785. In the full grown fetus there is no nucleus of bone for the large cuneiform bone.

§ 786. It is articulated by its posterior face, with the most internal compartment of the anterior face of the scaphoid bone (§779); by the greater posterior part of the cartilaginous portion of the external face, with the second cuneiform bone (§ 789); by the small anterior part of this same portion, with the second metatarsal bone (§ 799); finally, by its anterior face, with the posterior face of the first metatarsal bone (§ 797).

b. Of the second cuneiform bone.

§ 787. The *second cuneiform bone* called also the *smallest cuneiform bone* is about one third the size of the preceding. It is particularly much narrower from above downward and from before backward, so that its extent downward or forward is not so great, although upward and backward it proceeds as far as that. It is situated so that its broad face forms a part of the back of the foot, while its lower, sharper, and wedge-shaped edge looks toward the sole. The upper face is square, convex, and slightly rough; the posterior and anterior are triangular, strait, and covered with cartilage. Most of the internal edge is also covered with cartilage; it is destitute of it in but two small slightly concave spaces, the posterior of which extends nearly in a straight line from the centre of the lower edge to the upper, without however reaching it, while the anterior occupies the lower part of the anterior edge. The external face is covered with cartilage in its upper and posterior part, and is uneven and rough in its anterior.

§ 788. Ossification does not begin in this bone till after birth, and a little later even than in the large cuneiform bone.

§ 789. The second cuneiform bone articulates by its posterior face, with the second compartment of the anterior face of the scaphoid bone (§ 779); by the interior, with the first cuneiform bone (§ 786); by the external, with the third cuneiform bone (§ 792); and by the anterior, with the second metatarsal bone (§ 799).

c. Of the third cuneiform bone.

§ 790. The *third cuneiform bone* is about half the size of the first. The form and direction of its faces resemble those of the second very much, but it is a little more contracted from within outward than the last. It is as long from before backward as the first, so that it proceeds equally as far forward; but as it is lower and does not equal it in height, it does not extend equally as far downward.

The larger and upper portion of its triangular and plane posterior face is faced with cartilage; so, too, of the upper and posterior half of the external face, while its inferior and anterior part, which is more extensive than the other, is uneven and rough. Almost all the internal face is very rough and destitute of cartilage. We only perceive a layer of cartilage some lines broad, along the upper part of its posterior edge, and two others which are smaller and rounded, situated one above the other, and occupying nearly the same extent along the anterior edge. The anterior face is slightly concave and triangular, and is every where covered with cartilage.

§ 791. The third cuneiform bone, although much smaller than the first and the scaphoid bone, ossifies before them, and it appears not in the full-grown fetus, but at the end of the first month, as an osseous germ which is very considerable.

§ 792. It articulates by its posterior face, with the third compartment of the anterior face of the scaphoid bone (§ 779); by its anterior face, with the third metatarsal bone (§ 801); by the posterior and cartilaginous part of the internal, with the second cuneiform bone (§ 789); by the two anterior cartilages of the same face, with the second metatarsal bone (§ 801); finally, by the cartilaginous portion of its external face, with the cuboid bone (§ 782.)

II. OF THE METATARSAL BONES.

§ 793. The *metatarsus* is composed, like the metacarpus, of five cylindrical bones, which are formed generally after the same type, and are nearly equal in length; but which, independently of several less important differences, vary much in thickness. Like all cylindrical bones, the body is thinner than the extremities, and presents three faces which are separated by as many edges: the inferior is usually the sharpest. Among these faces, one looks more or less upward, and is called the *superior* or *dorsal* (*faces dorsalis*): the other two are lateral, an *external* and an *internal*. The bone considered as a whole, is slghtly arched; hence it appears slightly convex above and more strongly concave below.

The posterior extremities or the *bases* (*basis*), are generally triangular. They terminate backward by more or less plane and cartilaginous surfaces, by which they articulate with the anterior range of the tarsal bones. They are also furnished on one or on both sides with one or more facets, by which they are fitted to each other and to the bones of the anterior range of the tarsus. Besides, part of the lateral faces of these posterior extremities is rough for the insertion of fibrous ligaments.

The anterior extremities or the *heads* (*capitula*), are generally thinner than the posterior, rounded and terminated forward by an articular convex surface, behind which is a *depression* (*sinus*) which surrounds all the head. Beyond this depression we observe four tubercles, one at the upper and the lower part of each side.

