AN

ILLUSTRATED SYSTEM

OF

HUMAN ANATOMY,

SPECIAL, GENERAL AND MICROSCOPIC.

BY

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WITH THREE HUNDRED AND NINETY-ONE ENGRAVINGS ON WOOD.

"Oculis subjecta fidelibus."

PHILADELPHIA:
GRIGG, ELLIOT AND CO.,
No. 14 North Fourth Street.
1849.

PHILADELPHIA:
T. K. AND P. G. COLLINS, PRINTERS.

TO

STUDENTS OF MEDICINE

THE

FOLLOWING PAGES

ARE MOST RESPECTFULLY

DEDICATED

BY

THE AUTHOR.

CONTENTS.

PREFACE.

In preparing this work for the press I have been influenced by the usual incentives to publication, one of which, and not the least, is the desire to be enrolled among the expositors of a science that has occupied many of the best years of my life. I need not be reminded that my enterprise must necessarily be devoid of that originality which gives charm to authorship: for a writer on Special Anatomy in our day must for the most part be content to clothe familiar facts in new language. Nor is even this object always attainable in a path that has been trodden for centuries by ambitious and aspiring minds, who, like voyagers in search of undiscovered lands, have left comparatively little to reward the zeal of their successors.

Not so, however, in Microscopic Anatomy, which presents a new field for discovery, replete with surprising and instructive revelations. It has already banished a legion of venerable conjectures, and substituted simple truth for vague hypotheses; and by unveiling the very germs of organized and organizable matter, has taught us the origin and development of the tissues, together with a portion, at least, of their hitherto doubtful functions.

In this department, however, I have not entered the lists as a discoverer, but as a learner; for although I commenced with the intention of furnishing a series of original drawings, I soon found that it required a more practised eye and hand than mine to do justice to these delicate manipulations, and that I must be content with the humbler task of occasionally verifying the observations of others.

In connection with this subject I have much pleasure in acknowledging the kindness of Dr. John F. Meigs in allowing me the use of one of Oberhaeuser's

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microscopes until I could replace it by a good instrument of my own; and I further gratefully record the attention of the distinguished Professor Retzius of Stockholm, in sending me, at different times, several series of organic tissues admirably prepared for the microscope with his own hands.

The present state of Anatomical science forbids its entire separation from Physiology, inasmuch as the results of microscopic discovery have more than ever blended the function of parts with their structure. A glance, however, at this work will show, that Physiology has been therein considered in a merely elementary manner, and as far as possible with regard to facts alone, without reference to doubtful propositions; for my aim has rather been to invite, on the part of the student, increased attention to this pleasing and all-important branch of professional learning, as more fully elucidated in the several works referred to in the following pages.

The illustrations have been derived from many different sources, for the most part specifically acknowledged. The muscular and osseous systems, however, are chiefly taken from Bourgerie and the beautiful atlas of Bonamy and Beau, whence they have been reduced by good artists, and subjected also to such modifications as appeared to me conducive to their further utility. Some original drawings have also been added, for which I am partly indebted to my friend and former pupil, Dr. William Gambel, and in part to my son, Cadet Morton of West Point; at the same time I have myself bestowed incessant vigilance on these fatiguing but important details.

It will be observed, however, that some divisions of the work are less fully illustrated than others, for it was found impossible, in a first edition, to do equal justice to them all. Thus, attention has been more especially given to the central, rather than to the peripheral portion of the nervous system, simply because the latter constitutes one of the most difficult problems of Anatomy and Physiology, and therefore demands all the light pictorial aid can bestow upon it.

The microscopic characters of the several tissues are also delineated with extreme care from the best authorities; and to accomplish this object, I have been content to bestow less illustration upon those parts of the vascular system that possess least practical importance.

The section on Muscular Action has been written at my request by my friend Dr. Joseph Thomas of this city, also a former pupil of mine, whose familiar

acquaintance with this branch of Physiology has enabled him to delineate it in an entirely satisfactory manner.

I have only to add, that it has been my constant aim to convey clear and concise impressions of the structure and functions of the various tissues, and I shall feel sincere gratification, if my work may happily tend to facilitate the studies of those to whom it is dedicated.

S. G. M.

PHILADELPHIA,
November 23, 1848.

LIST OF ILLUSTRATIONS.

The following wood-engravings have been executed under the author's personal supervision, by Messrs. Gilbert & Gihon, George Thomas & Co., Frederick Maas, T. K. Keilly and J. H. Brightley.

HUMAN ANATOMY.

HISTOGENY; OR, THE ORIGIN OF THE TISSUES.

THE CELL DOCTRINE.

THE cell-doctrine, for which we are chiefly indebted to the researches of Schleiden, Schwann and Valentin, has become the basis of all physiological investigation, and the first step in the study of the development of the tissues. It becomes necessary, therefore, briefly to inquire into the form and metamorphoses of those minute bodies called *cells*, together with the functions they subserve in the animal economy.

Blastema.—The basis of every forming structure of the human body is a fluid known as the *blastema*, or *cytoblastema*—a smooth, transparent medium, of a remarkably homogeneous and glassy appearance, whence it has also received the name of *hyaline*.

When, however, this fluid is subjected to the action of the microscope, it is observed to be pervaded by minute, spheroidal cells, between which again are interspersed an infinitude of yet smaller, graniform bodies, which have the appearance of specks or dots in the blastema. They are the nucleoli of Schwann, —the elementary granules of Henlé.

This fluid contains within itself the elementary material of every variety of animal tissue; in other words it is the primary, though amorphous, condition of *organizable matter;* while the granules that float in it constitute the first trace of real organization.

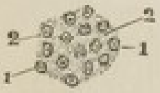
What is this blastema—this all-producing plasma? This question is not of ready solution; but by most physiologists the plasma is regarded as identical with the liquor sanguinis of the blood; that fluid in which the red corpuscles are suspended. It was at one time supposed that the blood-corpuscles were deposited entire in the tissues, and that growth and nutrition resulted from them alone; but in the present state of physiological science they are believed to take no part in the formative process.

Organization of Cells.—Each cell presents a triple organization, as seen in the nucleolus, the nucleus and the cell-wall, or investing envelope.

1. The *nucleolus* is a dark spot in or near the centre of the cell, which is supposed by Schwann, as already stated, to be its rudimentary element. A nucleolus, however, small as it is, is not always a single granule, but often an aggregation of granules; and the first apparent change in the blastema is an opacity caused by the presence and multiplication of these nucleoles, of which two or three are sometimes seen in the same cell.

Fig. 1 shows some of these primitive granules disseminated in the blastema, and others already forming the centre of several nuclei.—1, nucleus with its nucleolus; 2, primitive granules.

Fig. 1.

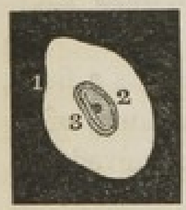


Free granules, nucleoli and nuclei.
After Mandl.

2. The *nucleus* is supposed to be an aggregation of molecules around the original nucleolus; and since new cells are constantly evolved, in the manner hereafter to be noticed, by the nucleus, this is sometimes called the *cytoblast*, or *cell-germ*, as expressive of its peculiar function. The metamorphoses of the nucleus are various. It sometimes sends out radiating prolongations, and in other instances resolves itself into a fasciculus of fibres; whence, according to Henlé, the origin of yellow fibrous tissue. Again, it appears to separate into distinct fibres, each composed of a linear aggregation of granules; and this is supposed to be the mode in which the dental tubuli are formed. The nature and extent of these transmutations, however, are involved in much obscurity.

The relation of the several parts of the cell are seen in Fig. 2.—1, periphery of the cell, or cell-wall; 2, nucleus; 3, nucleolus, in the centre.

Fig. 2.