As the anterior and posterior extremities of the metatarsal bones extend beyond the body in every direction, we observe between every two of the metatarsal bones an interval called an *interosseous space* (*interstitium interosseum*).

§ 794. The metatarsal bones gradually form by the union of two pieces of bone. The largest, which represents the body, appears first in the third month of pregnancy, and is perfectly developed in the full-grown fetus. The processes do not begin to ossify until the second year. These two pieces of bone do not fuse entirely till about the period when the subject is perfectly developed; but they do not all unite at the same time in all the metatarsal bones. It is remarkable, that here, as in the metacarpus, the first bone differs from the four others, by the development of its second germ in the base, instead of forming in the head as it does in the latter, which renders this and the metacarpal bone of the thumb similar to the first phalanx of the hand and foot.

§ 795. The metatarsal bones articulate by their posterior faces, with the anterior range of the tarsal bones; most of them by their posterior faces, with each other; and by their anterior extremities, with the first phalanges of the toes.

I. OF THE FIRST METATARSAL BONE.

§ 796. The *first metatarsal bone*, or the *metatarsal bone of the great toe*, is much larger, but shorter than the other. Of the three faces of its body, the upper is inclined a little inward, the internal is concave and inclined downward; and the external is almost plane, and its direction is perpendicularly from above downward. The internal and external edges unite with each other at an obtuse angle, and with the superior edge at a right angle. The base is very elevated, in proportion to its breadth, and backward presents an earshaped surface, the convex edge of which looks inward, and the concave edge outward. We often, but not always find, at the upper part of the external lateral face of its posterior extremity an oblong, plane or slightly concave cartilaginous articular facet, which corresponds to an analagous facet of the second metatarsal bone.

The head is broader than those of the other metatarsal bones, and the articular facet is divided by a strong longitudinal crest into two depressions, which extend from the centre to the posterior edge, and of which the external is deeper than the internal.

§ 797. The first metatarsal bone articulates by its posterior extremity, with the anterior face of the large cuneiform bone (§ 786); sometimes by the external lateral face of its base with the second metatarsal bone (§ 799); by the upper part of its anterior extremity, with the posterior extremity of the first phalanx of the great toe; by the inferior, with the two sesamoid bones, which are found in the flexor muscle of the great toe.

II. OF THE SECOND METATARSAL BONE.

§ 798. The *second metatarsal bone* is the largest of all, and extends further backward than the others, except the fifth. Its base has the form of an equilateral triangle, the summit looking upward: it is very concave, especially at its upper part, and its external edge is very much notched. The internal lateral face presents a plain cartilaginous facet, which varies in situation, sometimes existing directly before the internal edge and at the highest part of the posterior face, and sometimes much more forward and downward, and separated from this edge by a groove for the attachment of a ligament. The external facet presents two articular facets, situated one above the other, and separated by a depression which varies in size, extent, and form: the upper differs considerably, being sometimes very long from before backward, and divided into two parts by a longitudinal eminence; sometimes it is shorter and single, or at least is divided imperfectly.

The upper face of the body is turned entirely inward, whence the internal edge is in fact the upper. The depression situated between the anterior articular facet and the tuberosities, is broader than in the following bones of the metatarsus.

§ 799. The second metatarsal bone articulates, by its posterior face, with the second cuneiform bone; by the internal lateral face of its posterior extremity, in the formation first described (§ 798) with the large cuneiform bone; and in the second mode (§ 798), with the first metatarsal bone (§ 797): by the anterior segment of the upper portion of the external face of its base, with the third metatarsal bone (§801): by its posterior segment, with the third cuneiform bone (§ 792), a connection which is sometimes perceptible with difficulty, and is often deficient; finally, by its lower face, with the third metatarsal bone (§ 801) and the third cuneiform bone (§ 792), and sometimes with only one of them.

III. OF THE THIRD METATARSAL BONE.

§ 800. The *third metatarsal bone* is frequently the shortest of all. It is compressed laterally in all its length. Its posterior extremity advances a little farther than that of the second. Its posterior articular face is also triangular, but a little narrower and even. Directly before the posterior edge of the internal lateral face we observe, sometimes, one facet, and sometimes two, situated one above the other, and separated by a depression which presents no cartilage. This facet has a a rounded triangular form. The external lateral face presents one which is always single, but more extensive, situated exactly opposite the internal. The body and the head are formed as in the preceding bone.