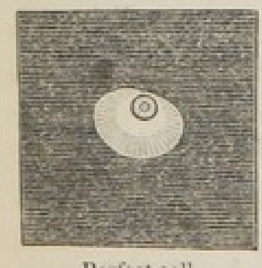


Nucleated cell.
From Gorber.

3. The *cell-wall*. This name is applied to the envelope of the cell; a transparent and most delicate membrane, subject to remarkable vicissitudes of form and consistence, but invariably composed of the element called *protein* by the chemists; who further inform us that the blastema in which the cells float is principally albuminous matter, while the fluid contents of the cell—the medium that is interposed between the nucleus and the cell-wall—is not albumen but fibrin; the former being received into the cell on the principle of endosmosis, and there becomes converted into the fibrinous element.

The perfect cell thus formed, is further illustrated in Fig. 3.

Fig. 3.



Perfect cell.
After Todd & Bowman.

Development.—It has been stated above that the nucleus is an aggregation of granules, each of which is capable of being developed into an independent cell. These new cells may be completely formed within the primitive cell; or the latter may rupture, and scatter its contents into the surrounding blastema, where they assume in turn their characteristic triple organization, producing and reproducing almost without end.

Again, cells form in an isolated manner in the simple blastema, from pre-existing granules, when these are in contact with living tissues. The granule attracts to itself, assimilates and organizes, a portion of

the nutritious fluid, a part of which becomes the cell-wall, and another part the contents of the cell.

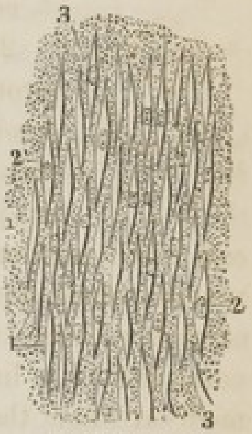
The cell thus formed is generally of a spheroidal shape, as represented in fig. 2; but sometimes it is more or less elongated, as in fig. 1. It is liable to various other modifications, becoming flattened, fusiform, prismatic, polyhedral, or caudate, according to the circumstances in which it is placed.

Some of these remarkable metamorphoses are exhibited in the annexed drawings. Fig. 4 illustrates the transition from cellular to fusiform tissue.—1, circular and oval cells, with nuclei and nucleoli; 2, others becoming pointed; 3, fusiform cells containing nuclei; 4, fusiform cells more elongated, and destitute of nuclei.

Fig 5 shows a modification of the same phenomenon.—1, fusiform bodies without nuclei; 2, nucleated fusiform cells; 3, granular intercellular substance.

Fig. 4.

Fig. 5.



Modifications and transitions. The forms of the cell just noticed, may become so elongated as to resemble woody fibre, and their nuclei disappear, and be replaced by deposits of a different nature. Such cells, however, are chiefly observed in those lymph-exudations that are thrown out upon inflamed surfaces.

It frequently happens that a series of cells arrange themselves in longitudinal lines; the proximate surfaces of the cell-walls disappear, and a tubular cavity is thus formed, which is the origin of various tissues. Thus it may become filled with fibrous elements, and constitute muscular structure. The origin of nervous filaments is explained in the same way; and the remark is also applicable to cellular membrane. Bone is derived from cells in which a deposit of earthy matter takes place; and the horny structures become such by an altered condition of the epidermic cells.

Isolated or transition cells.—These bodies float in the fluid blastema without any connection with each other, in which respect they differ from the permanent cells, or those which continue to form an integral part of the tissues. If the fœtus be examined within the first month of uterine life, it will be found to consist exclusively of these isolated cells, floating in an albuminous fluid; and although they all possess the same simple homogeneous character, they are capable, by a series of vital processes, of being transformed into all the varied structures of which the perfect human frame is ultimately composed. The corpuscles of the blood and lymph are also sometimes referred to this class of cells; but, as we shall hereafter show, they pertain to another series of organisms.

The ephemeral nature of the transition cells is well illustrated in the epidermis; for this tissue, where it lies in contact with the cutis vera, consists of a layer of soft and granular nuclei mingled with perfect cells (the *rete mucosum*) of the usual spherical shape. As they approach the surface they become flat-

tened, lose their cavity and at last are mere dry scales, which are thrown off to give place to new crops of the same transitional kind.

The nails, in like manner, are formed of dried, adherent cells; and the black pigment of the negro is secreted by a class of cells which are mingled with those of the epidermis. So also the epithelial mucous membrane is composed of layers of cells, which are formed and thrown off like those of the epidermis; with this difference, however, that being generated on moist surfaces, they are not thrown off in the desiccated state.

These transition cells of the epidermis and epithelium, originate in molecular granules which are diffused through the substance of the basement membrane.

The *permanent cells* differ from those of the dermoid tissues, in being developed, not from mere granules, but *within* the parent cell, which, instead of dissolving, may remain for a length of time as a thin envelop around them; so that these secondary cells, while still thus enclosed, may develop a third generation as perfect as themselves. These delicate envelops or *cell-walls*, may become thickened and strengthened by additional nutrition, and thus remain as permanent vesicles, forming part of perfectly formed structures; of which an example is seen in the adipose tissue. We see the same arrangement in permanent cartilage, through which cells are freely scattered, and cemented together by *intercellular substance*, which in this, as under all analogous circumstances, presents in itself no distinct traces of organization.

Functions.—It was taught by Schwann and Valentin, that *the universal primitive form of every tissue is a cell*, which is preceded by the nucleus as the mediate product of the formative power; but it seems nevertheless certain, from more recent investigation, that while some tissues originate from cells that subsequently disappear; and while other tissues always retain more or less of their primitive cellular character, there is a third class in which cells have no other agency than that of preparing the plastic basis of organized structure. Such, according to Dr. Carpenter and others, is the case with respect to the *basement membrane*, which is for the most part destitute of cell-structure. The same remark is applicable to the *white fibrous tissues*—tendon and ligament for example—which are supposed to be produced by the consolidation of a plastic fluid elaborated by cells;* or from the granules of the blastema.

An essential office of cells appears, therefore, to be the transformation of albumen—the chemical compound that forms the raw material of the animal tissues—into fibrin; imbibing the former in its simple albuminous form, and returning it as fibrin, in order to supply the constant drain of that substance caused by the nutritive functions.

But besides their almost universal agency in the development of the tissues, the cells perform the most diversified offices of a strictly functional character. "Selection, absorption, assimilation, respiration, secretion and reproduction, are performed by the agency of cells, in the animal as in the vegetable kingdom —in the complex human organism, as in the humblest cryptogamic plant. Thus,

* Carpenter, Principles of Physiology, §§ 135, 136.

the *absorbent cells*, at the extremities of the placental villi, select and draw into themselves, as materials of their own growth, certain substances in their neighborhood; and having come to their full term of life, they burst, or dissolve away, and give up their contents to the absorbent vessels, which carry them into the general current of the circulation, where they are mingled with the blood."*

It may suffice, for our present purpose, to mention one other example of the agency of *cell-growth* in the organic functions. Thus the *reproductive process* is itself accomplished by a special set of cells, destined to prepare the germs of new beings; for these last are primarily enveloped in appropriate cells, wherein they remain in a passive state, until the exigencies of nature rupture the cell, and diffuse the molecular elements of generation.

Vibratile cilia.—The epithelial cells of mucous surfaces (ciliated epithelium) are often fringed with hair-like processes, of which the pointed peripheral ends are free. The minuteness of these appendages may be conceived of by the fact, that the largest of them are the five-hundredth part of an inch in length; the smallest, less than half that size. They have been observed on the mucous membrane of the nasal, frontal and maxillary sinuses, of the lachrymal apparatus, the Eustachian tube, and the air-passages from the larynx to the bronchi. The cells of this ciliated epithelium are provided with nuclei in the usual manner.

The cilia are endowed with a remarkable and almost incessant motion, which is altogether involuntary, and which even continues long after death, especially in the inferior animals. During this motion, "each filament appears to bend from its root to its point, returning again to its original state, like the stalks of corn depressed by wind."