§ 801. This bone articulates by the posterior part of its base, with the third cuneiform bone (§ 793); by the internal face, with the second metatarsal bone (§ 799); by the external, with the fourth (§ 803); and by the anterior face of its head, with the first phalangeal bone of the third toe.

IV. OF THE FOURTH METATARSAL BONE.

§ 802. The *fourth metatarsal bone* is usually a little longer and always extends back farther than the third. It is less compressed from one side to the other than the second and the third; hence its body is more rounded and its upper face is turned directly upward, while the other two are turned to the sides. The posterior face of the base is lower than in the second and third metatarsal bones, is oblong, and a little more concave. On the internal lateral face is a surface which is sometimes single and sometimes divided into two unequal parts by a perpendicular eminence, and which is separated from the posterior face by the attachment of a ligament. This surface is oblong and very extensive, slightly convex, and covered with cartilage; it occupies the upper half of this face. The external lateral face presents a similar triangular, flat, articular surface, which extends to the posterior face, both before and below which is the attachment of the ligament.

§ 803. This bone articulates by its posterior face, with the internal segment of the anterior face of the cuboid bone (§ 782); by the internal, sometimes with the third metatarsal bone alone (§ 801), sometimes as in the second (§ 802), by the posterior segment of the cartilaginous face with the third cuneiform bone, which then presents a small cartilaginous facet at the anterior and upper part of its external face; finally by the external lateral part of its base, with the fifth metatarsal bone.

V. OF THE FIFTH METATARSAL BONE.

§ 804. The fifth metatarsal bone has the same length as the fourth. It differs in form from all the others. The body is not compressed from one side to the other or rounded, but flattened from above downward, especially in its external portion, formed by the upper and external faces, the last of which has become entirely inferior, and which are separated from each other by a sharp edge. The body also is thicker than the bodies of the second, third and fourth metatarsal bones. The base is triangular and compressed, not from right to left but from above downward, which makes it more broad than high. Its posterior face is very oblique from behind forward and from without inward. Its base is not, as in the other metatarsal bones, entirely covered with cartilage; this is seen only on its internal portion, which is flat, triangular, and almost rounded, while the external is smaller and separated from the preceding by a perpendicular fissure, and has a considerable *eminence* (*tuberositas*), which is rounded and turned outward, and which renders the bone very broad in this part. The internal face of the base has on its upper part a broad, flat facet which is covered with cartilage. The head is more broad than high; it is also often narrower and lower than the body. From the great convexity of the internal face of the fifth metatarsal bone and the slight concavity of the external face of the fourth, the fourth interosseous space is very narrow.

§ 805. This bone articulates by its posterior face, with the external segment of the anterior face of the cuboid bone; by the internal face of its base, with the fourth metatarsal bone; and by its head, with the first phalangeal bone of the fifth toe.

III. OF THE BONES OF THE TOES.

§ 806. We count fourteen bones in the toes, each one having three phalanges excepting the large toe (*hallux*), which has only two. These bones of the phalanges belong to the class of long bones, and resemble perfectly in their most essential characters those of the fingers (§ 725, 726.)

I. OF THE FIRST PHALANX.

§ 807. The first or the posterior phalanx is the longest. The two extremities of these bones are much thicker than the body, especially the posterior, which is much higher and broader than the anterior. The body on its inferior face is concave from before backward and straight from one side to the other. The upper is straight in the first direction and very convex in the second. These two faces are separated from one another by an external and an internal lateral edge.

The *posterior extremity*, the *base* (*basis*), presents posteriorly a very concave articular surface, which is rounded and broader in the phalanges of the first and fifth toes than in the others. We observe on each side, where the upper face is continuous with the lower, a very projecting *tubercle* (*tuberculum*)

The anterior extremity, or the *head* (*capitulum*), is broad, and forms before an articular surface, which is slightly concave from above downward and presents on each side a rounded *depression* (*sinus*), behind which we see a tubercle.

Among the phalanges of the first range that of the large toe is the largest. It differs also from the others in being flat and contracted from above downward.

§ 808. These bones are developed much later than those of the metatarsus, and generally do not begin to appear till toward the end of the fourth month of pregnancy, except in the first phalanx of the large toe, which appears sooner than the others.

§ 809. They articulate posteriorly with the anterior extremities of the metatarsal bones, and anteriorly with the posterior extremities of the bones in the second phalanx.

II. OF THE SECOND PHALANX.

§ 810. The *bones of the second phalanx* (*phalangini*) are generally constructed after the same type as those of the first; but they differ from them: 1st. In their length, which is less, although they are nearly as broad; hence they are nearly as broad as they are long. 2d. They are much flatter from above downward. 3d. There is less of difference in respect to the thickness of their bodies and extremities, which sometimes do not differ. 4th. The forms of their articular surfaces vary; in fact the posterior is broader and divided by a longitudinal projection into two slightly concave lateral portions, while the anterior, which is slightly concave, does not present the longitudinal groove at its central part.

§ 811. Ossification does not commence till after the fifth month of pregnancy.

§ 812. These bones articulate by their posterior extremities with the heads of those in the first phalanx, and by their anterior with the posterior extremities of the third range of bones.

III. OF THE THIRD PHALANX.

§ 813. The *bones of the third phalanx* (*phalanx tertia*, s. *unguinis*) are composed of a very small body, of an anterior and a posterior extremity, which are larger. The posterior extremity on its posterior face is covered with cartilage, rounded, oblong, much more broad than high, and simply concave, except in the first, where this surface is divided by a slight eminence into two lateral parts. The edge of the posterior face is surrounded by a depression, before which are numerous asperities which extend all round the bone. The anterior extremity or the *summit* is rounded and very rough.

§ 814. This phalanx ossifies before the second. The anterior phalanx of the first toe appears sooner than the posterior and even than all the other phalanges. The point of ossification is not developed first in its centre but at its summit.

§ 815. These bones articulate by their posterior extremities with the anterior extremities of those in the second range. They are often fused with the latter; this must doubtless be ascribed to pressure, since the fusion is usually observed in the external toes, on which compression acts with most force.

SECTION IV.

COMPARISON OF THE BONES IN THE DIFFERENT REGIONS OF THE BODY.

§ 816. Like all the organs, the bones of the right and left sides are the most similar: the analogy is even so great between them in this direction that it is almost equivalent to a perfect resemblance, since the differences are too slight to be noticed.

We consider next the longitudinal direction: here we observe, 1st, that the bones of the upper and lower halves of the trunk correspond.

The central region of the trunk, that which is formed by the dorsal vertebræ, the ribs, and the bones of the sternum, divides into an upper and a lower half; for the ribs diminish very much in length both above and below the prœcordial region, and the upper and lower pieces of the sternum may be compared to each other, since both terminate by jagged edges.

The lumbar and the cervical vertebræ are analogous in their want of ribs. The greater number of the cervical vertebræ is compensated for by the greater volume of the lumbar.

The head corresponds to the sacrum and the coccygæal bones.

But the analogy betwen the bones of the upper and lower extremities is striking. This analogy is seen:

1st. In the number of the divisions of the limbs. In fact each extremity is divided into four regions or sections.

2d. In the form and the number of the bones which serve as the bases of each of these regions.

The iliac bone of the lower extremity corresponds to the scapula and the clavicle of the upper. The two extremities differ, as the upper possesses two bones, while one only is found in the lower; but this difference is unimportant, and besides it does not exist in the early periods of life. The iliac bone is formed by the union of three principal pieces: the posterior, the largest and broadest, called the *ilium*, corresponds to the *scapula;* the anterior, narrower, called the *pubis*, represents by its body the coracoid process, and by its horizontal branch the external part, of the clavicle; the inferior, which is thicker, called the *ischium*, corresponds by its body and descending branch, to the acromion process of the scapula, and by its ascending branch to the anterior part of the clavicle. The crest of the ilium and the base of the scapula, the coracoid process and the pubis, the acromion process and the ischium, are developed by special nuclei of ossification.

We find only one bone in the arm and one in the thigh; they correspond perfectly in form and mode of development. Both have a rounded head, and the tubercles of the humerus represent the trochanters of the femur. At the lower extremity we see a surface in the form of a pulley, constituting a ginglymus joint.