The function of the ciliary filaments is to propel fluids over the surface on which it takes place; and it is consequently limited, in man, to the internal surfaces of the body, and always takes place in the direction of the outlets, towards which it aids in propelling the various products of secretion.†

Fig. 6.

Vibratile or ciliated epithelium. 1, nucleated cells resting on their smaller ends. 2, cilia. From Henlé.

Some physiologists regard the spermatozoa of the seminal fluid, as isolated cilia, or cell-germs of a peculiarly elongated form, and possessing an inherent power of motion. How far this idea is tenable, will be considered in another place.

* Carpenter, Principles of Physiology, § 245.

† Idem, §§ 135, 136.

OSTEOLOGY.

OSTEOGENY: OR, ORIGIN AND GROWTH OF BONE.

If the human embryo be examined within the first month of its uterine existence, it presents a semi-fluid substance embraced in a delicate membranous sac, of which the outline presents but a rudimentary trace of organization. The contained mucous or jelly-like fluid has also an unformed and homogeneous appearance, in which the unassisted eye can perceive no vestige of those elements which are to be rapidly evolved into perfect harmony of proportion and adaptation.

If, however, a portion of this gelatinous substance be subjected to the action of a microscope, it is observed to be composed of minute, transparent vesicles contained in an equally delicate medium. These vesicles are cells, such we have already described them, with their nucleolus, nucleus and cell-wall, constituting the rudimentary elements of the future being; while the medium in which they float is the blastema, hyaline, or plasma,—that organizable fluid, which becomes metamorphosed into the different animal tissues, by the agency of the cells which imbibe it.

In the formation of bone, which is called *osteogeny*, the fluid element is first transmuted into cartilage, and the latter into osseous structure. In the first step of this process, the cells assume a lenticular or irregular form, and gradually become of a whitish, opaque appearance, indicative of their transition into cartilage. Their nuclei, as the process goes on, become more and more distinctly granular, the granules of the same cell being sometimes at a distance from each other, but oftener crowded together. The hyaline increases in quantity in a certain ratio to the development of new cells, now from their changed color and consistence called *cartilage-corpuscles;* and this increase of the contained and the containing elements, proceeds until the process of ossification is completed in the manner next to be described. It is important, however, to premise, that these advances towards the formation of the temporary cartilage, have taken place within membranous sacs or canals, which represent the nascent condition of the periosteum itself.

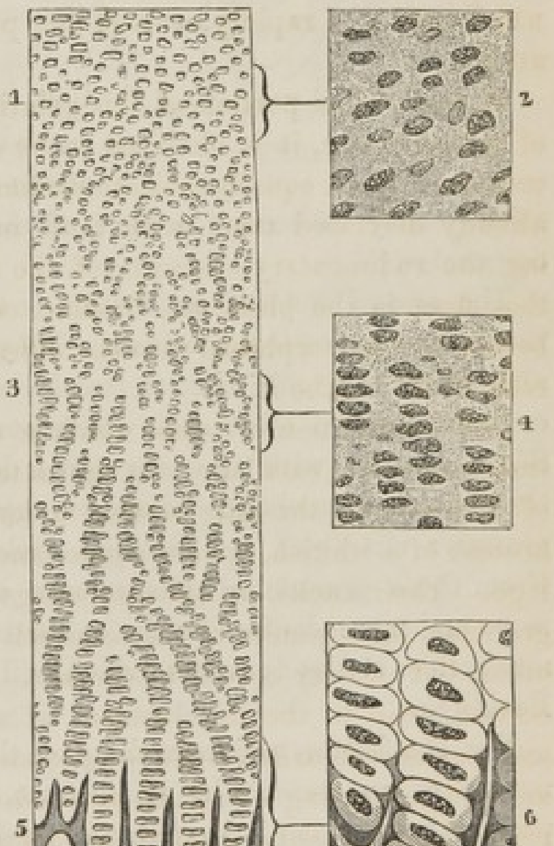
It is not to be supposed, however, that all bone is formed in cartilage: on the contrary it seems now proved beyond cavil, that there is an *intra-membranous*

as well as an *intra-cartilaginous* formation of bone; and that the periosteum, notwithstanding the objections of some physiologists, performs a very important part in this function. Our remarks will be first devoted to the intra-cartilaginous deposit of bone.

The incipient points of ossification, in this instance, are not in the cartilage corpuscles, as one might naturally suppose, but the intervening matrix in which the cells are disseminated, and which is called the inter-cellular substance. The process, moreover, takes place in extremely thin, cup-shaped lamina, more or less elongated and separated by occasional partitions into pouches or cul-de-sacs, as seen in the vertical section Fig. 7. These points of ossification are first observed in the centre of long bones; and they are no sooner formed than a remarkable change takes place in the relative position of the cartilage corpuscles, which now arrange themselves in a linear series in the direction of the ossifying surface; or, as Mr. Tomes expresses it, each corpuscle develops others, which are directed towards the line where ossification has commenced.

The cartilage cells or corpuscles are about the $\frac{1}{2000}$ of an inch in diameter, and each one embraces two or more nuclei, round which smaller cells are developed, to be in turn evolved into perfect form, and undergo the transition from cartilage to bone.

Fig. 7.



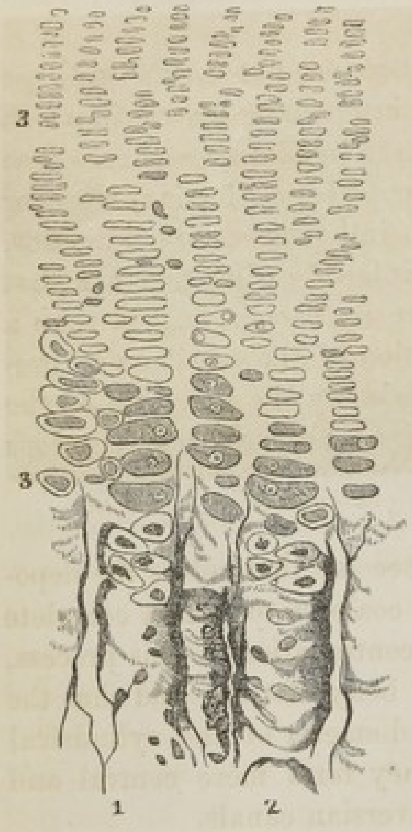
At first the aggregation is irregular, and the series small; but nearer the point of ossification, the cells form rows of twenty or thirty, in a slightly undulated line, and in the longitudinal axis of the bone. The cells composing them are closely in contact, so that even their nuclei appear occasionally to touch each other, and to partake of the same flattened and expanded shape as the cells that inclose them.

The annexed drawing, from Todd and Bowman, Fig. 7, which has been republished in most of the recent chapters on osteogeny, is so illustrative of the subject that I insert it without apology. It represents a vertical section of a portion of cartilage, derived from a surface proximate to the point of ossification. 1. Ordinary appearance of temporary cartilage; that is to say, a firm, translucent matrix, through which are disseminated cartilage cells of variable size and form. 2. Portion of the same cartilage more highly magnified. 3. Cells assuming the linear direction. 4. Same, more highly magnified. At 5, ossification is extending into the intercellular spaces (colored dark), and the rows of cells are seen resting in the cavities so formed. 6. The same more highly magnified.

In further illustration of this difficult subject,

we annex a drawing, Fig. 8, from Dr. Sharpey, taken from the head of a fœtal humerus. That distinguished anatomist remarks, that the grouped cartilage-cells are placed transversely, as if they had been flattened and piled one upon another; but in the immediate vicinity of the bone, they become greatly enlarged and more rounded. The matter they contain is sometimes pellucid; in other instances it is slightly granular, with a nucleus and one or more nucleoli. In Fig. 8, 1 and 2 represent two of the newly formed osseous tubes or areolæ, with a few cartilage-cells and granular corpuscles lying in them. 3, 3. Cartilage-cells near the ossifying surface, exhibiting the appearances above described.

Fig. 8.



As the ossification of the cartilage corpuscles goes on, the containing cup-shaped cavities are connected into closed areolæ of bone, the parietes or lamellæ of which are at first extremely thin. They soon, however, become thicker, and embrace elongated oval bodies which are their proper lacunæ, and the remains of the nuclei of those cells of which the lamellæ were formed.*

It is thus that the cartilage cells enter the osseous tubuli already prepared for them, and in this way complete the *first stage* of ossification, in which no blood-vessels are directly concerned. The bony lamellæ mark the boundaries of the cancelli and Haversian canals, which are subsequently to occupy a part of the space hitherto filled by the cartilage-corpuscles.†

The *second stage* of ossification is that in which the cartilage-corpuscles are themselves converted into bone. They are observed to become flattened against and attached to the osseous lamella already formed, and at the same time so crowd upon each other as to obliterate the lines of demarkation between them. Simultaneously with these changes a deposit of calcareous matter takes place in their interior, involving the whole corpuscle except its nucleus, which retains its granular character and remains isolated in the surrounding earthy deposit. From these granulated cells, minute canals are seen to branch off, and become more and more distinct as the calcareous deposit goes on around them, forming numberless stellate cavities, which will be hereafter noticed as the corpuscles of Purkingé.

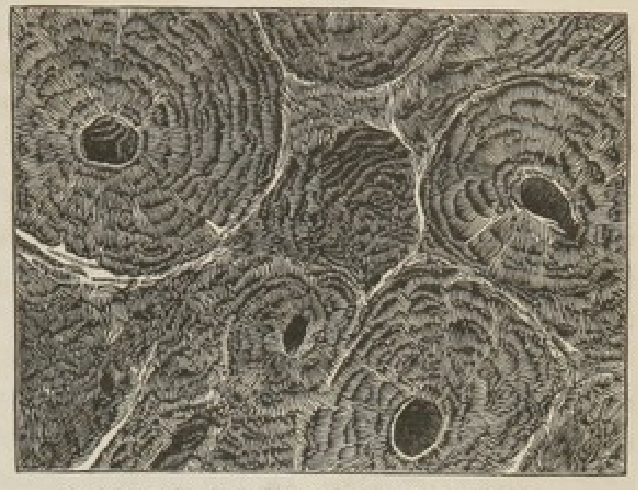
For the better understanding of this subject, it is necessary to explain the nature of an *ossicle;* by which term is meant that miniature element of the perfect bone which is represented in the microscopic osseous cylinder, with its central canal, its concentric lamellæ, and its exterior casing of compact bony tissue. The ossicle is, indeed, a true epitome of any one of the long bones;

* Todd and Bowman, Physiological Anat., p. 118.

† Carpenter, Elements of Physiology, § 301.

for the latter are only aggregations of these cylinders which, under the microscope, resemble a fasciculus of pipe-stems, placed side by side, the intervening angles being filled with bone that connects the ossicles together. Fig. 9.

Fig. 9.



Ossicles, with their Haversian canals, laminæ, &c.

Now in the commencement of this second stage of ossification, these embryo ossicles, begun in the first stage, are open canals, which are to be filled, or nearly so, by a deposit of bone. This process is effected in the following manner. The cartilage-corpuscles are observed to be attached and flattened to the *internal sides* of the tubular cavities, and then to become themselves the depository of earthy matter, at the same time that they coalesce to form a complete internal osseous lining to these cylinders. By the continuation of this process, one layer of cells after another is converted into bony matter; and thus the tubes, which were at first identical with the whole diameter of the cylindrical ossicles, become gradually reduced in size until they form mere central and longitudinal perforations, which are, in fact, the Haversian canals.

The annexed diagram (fig. 10) will more fully explain this interesting point of osteogeny: it supposes a group of cylinders, or ossicles, cut through transversely, so as to expose the process of ossification in three of its phases. At 1, is represented a cylinder of bone filled with cartilage-corpuscles, the cylinder or casing being alone ossified. At 2 and 3, the process has completed several laminæ of bone, which lie one inside of the other, leaving a large canal still open, yet filled with unossified corpuscles. At 4, the process is complete; the laminæ are all formed, and the small opening of the proper Haversian canal marks the centre of the ossicle. It will now also be understood in what way the laminated structure of bone derives it origin. The inter-ossicular space, 5, is filled with bony matter, with its characteristic lacunæ.

Fig. 10.

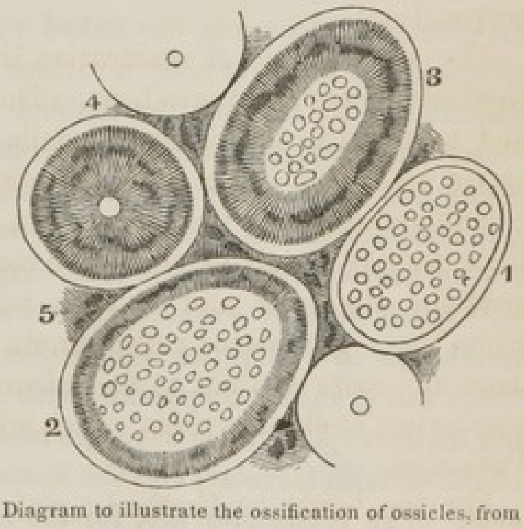


Diagram to illustrate the ossification of ossicles, from the inner periphery to the centre.

The centre of calcareous deposit in cartilage, is called the *punctum ossificationis;* a nucleus of bone that occurs for the most part in the interior structure, and is seen with remarkable regularity of time and place in the same bone, though extremely variable in both respects in the different bones. Thus, the simple rounded bones have a single punctum; the flat and irregularly formed bones have several puncta; and all the long, cylindrical bones have at least

three points of ossification, a central one for the shaft and one for each end; and the processes of bone have also each a distinct centre of the same kind.

When does the process of ossification commence? This question has been variously answered by different physiologists; but although the change does not generally and actively appear until the sixth or eighth week of fœtal life, yet its incipient stage has been observed by Beclard at the end of thirty days. These primary indications are always first seen in the clavicle; then follow in succession the lower jaw, the humerus, the femur, the forearm, the tibia, the vertebræ and the cranial bones; still later in development are the patella, and last of all the bones of the carpus, of which the os pisiforme is not ossified until the age of six to twelve years.*

Another important change occurs simultaneously with the conversion of the cartilage into bone; this is the appearance, within the cancellated structure and canals, of a new substance, a granular blastema, resembling that in which all new tissues originate. In the present instance it gives rise to the lining membrane of the cancellated cells and tubuli of bones, and which is, in fact, a multiform prolongation at first of the perichondrium, and then of the periosteum itself. Hence it becomes the medium by which blood-vessels are now conveyed to the innermost ossifying structures, as well for their present nutrition as for their future development.†

The *intra-membranous mode of ossification*, is also widely distributed in the human body; and since Dr. Sharpey has the merit of more fully illustrating this subject than had previously been done, we quote the following passages, which embody all that is requisite to our present purpose.

"The commencing ossification of the parietal bone, which may be selected as an example, appears to the naked eye in the form of a network, the little bars or spicula of bone running in various directions, and meeting each other at short distances. By and by, the ossified part becoming extended, gets thicker and closer in texture, especially towards the centre, and the larger bony spicula which now appear, run out in radiating lines to the circumference; the ossification continuing thus to spread and consolidate until the parietal meets the neighboring bones, with which it is at length united by suture.