The fore-arm and leg have each two bones which are very analogous. The upper extremity of the ulna terminates in a pulley like that of the tibia. These two limbs present a bone which articulates by ginglymus with that of the second division. True, the upper extremity of the ulna rises much higher than that of the tibia, but this is owing to a peculiar piece of bone which corresponds to the patella. This last ought to be considered as a process of the tibia, which never unites with the body of that bone; and the olecranon process of the ulna also sometimes remains, like it, distinct and separate from the ulna through life.(1)

The lower extremity of the ulna differs from that of the tibia by its smallness, but that of the radius is very similar to the inferior extremity of the fibula, which should be considered as a true compensation, since in the motion of pronation the upper extremity of the radius comes below the upper extremity of the ulna. In fact if we unite the lower portions of the ulna and radius, we obtain a bone very similar to what the tibia would be if the patella were joined with it. This analogy is rendered still more evident by another circumstance,—that the bones which succeed the tibia correspond to the anterior extremity of the radius; and it is favored also by comparative anatomy. In most quadrupeds, pronation is the proper state of the anterior extremity, so that the lower extremity of the radius is always situated on the inside. In others, the ulna does not extend to the carpus; and as for this reason its lower extremity does not articulate directly with any bone of the carpus in man, so the tibia unites to the fibula in most quadrupeds, and only the former bone descends to the tarsus. The upper and lower extremities of the tibia present on their fibular face a cartilaginous facet, like those on the radial face of the ulna, by which the two bones articulate with each other.

In this manner the analogy between the fore-arm and the leg becomes much more evident. The ulna and the tibia however on one side, and the radius and the fibula on the other, resemble each other in this point of view also, that the upper extremity of the first two possesses the greatest volume, while in the latter two the inferior is the largest.

Both bones run on their lower extremities and on the sides which are opposite to them rounded extremities, constituting the styloid processes and the malleoli. The radius is shorter than the ulna, and the fibula is shorter than the tibia, more especially if the patella be united with it.

The analogy between the bones of the hand and foot is very evident.

Those bones which correspond the least are the bones of the carpus and tarsus, which differ very much in size, those of the former being about a fifth as large as those of the latter, and being arranged also in a different order. We may however discover great analogies between them. The posterior carpal range corresponds to the os calcis, the astragalus, and the scaphoid bone. The anterior part of the scaphoid

(1) Delachenel, *Obs. anat. med.*, Bâle 1706, § 28.—Rosenmüller, *De oss. variet.*, Leipsic, 1804, p. 62.

bone of the hand resembles perfectly that of the foot. These bones are situated at the side of, and not over each other; and we find more in the hand than in the foot, as the former requires more motion and the latter more solidity. Hence why several bones of the posterior range articulate with the carpal extremity of the bones in the fore-arm and with the bones of the anterior range.

The number of the bones in the anterior range which articulate directly with the metacarpus and the metatarsus is the same. It is especially remarkable that both extremities of the last two bones of the middle section (the metacarpus and the metatarsus) are supported by but one bone, while each of the other three articulates with two bones.

The arrangement of the articular faces which unite the bones of the anterior range with each other, or with those of the metacarpus and metatarsus, are very similar. Thus the trapezium and the first cuneiform bone present forward a small facet, by which they articulate with the second metacarpal and second metatarsal bone. The second metacarpal bone on its ulnar side and the second metatarsal bone on its fibular side present an articular surface, divided into two portions, of which the anterior articulates with the succeeding metacarpal or metatarsal bone, and the posterior with the third cuneiform bone in the foot and the os magnum in the wrist. The third, fourth, and fifth metacarpal and metatarsal bones do not articulate, except with the corresponding bones of the carpus by their posterior face, and rarely articulate with each other.

The metatarsal and metacarpal bones resemble each other also in number, form, mode of development, and connections. In both, the first of these bones present analogous proportions, although not entirely similar in regard to the others, for they are thicker than these. The second is longer both in the hand and foot. The tubercle which increases the size of the fifth metatarsal bone exists at least in a rudimentary state in the fifth metacarpal bone. The first metacarpal and the first metatarsal bones differ from the others in their mode of development and in the same manner.

The phalanges of the fingers and toes are also formed on the same fundamental type, and however great may be the difference between them, they are modifications of the same formation.

The *differences* between the bones of the upper and lower extremities depend on the differences of their functions. They may be referred, 1st, to the greater solidity necessary for the pelvic limbs to sustain the trunk and the head, and the greater degree of mobility necessary to increase the relations of the organism with external objects; 2d, to the greater mass of the inferior extremities.