"When further examined with a higher magnifying power, the tissue or membrane in which the ossification is proceeding, appears to be made up of fibres and granular corpuscles, with a soft, amorphous, or faintly granular uniting matter. The fibres have the characters of the white fibres or rather fasciculi of the cellular (areolar) and the fibrous tissue, and are similarly affected by acetic acid. The corpuscles are, for the most part, true cells, with an envelope and granular contents; some about the size of blood-particles; but many of them two or three times larger. In certain parts the fibres, but in most the corpuscles, predominate; and on the whole the structure might be said to be not unlike that of a fibrous membrane in an early stage of development. The bone,

* Beclard, Anatomie Génerale, p. 471.

† Todd and Bowman, p. 120.—Carpenter, Phys., §§ 302, 303.

seen by transmitted light, is dark and opaque; and near the growing edge it is decidedly granular.

"On now observing more closely the bony processes or spicula at the circumference, where they shoot into the membrane, it will be seen, as you trace them into the soft tissue, that they gradually lose their opaque and granular character, indicative of earthy impregnation, and are prolonged a little way into the membrane, in form of bundles of transparent fibres, having all the characters of those of fibrous tissue. Those fibres are in some parts closely gathered into thick bundles; but more generally the fasciculi are smaller, and irregularly interlaced or reticulated, with corpuscles lying between them; and we may often observe that where the earthy deposit is advancing to invade the fibres, the recently and as yet imperfectly calcified bone with which they are continuous, presents a similar open and coarsely reticular structure; though the older, harder, and more opaque part is comparatively solid and compact. The appearance referred to is especially well seen at those places where a cross bridge of bone is being formed between two long spicula; we may there distinguish the clear soft fibres which have already stretched across the interval; and the dark granular opacity indicating the earthy deposit may be perceived advancing into them, and shading off gradually into their pellucid substance, without a precise limit.

"It thus appears that in the intra-membranous ossification, the growing bone shoots into the soft tissue, in form of transparent fibres, resembling those of fibrous texture, more or less intermixed with granular corpuscles; and that these fibres become charged with earthy salts. As to the cells or corpuscles, they certainly seem in some way involved in the ossification along with the fibres; but I am not able to say what precise share they have in the process. It has been supposed that they eventually form the lacunæ of the bone; but we shall enter upon this question afterwards.

"As the bone extends in circumference, it also increases in thickness; the vacuities between the bony spicula become narrowed or disappear; and at a more advanced period the tabular bones of the cranium are tolerably compact towards the centre, although their edges are still formed of slender radiating processes. At this time, also, numerous furrows are grooved on the surface of the bone in a similar radiating manner; and towards the centre these are continued into canals in the older and denser part, which run in the same direction. The canals, as well as the grooves, which become converted into canals, contain blood-vessels supported by processes of the investing membrane, which deposit concentric layers of bone within; and when thus surrounded with concentric laminæ, these tubular cavities are in fact the Haversian canals."*

We now recur to the intra-cartilaginous development of bone. We have explained how this process takes place from cartilage-corpuscles within the elementary ossicles; and it remains to describe some other but simultaneous modes of growth.

In the first place it is observed that even these ossicles increase in diameter,

* See Quain's Anatomy, 5th edition, p. 101.

which appears to be owing to a reciprocal absorption and replacement of the osseous cylinder itself, within which new cartilage cells are at the same time generated, in order to fill the augmented space. This growth of the ossicle is proved, says Mr. Tomes, by the fact, that a transverse section of the femur of the human fœtus of seven months, will present many more canals than a section of equal measurement from the femur of an adult person.

Again, the diameter of bones is also increased by an exterior deposit, over their whole surface, between the latter and the periosteum, of graniform plasma or of cartilage-corpuscles, developing "not only new laminæ, but new systems of laminæ, and new involutions of the vascular surface to form new Haversian canals, so that the earlier systems of laminæ are covered over by the more recent ones, as proved by the experiments with madder."* It is also shown by the experiment of Duhamel, who placed a ring around the bone of a young pigeon; on examining the bone after it had completed its growth, the ring was found within the medullary canal, which had thus acquired a capacity equal to the previous diameter of the whole shaft.

Dr. Sharpey, however, denies that cartilage-cells have any agency in the increase of the diameter of a long bone, any more than they have in increasing the thickness of a flat bone; but that the enlargement in both instances is due to progressive calcification of the inner surface of the periosteum. The latter, he adds, is lined by an organizable plasma that takes on ossification by its own inherent function; and this opinion may, perhaps, derive some confirmation from the very slight attachment that exists between the periosteum and the bone in the growing state. We have great pleasure in subjoining Dr. Sharpey's remarks on this interesting question.

"It has been sometimes supposed that a formation of cartilage precedes the bone also in this situation; but such is not the case, for the vascular soft tissue in immediate contact with the surface of the growing bone is not cartilage but consists of fibres and granular corpuscles; in fact, the increase takes place by intra-membranous ossification, and accordingly the Haversian canals of the shaft are formed in the same way as those of the tabular bones of the skull—that is, the osseous matter is not only laid on in strata parallel to the surface, but is deposited around processes of the vascular membranous tissue which extend from the surface obliquely into the substance of the shaft; and the canals in which these vascular processes lie, becoming narrowed by the deposition of concentric osseous laminæ, eventually remain as the Haversian canals.

"That the ossification at the periosteal surface of the bone does not take place in cartilage, may also be made apparent in the following manner. Strip off the periosteum from the bone at the end of the shaft and from the adjoining cartilage also, taking care not to pull the latter away from the bone. A thin membranous layer will still remain, passing from the bone to the surface of the cartilage; now, take a thin slice from the surface, including this membrane with a very thin portion of the bone and of the cartilage, and examine it with the microscope,

* Todd and Bowman, p. 122.

scraping off the cartilage from the inside if it be too thick. You will then see that the superficial part or shell of the bone, if it may be so called, is prolonged a little way over the surface of the cartilage by means of pellucid coarsely-reticulated fibres of soft tissue into which the earthy deposit is advancing. These fibres are intermixed with granular corpuscles or cells, but form no part of the cartilage, and they are, no doubt, of the same nature as those seen in the intra-membranous ossification of the skull. Their reticulations are, in most cases, directed transversely, and sometimes they are little, if at all, in advance of the limit between the bone and cartilage. I have observed the structure here described in several bones of the (well advanced) fœtal sheep; also in the human scapula, humerus, femur, tibia and fibula, metacarpus and metatarsus, and it probably occurs in all the long bones."*

From the foregoing facts it is at least reasonable to infer, that some bones grow by intra-cartilaginous deposits; others in the intra-membranous way; and that some again are formed by a variable combination of these processes.

Bones also grow in the longitudinal direction, by which means every fibre becomes elongated. This process is first seen in the centre of long bones, where it commences by a ring, from which the fibres extend towards the extremities, so that at birth the shaft is completed, and each end is capped by an *epiphysis*. This epiphysis, like the body of the bone, consists at first of cartilage; and although it ossifies simultaneously with the shaft, is separated from the latter, during the whole period of the growing state, by a lamina of cartilage, which is the nidus of ossification for the shaft, and a principal means by which its elongation is effected. For, the cartilage-corpuscles that form the termini of the fibres at the ends of the shaft, are not only converted into bone, but their places are continually supplied by fresh corpuscles until the adult condition is attained. But besides this growth from the epiphyses, there is also, in the long bones, an interstitial elongation of the fibres throughout the whole shaft. In what precise manner this is effected I am not prepared to explain; but in proof of the position I submit the following remarks.

The experiments of Hales and Hunter, so often quoted, seem at first sight to oppose this view. They inserted metallic substances into the shaft of a growing bone, and found upon examination, after the progress of growth, that the distance between them had not altered. One is compelled, however, to suspect some fallacy in these experiments, for this simple reason—that all the inequalities of a long bone are removed further and further from its centre in proportion to the elongation of the shaft, and without any agency of the epiphysis. For example, the trochanter minor of the os femoris is below the terminal epiphysis, and yet the distance between it and the centre of the bone is constantly augmented until the growing state has ceased altogether. By what agency, then, is this separation of parts effected? Certainly not by the epiphysis, as we have already remarked; nor can it be explained on any other principle than the elongation of the component osseous fibres. These fibres do not run the whole

* Quain, Loco citat.

length of the bone, but are of variable lengths, and are composed of Haversian ossicles. Now since the latter are proved to increase in diameter, we may safely infer that by a similar interstitial process they increase also in length; and where the ossicles are deficient, as in the cancellated tissue, the cancelli are known to increase in size from their primitive state to their perfect development; showing a medium of elongation for that part of the bone in which they are distributed.

If the experiments of Hales and Hunter threw doubts on this point, other observations have tended to confirm it. "Thus holes have been bored in the tibia of a dog at definite intervals, which intervals, after the lapse of some days, have been found altered in the relative lengths. The intervals near the ends of the bone have increased considerably, while those situated near the centre of the bone have scarcely changed. As regards the growth of bone, the laws common to every other tissue, and to the whole body will, I think, be found to hold good. And the growth of these organs will be found to be interstitial, pervading the whole substance, though the action will be more energetic at some points than at others, as the neighboring organs may require greater length or breadth in one direction than in another."*

Another phenomenon remains to be noticed. During the second embryotic month, as heretofore stated, the bones are almost wholly represented by cartilage, in which is dispersed a multitude of minute cellæform cavities. These, however, enlarge in the progress of growth, and their parietes becoming ossified, they constitute the proper cancellated structure; while in the centre of the long bones this change is still more remarkable in the formation of a continuous tube, in and around which the cancelli are arranged in a reticular manner. This tube is the medullary canal. This aggregation of the osseous matter in a hollow cylinder, instead of a solid one, observes Dr. Carpenter, is the form most favorable to strength, as may be easily proved upon mechanical principles. The same arrangement is adopted in the arts, whenever it is desired to obtain the greatest strength with a limited amount of material.†

Several of the preceding facts in relation to the growth of bone, have been either ascertained or corroborated by giving madder with the food of growing animals. Between this substance and phosphate of lime a chemical affinity is said to exist; so that when the madder is introduced into the system, it at once combines with the lime, to which it imparts its peculiar color. This result takes place with surprising rapidity. Flourens, for example, gave a few grains of the drug to a young pigeon, and having killed the bird after the short lapse of five hours, he found the bones already tinged of a bright red color. Duhamel, with whom the experiment originated, had some young animals fed for several months with aliments in which madder was alternately mixed and omitted; the result was, that the long bones presented successive layers of white and red bone from the medullary canal to the exterior surface; the most internal lamina having been the first deposited, and the outer ones the last.

* Tomes, in Cyclopædia of Anat., p. 853.

† Elements of Physiology, § 305.

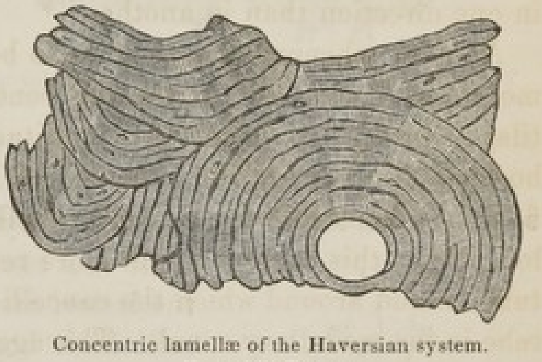
MICROSCOPIC CHARACTERS OF ADULT BONE.

Having thus traced the origin of bone from the simple formative cell through the mediate state of temporary cartilage to its mature condition, we next proceed to examine its ultimate structure as revealed by the microscope; and here three remarkable conditions present themselves—the laminæ, the canals and the corpuscles.

Laminæ.—It has already been observed that each ossicle is composed of concentric lamellæ in its forming state, and that these layers are arranged with more or less regularity in concentric rings, of which the exterior one constitutes the envelope and boundary of the series within it. These laminæ are variable in each series, but are generally ten or twelve in number; of which the internal is most distinct, and the others less so in proportion as they approach the circumference.

Fig. 11 represents a transverse section of a portion of the compact tissue of the tibia, which has been macerated in weak muriatic acid. The laminæ are brought distinctly into view, but the lacunæ, being filled with fluid, are less plainly seen.*

Fig. 11.



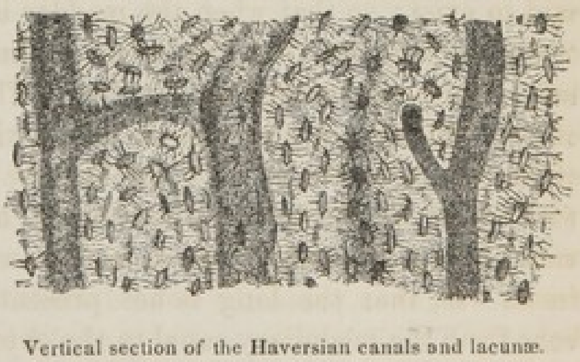
Concentric lamellæ of the Haversian system. From Mr. Tomes.

They form a cylinder with a central perforation called the Haversian canal, and they are interspersed throughout with minute cavities known as the lacunæ or corpuscles of Purkingé; and this triple combination of parts constitutes what modern anatomists call the *Haversian system.* Fig. 13.

Haversian canals.—These are seen everywhere in the compact structure of long bones, and in the similar osseous covering of bones of other classes. They consist of minute tubular cavities about the $\frac{1}{300}$ or $\frac{1}{500}$ part of an inch in diameter, running for the most part longitudinally in respect to the bones, but crossed at irregular intervals by communicating tubes, so as to present a reticulated appearance.

Fig. 12 is a vertical section of a fragment of the tibia, very highly magnified, in which the canals and one of their transverse connections are exhibited, together with the lacunæ that everywhere communicate with them. Fig. 13 represents the same structure cut across, showing the manner in which the *canaliculati* diverge from the Haversian canals, and maintain a connection between the two.

Fig. 12.



Vertical section of the Haversian canals and lacunæ. From Lessing.

* Tomes, in Cyclopædia of Anatomy, art. *Osseous tissue.*

These canals are not parallel to each other, even in the longitudinal series, but more or less curved and uniting at various angles, so as to enclose in some instances, elliptical or irregular portions of bone.

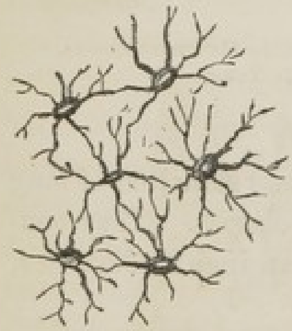
The office of these canals, and their associated lacunæ, is to give passage to blood-vessels, which are thus conveyed to the intimate structure of the bones, and form a vascular lining membrane to the canals themselves. It is prolonged, in like manner, into the cancellated structure, lines the whole medullary canal, and is, in fact, a continuous extension of the exterior periosteum, which penetrates into the multitudinous foraminæ of the surface. Thus, at the expense of some repetition, we may observe, that the central medullary canal is but an enlarged Haversian canal or cancellus; and the whole cylindrical shaft of a long bone, the humerus, for example, is a collection of ossicles, each of which is a miniature representation of the bone itself.

Fig. 13.

Transverse section of the Haversian canals and lacunæ. From Lessing.

The Haversian canals exist in the simple tubular form only in the compact structure of long bones. Thus they are seldom found in the partitions that form the cancellated structure; but they terminate in the latter, and are continuous with it, so that the cancelli have been regarded as a modification or expansion of the canals.

Fig. 14.



Lacunæ or corpuscles of Purkingé, with their connecting tubuli. From Lessing.