Hence why the iliac bones are united with each other and with the sacrum by a fibro-cartilaginous mass which admits of no motion, and why the anterior and posterior pieces of the iliac bone on each side fuse into one, while the scapula remains distinct from the clavicle. Hence also the reason that the scapula is attached to the vertebral column only by muscles, and that the clavicle is united in front with that of the opposite side, the sternum and the first rib, only by loose synovial and fibrous ligaments. Hence, finally, the reason that the internal edge of the bones of the pelvis is very broad and that of the scapula very thin.

The cotyloid cavity of the femur is very deep, the corresponding glenoid cavity of the scapula is on the contrary flat, so that the scapulo-humeral articulation is secured only by the adjacent processes and by the external ligaments.

Hence the head of the femur is much larger than that of the humerus. We cannot perceive at all on this last a depression to receive the round ligament which strengthens the ilio-femoral joint within the capsule.

The body of the humerus is twisted, that of the femur is almost straight and arched in only one direction.

The humerus is destitute of a neck, and its tuberosities are not distinctly marked. The trochanters in the femur are largely developed, and the neck, which is very long, separates from the body to extend the head into the cotyloid cavity.

The differences observed in the lower ends of the two bones, and in the arrangement of the knee and elbow joints, produce exactly the same effect.

In the upper extremities the articular surfaces are surmounted on each side by large condyles which do not exist in the lower extremities. In the latter the joint is a ginglymus, and deep depressions exist between the two condyles of the femur and asperities between those of the tibia. There we find, beside the ginglymus articulation which is more plane, a rounded head, for the rotatory articulation with the radius.

In the lower extremity one bone only, the tibia, is connected with the femur; the fibula articulates only with the tibia, of which it in some measure forms a part. In the upper extremity both bones of the fore-arm articulate with the humerus, and the radius moves very freely. The bones of the fore-arm, which are united above and below by loose attachments, and which are nearly of the same size, can be displaced in several different ways in relation to another, and these changes allow the hand to perform very important motions. The firm union of the bones of the leg, both at their upper and lower parts, and also the fact that the fibula from its small proportional development should be considered as a part of the tibia, causes the two bones to be almost motionless upon each other, and the motions of the foot to be simply flexion and extension.

The articulation of the foot is much more firm than that of the hand, both because the malleoli descend very low, and from the form of the articular surfaces of the bones of the leg and astragalus, whence these bones articulate with only one bone of the tarsus.

The bones of the tarsus are attached to one another by very solid bands; the pisiform bone, which is loosely articulated, is entirely deficient, or rather this bone is represented by the sesamoid bone in the tendon of the peroneus longus muscle.

Their mass exceeds that of the bones of the carpus ten times.

The bones which are situated at the side of each other in the carpus, are arranged before each other in the tarsus.

The metatarsal bones are larger, narrower, and more contracted, while those of the metacarpus are broader, concave, and better disposed to grasp and hold objects.

The metatarsal bone of the great toe is much stronger and thicker than the metacarpal bone of the thumb, and cannot separate itself from the others as this can.

The same differences exist between the phalanges of the fingers and toes as between the metatacarpal and the metatarsal bones ; only those of the toes, excepting the first, are much shorter and more imperfectly developed.

The phalanges of the toes are the only exceptions to the second of the general differences pointed out between the two limbs, since they are smaller than those of the corresponding fingers.

§ 817. The resemblances between the anterior portions of the body and the posterior are in this as in the other systems the slightest of all. We however have already shown that the sternum corresponds to the vertebral column, the frontal bone to the squamous portion of the occipital bone, the arches to the bodies of the vertebræ.

END OF VOL. I.

INDEX TO VOLUME I.

HENRY C. SLEIGHT

PROPOSES TO PUBLISH BY SUBSCRIPTION AN AMERICAN TRANSLATION

OF THE

MANUAL

OF

GENERAL, DESCRIPTIVE, AND PATHOLOGICAL

ANATOMY,

BY

J. F. MECKEL,

Professor of Anatomy in the University at Halle.

PROFESSOR BRESCHET's preface to the French translation states that "for a long time we have wanted a work which comprised all the facts of General, Descriptive, and Pathological Anatomy and Physiology. A work of this character required a knowledge as extensive as it was profound, and has been ably executed by PROF. MECKEL."

The translation will be from the French, including the valuable notes of BRESCHET and JOURDAN, revised from the original German, with notes, by A. SIDNEY DOANE, A. M. M. D.

Subjoined are the opinions of some of the most eminent physicians and surgeons of the United States, in regard to the merits of the original:

Dear Sir, *Boston, Sept.* 10, 1830.

I am happy to learn that you propose to translate into English the Anatomy of Prof. Meckel. This book has been in my hands for some years; and I have been so much gratified with its character as a scientific work, that I proposed to Prof. G. to translate it, and offered him such aid as I was able to afford him. As you are about to present it to our profession in the English language, I shall consider myself discharged from the duty of bringing it forward, and shall very cordially unite with you in making known its merits to the American public. I am very faithfully yours, J. C. WARREN,

Prof. of Anat. and Surg. in Harvard Un.
Cambridge, Mass.

DR. DOANE.

Philadelphia, Sept. 30, 1830.

It gives us pleasure to learn the intention of publishing an American version of the Manual of General, Descriptive, and Pathological Anatomy of J. F. Meckel, Prof. of Anatomy in the University at Halle. A frequent reference to this work has assured us fully of its superior character as an exact, methodical, and highly scientific production, evidently sustained by an immense quantity of practical information on the part of its author. We have always considered it as an excellent digest of the present state of Anatomy, and shall be glad to find so instructive a guide put within the reach of the medical men of the United States.

PHILIP S. PHYSICK, M. D.
Prof. of Anat. in the University of Pennsylvania.
W. E. HORNER, M. D.,
Adj. Prof. of Anatomy.

A. SIDNEY DOANE, M. D.

Extract of a letter from Benj. H. Coates, M. D., dated
Philadelphia, Nov. 5, 1830.

From the reputation of M. Meckel for learning, practical skill, and a philosophical mind, a work of the very first class might be depended upon with safety, from the fact of its coming from his hands. Yet for the purpose of a more particular judgment, I referred to the French translation, and find it every way worthy of his acknowleged character. It is precisely such a work, combining the facts which have been accumulating for hundreds of years with modern philosophical views, as was best calculated to give a connected view of the present state of anatomical knowledge, and to fill a gap very much felt in the medical literature of America.

DR. A. S. DOANE.

Dear Doctor, *New York, Oct.* 20, 1830.

I am pleased to learn that you intend to favor the lovers of Anatomy with an English translation of Prof. Meckel's valuable work on General, Descriptive, and Pathological Anatomy. For some years past I have been in the habit of referring to this work, and have admired it for accuracy and minuteness. The students and practitioners of America will be under great obligations to you for the treat you are about to give them.

My best wishes attend the undertaking, and believe me to be yours very faithfully,

VALENTINE MOTT,
Prof. of Surg. in Col. of Physicians, N. York.

DR. DOANE.

New York, Nov. 9, 1830.

I consider the Anatomy of Meckel as the best treatise on General, Descriptive, and Pathological Anatomy that has ever been written, and have no doubt that the translation and publication of it in this country will greatly advance our knowledge of this science.

ALEX. H. STEVENS, M. D.,
Prof. of Surg. in the Col. of Physicians, N. York.

DR. A. S. DOANE.

Sir, *Col. of Physicians and Surgeons, New York, Oct.* 19.

I was pleased to learn that it is your intention to prepare and print a translation of Meckel's Anatomy. It is a work which holds a higher place in my estimation than any other treatise on the same subject with which I am acquainted. This opinion of its merits inducing me to make the book one of frequent reference for the pupils of this University, its publication in English will confer a favor on them by aiding their researches. Permit me however to caution you against the numerous errors, doubtless of haste or of the press, which may be found in the French translation. These mistakes are sometimes important, and to avoid them it will be necessary to compare your version with the original or with some other good authority.

With my best wishes for your success, I remain yours respectfully,

J. AUG. SMITH.
Prof. of Anat. and Physiology in
Col. of Physicians, N. York.

DR. DOANE.

Dear Sir, *Washington City, D. C., Aug.* 2, 1830.

I am highly gratified to learn that you are translating from the French the Anatomy of J. F. Meckel.

The work is one of great value, and should be in the hands of every professor and student of Anatomy in the United States.

It will prove a valuable acquisition to the profession of our country, I have no doubt.

THOMAS SEWALL, M. D.
Prof. of Anat. and Physiol., Columb. Col.

A. S. DOANE, M. D.

Dear Sir, *Baltimore, Nov.* 25, 1830.