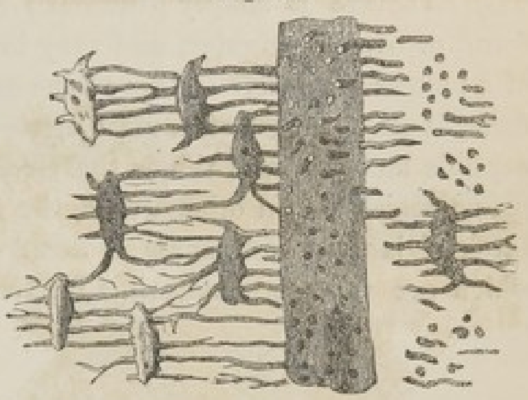
Lacunæ.—These microscopic appendages of bone are also called the *corpuscles of Purkingé*, on the supposition, at the time of their discovery, that they were solid; but they are now generally designated as *bone-cells*, a name to which there is the obvious objection that it tends to a confusion of terms. These cavities are mostly of a flattened oval or wedge-shape, and when seen with a glass of slight magnifying powers, appear to be mere stellated points; but when magnified in a higher degree, they prove to be excavations in the bone, deriving their stellate character from numerous associated pores or *canaliculi*. Fig. 14. They are often placed on the surface of the laminæ, (Fig. 16); and when concentric laminæ occur, as in the Haversian system, the cells are arranged in circular lines between the rings, whence they communicate, in the manner presently to be described, with each other and with the central canal. These lacunæ are regarded by most anatomists as the remains of the granular nucleus of the cartilage-corpuscle, which, having performed its function in the development of bone, now contracts upon itself so as to form a cavity that performs an important part in the nourishment of the osseous tissue. These

lacunæ are of variable size, but their average length is estimated at the $\frac{1}{1800}$ part of an inch, and about half as much in width.

These lacunæ contain a soft granular matter, which is by some supposed to be a persistent cell-nucleus, designed to subserve an important function in selecting the material which the canaliculi are destined to convey.

The tubuli or pores connected with the lacunæ are given off from them in every direction, mostly diverging, but sometimes running in parallel curved lines. Those that arise from the inner margin of the cell open into the proximate Haversian canal; while those that pursue the opposite direction inosculate with others coming from the adjacent lacunæ, in the manner of a network.

Fig. 15.



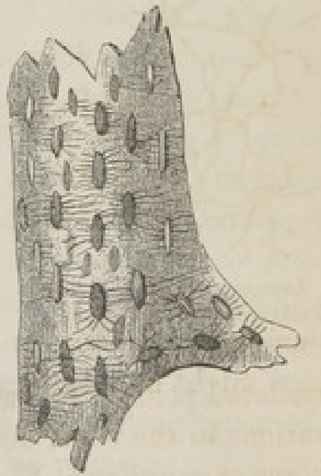
Haversian canal, lacunæ and connecting tubuli. From Lessing.

Fig. 15 illustrates these several parts, and their manner of communication.

It is thus that a perfect communication is established between all parts of the ossicle; for the exterior surface of the latter is dotted with microscopic orifices which mark the origin or termination of these tubular pores. Again, the external lacunæ sometimes connect with those of another ossicle; and occasionally, also, lacunæ of irregular shape lie in the angular interval between two or more ossicles, and communicate with the cells of them all.*

We have elsewhere remarked that the Haversian canals are found only in the compact bony structure, or in the more strongly developed cancelli; but the lacunæ, on the contrary, can be detected everywhere in the human bone. The most delicate septa between the cancelli are furnished with them and their divergent tubules; so that they may be regarded as an essential feature of osseous tissue wherever the latter has an organized form.

Fig. 16.



Lacunæ in a minute fragment of cancellated bone, very highly magnified. From Lessing.

The annexed drawing, Fig. 16, represents a simple fibre from the cancellated texture of the femur, very highly magnified, and exposing the many lacunæ with which it is furnished, together with the tubuli that form the medium of communication between them.

We have thus examined the several constituent parts of osseous organization; but the question yet remains to be answered—What is the nature of the substance of bone? What is the ultimate condition of the particles that constitute, of themselves, the parietes of the cancelli, the canals and the lacunæ? Most anatomists have regarded this substance as homogeneous and without appreciable structure; but Mr. Tomes remarks, that

* Todd and Bowman, Phys., p. 113.

when it is examined with high magnifying powers, there is no difficulty in detecting a distinct though very delicate structure. For this purpose Mr. Tomes recommends a thin plate of bone, as part of the ethmoid of any small animal; but preparations obtained from calcined bone, either by bruising a fragment of it, or subjecting it to the action of diluted muriatic acid, will answer equally well. Such portions of bone contain no Haversian canals, nor Purkingean corpuscles. The structure is simply granular; the granules are of an irregular spherical form, or oval or angular, and vary in size from one-sixth to one-third the size of a blood-corpuscle.* Where bone exists naturally in an exceedingly attenuated form, it may consist of a mere aggregation of these granules, without any perceptible lacunæ; and this is the simplest form in which the osseous tissue can present itself.† In other words, the organic tissue of bone, with its varied apparatus of lacunæ and canals, is itself constituted of these amorphous molecules, which are the mere materials for the construction of definite and permanent forms.

OF THE BONES IN GENERAL.

The bones form the basis of that admirable superstructure which is developed in the perfect man; and so important is a knowledge of them, that they in a measure hold the same intimate relation to the soft parts, that an alphabet does to a language. Having already described their origin and progressive evolution, we next proceed to examine their more obvious physical characters, their chemical composition and modes of nutrition.

Number of the Bones.—This is variously estimated by different anatomists, inasmuch as certain bones are regarded as single by some, while by others they are described as consisting of several parts. Thus, while the os innominatum is in reality a single bone in the adult, it is separable into three portions in the juvenile periods of life; and hence, as well as for purposes of convenience, is generally spoken of in the plural. The same remark is applicable to the sacral vertebræ, which may be counted as five bones according to their primitive division, or as one in their adult and inseparable state. The sessamoids, also, although perfect bones, only become so at the period of adolescence, and are then liable to variations in different individuals. These examples, and others that might be mentioned, have led to considerable discrepancy in enumerating the many parts of which the skeleton is composed, but which may be given with proximate accuracy as follows:

Cranium - - - - - - - - -	8
Face - - - - - - - - - - -	14
Thorax, viz: ribs and sternum - - - -	25
True vertebræ - - - - - - - -	24
Pelvis, viz: sacrum, coccyx and innominata - -	4
Superior extremity, including scapula and clavicle -	64

* Tomes, Cyclopædia of Anat., art. *Osseous tissue.*

† Todd and Bowman, i. p. 109.

Inferior extremities, including patellæ - - - -	60
Os hyoides - - - - - - - - - -	1
	200

The sternum is a triple bone for many years after adult age, but there is a tendency to consolidation which becomes complete in after but uncertain periods of life.

The sessamoids are omitted on account of their variable number; sometimes there are two of them in each hand and two in each foot; but in other instances they are more or less. The patella is in its functions a sessamoid, but since it is always present, it should of course be retained in the enumeration.

The teeth are no longer classed with true ossific textures; and the bones of the tympanum, as well as the ossa triquetra, are by common consent, omitted in specifying the parts constituting the skeleton.

There are other circumstances that render this enumeration in some degree variable and even arbitrary; but we can adopt no better rule than to consider those only in the light of separate bones which are isolated at the time of their perfect development.

External characters.—Bones are naturally divided into three series—long, flat and round. The long bones are seen in the extremities, in which they have been compared to levers acting on each other. They consist of a shaft or diaphysis, and two extremities; the former being sometimes semi-cylindrical in form, in other instances triangular, and nearly straight. The bone swells out at its extremities, constituting at one end a head, which is spheroidal and smooth; at the other a condyle which is of irregular form, sometimes grooved or bifurcated, but also presenting one or more smooth surfaces for articulation with the contiguous bones.