I am gratified to learn that you design to furnish the American public with a translation of Meckel's standard work, the Manual of General, Descriptive, and Pathological Anatomy. The merits of the work have been known to me for some years. In no work are the facts which constitute the science of Human Anatomy embodied with more judgment. When faithfully translated, it should be in the hands of every practitioner and pupil of medicine.

You have my best wishes for your success.

Very respectfully yours,

N. R. SMITH,
Prof. of Surg. in the Un. of Maryland,
at Baltimore.

SIDNEY DOANE, M. D.

The above work will be comprised in three octavo volumes, of between 500 and 600 pages each, bound in first quality sheep, and will be delivered to subscribers at three dollars per volume, payable on delivery of each volume.

The first volume is now ready for delivery. The following are some of the corrections made in it by the American translator:

ERRATA OF THE FIRST VOLUME OF THE FRENCH TRANSLATION.

P.	L.	
18,	1,	*for* fibre, *read* tissu.
36,	15,	" nerveux, " vasculaires.
42,	1,	" vertèbre, " colonne vertébrale.
48,	28,	" dix, " douze.
52,	16,	" cœur, " foie.
63,	29,	*erase* de l'ouïe.
65,	8,	*for* suture, *read* fissure.
91,	24,	" ivoire, " émail.
92,	12,	" médullaire, " musculaire.
94,	33,	" nerveux, " osseux.
96,	2,	" animale, " organique.
"	30,	*after* valvules, *supply* du cœur.
115,	22,	*for* vasculaire, *read* musculaire.
116,	21,	' azote, " carbonne.
145,	3,	" vesicule, " ventricule.
147,	34,	" ventricule, " oreillette.
154,	22,	" veine, " artère.
172,	31,	" au, " du.
180,	7,	" premier, " dernier.
181,	12,	" nerveux, " veineux.
187,	5,	" femmes, " hommes.
"	7,	" l'homme, " la femme.
207,	21,	" les artères, " les lymphatiques.
227,	33,	" se divisent, " ne se divisent pas.
247,	31,	" nerfs, " muscles.
249,	7,	" olfactif, " auditoire.
"	21,	" huitième, " cinquième.
252,	34,	" nerfs, " vaisseaux.
258,	16,	" intercostales, " spinaux.
259,	12,	" intercostaux, " spinaux.
284,	13,	" refusé, " accordé.
"	15,	" accorder, " refuser.
302,	13,	" graisse, " moelle.
342,	31,	*after* interne, *insert* ou externe,
368,	6,	*for* intermaxillaires, *read* inter-articulaires.
404,	10,	" organes, " muscles.
408,	20,	" le canal intestinal, " l'ésophage.
425,	7,	" moins, " plus.
425,	8,	" plus, " moins.
429,	12,	" musculaires, " annulaires.
434,	10,	*after* muscles, *supply* d'un membre.
458,	35,	*for* muqueuses, *read* sereuses.
467,	3,	" interne, " externe
472,	5,	" moins, " plus.
514,	38,	" poumon, " vaisseau.
527,	14,	" droite, " gauche.
553,	12,	" muscles, " os.
565,	10,	" cinquante-trois, " cinquante-six.
"	11,	" soixante-deux, " soixante-six.
574,	24,	" cervicales, " dorsales.
575,	21,	" dorsales, " cervicales.
577,	1,	" dorsales, " cervicales.
579,	18,	" *after* apophyses, *insert* transverses.
581,	11,	*for* force, *read* forme.
590,	6,	" sacrum, " coccyx.
592,	4,	" douze, " dix.
615,	21,	" convexité, " concavité.
642,	11,	" occipitaux, " pariétaux
659,	2,	" postérieur, " supérieur.
688,	6,	" sacrum, " sternum.
718,	33,	" ce même os, " le trapèze.
720,	2,	" corps, " carpe.
722,	15,	" trapézoïde, " trapézium.
726,	21,	" scaphoïde, " os magnum.
730,	13,	" fétus, " doigts.
736,	25,	" omoplates, " os de l'épaule.
739,	30,	" coccyx, " pubis.
746,	21,	" gauche, " droite.
764,	24,	" de la première année, " du premier mois.
767,	35,	" métacarpiens, " métatarsiens.
"	37,	" métacarpe, " métatarse.
772,	31,	" première, " seconde.