The flat bones are more or less concave on the inner side and correspondingly convex on the outer surface, answering to the costa and the dorsum of anatomical nomenclature; while some bones are both hollowed out and swelled up on the same surface, as in the os innominatum. The circumference is thicker than the included part, which last is greatly modified for the accommodation of visceral organs, or by the action of the adjacent muscles.

The third series of bones, those of a rounded form, are numerous and usually aggregated, as in the wrist and tarsus; while those of the vertebral column are much more variable in conformation.

All these classes of bones present on their exterior surface a variety of prominences, depressions and foramina, which conduce either to the action of the part or to its nourishment. The ordinary smooth prominences of bones are called *processes* or apophyses, and have received specific designations from their fancied resemblance to other objects. They serve for the insertion of muscles, tendons and ligaments, and their size depends much on the activity and strength of the attached parts; not that these processes, as some anatomists have taught, are produced by the attachments; inasmuch as the former are developed, though more feebly, on bones which have never been acted upon by muscular contrac-

tion, owing to paralysis that has commenced in infancy and continued through life. *Tuberosities* are but larger and rougher processes; and *spines* are similar projections more or less elongated and pointed.

A *crista* or crest is a rounded or flattened margin placed on the periphery of a bone, something in the manner of a tire on a wheel. The crista of the ilium is the type of this conformation.

The depressions or concavities are various, being arranged into the articular and non-articular. The former, as their name implies, receive those corresponding terminal portions of bone that combine to form the joint; the deeper cavities being called *cotyloid*, and the more shallow ones *glenoid*. The non-articular cavities are seen in many fossæ, sinuses, and cells that exist in different parts of the skeleton.

Foramina are perforations in bones that either pass entirely through their parietes, or wind into their structure until, by becoming less and less in diameter, they are gradually lost to the eye. A foramen usually transmits a nerve or a blood-vessel, or several nerves; or it may serve for the attachment of the fibres of the periosteum, and thus indirectly for the ligaments themselves.

Bones present certain smooth surfaces, where the muscles play freely over them, as in the instance of the anterior face of the os femoris; in other places they have rough, unequal margins, or prolonged ridges, to which ligaments or tendons are attached.

Internal structure.—A longitudinal section of any long bone, but especially of the humerus or tibia, exhibits two very different arrangements of osseous fibre, one of which is called the compact, the other the cellular substance.

In the compact structure the fibres are so closely applied as to assume the hardness of ivory, the interstices being hardly perceptible to the unassisted eye. This solid tissue is most evident in the middle of the shaft of long bones, whence it gradually diminishes towards their extremities; but all bones, whatever their form, have an exterior layer or periphery of the same nature, although it is often extremely thin.

The true character of this compact bone has already been explained, with its corpuscles of Purkingé, and Haversian canals. To the latter is due the longitudinal arrangement of the fibres of long bones, and indeed, the irregularly fibrous character of other bones. Hence it is that in bones of rounded or flattened form, the fibrous appearance is often absent, owing to the fact that the canals do not run parallel to the surface, but are directed towards the articular and other surfaces. This point, although long maintained by the majority of anatomists, was denied by others; but recent investigations into the course and character of the Haversian canals, as already explained, has entirely settled this question. The fibres, besides being longitudinal, as in the femur, are constantly intersected by others which take a transverse or oblique course, and the latter are of perpetual occurrence in all the rounded and irregular bones. This arrangement of the fibres is admirably shown by immersing the compact part of any one of the long bones in diluted muriatic acid until the earthy matter is removed, when the filaments and fasciculi of the animal portion can be separated with the utmost

facility. It is also then manifest, that the long bones are not only composed of longitudinal fibres, but that these last give rise to a laminated structure that commences at the periphery and extends to the medullary canal; and the same is true of every component ossicle. The exterior laminæ are readily separable, while the inner ones adhere to each other with more tenacity. These laminæ, which enclose one another, and are of course more or less concentric, are also seen in bone that has partially decomposed by exposure to the air; but is more especially evident under the microscope.

The internal structure of bones is arranged in a cellular manner, called its spongy or cancellated texture. The cells are of irregular form, delicate and open in the central cavities of long bones, where they have a finely reticulated appearance. Their number increases towards the ends of the bones; the laminæ of which they are composed unite in every possible direction, and the cells thus formed communicate freely with each other.

The ends of the long bones are composed entirely of these cells, excepting an exterior layer of compact texture; and the same remark is true of all the round and flat bones. The cells, or cancelli, in common with the cylindrical cavities of bones, are lined by a most delicate web-like tissue called the medullary membrane or internal periosteum, which contains the medulla or marrow, and is a medium of transit for the blood-vessels.

Composition.—When bone has reached its mature state in the adult person, it is found to consist of two parts of earthy to one of animal matter; a fact that may be readily ascertained independently of chemical analysis. If one of the long bones, for example, be immersed for many days in diluted muriatic acid (one part of acid to seven of water), all the earthy matter is removed, and nothing remains but the animal structure, which possesses the color and consistence of cartilage, and retains the perfect conformation of the original bone. Again, if a section of it be examined under the microscope, it is seen to possess all the minute apparatus of osseous structure, as seen in the Haversian canals, the corpuscles of Purkingé and the intermediate tubuli.

If, on the other hand, a bone be subjected to the action of heat, its animal texture is destroyed and the earthy matter alone remains; and in this as in the former instance, the preparation retains the exterior form of the unaltered bone, while the microscope reveals the whole apparatus of lacunæ and canals.

The chemical analysis of bone presents, according to Berzelius, the following results:

Soluble animal matter - - - - -	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 chloride of lime - - - - -	1·20
	100·00

The presence of fluate of lime in bones has been denied by some chemists; Fourcroy and Vauquelin could never detect it; but they met with some iron, manganese, silex, alumine and phosphate of ammonia. Does the composition of the adult bone vary with age, diet and other circumstances? Does the bone of the Hindoo, who throughout life has eaten nothing but rice, present the same constituents as that of the Esquimau, who lives exclusively on animal food? Some nations eat little else than fish; others, roots; and the Ottomacs of the Orinoco combine an unctuous clay with all their aliments, and which to them seems to answer the purpose that salt does with other nations. These customs may possibly modify the chemical constituents of the bones.

These relative proportions of animal and earthy matters are subject to great variation in the different periods of life. Thus, while in childhood the animal matter is greatly in preponderance, the experiments of Schreger show that in old age the earthy constituents make up seven-eighths of the whole structure. Hence the strength and resistance of the bones in the one case, and their brittleness in the other; hence also the cause of their speedy restoration after fractures; and, on the other hand, the difficulty or even impossibility of restoration after such accidents.

It is obvious that the earthy or inorganic matter is designed to give to bone its requisite strength and solidity; while the animal or organic part is the medium of growth and reproduction, at the same time that it tempers the fragile character of the other ingredients, and thereby augments their strength, and their power of resisting external injuries.

Periosteum.—This name is given to a strong, white, fibrous membrane that closely envelops all the bones excepting such parts of them as are covered by cartilage; yet even at the joints it may be traced over the capsular ligaments; thus realizing the opinion of the ancients, that the periosteum forms a continuous sac for the whole skeleton.

The periosteum is connected externally to the adjacent cellular substance, and thus indirectly with muscular tissue; and it is also the medium of attachment for ligaments and tendons. Its inner surface is connected with the bone by means of short, strong fibres, which enter the numberless foramina on the surface, and thus obtain a firm attachment to it. This adhesion, however, varies with age; for it is very slight in infancy and childhood, at which period the membrane may be stripped off without difficulty; but in old age it is only separable by violence, and will often tear before it leaves the surface of the bone.

The blood-vessels of the periosteum are numerous, and penetrate the subjacent bone in every direction through some of the numberless foramina on its surface. Its nerves have not been satisfactorily demonstrated, yet the sensitiveness of bones in an inflamed state proves that they are not destitute of nervous filaments. The presence of absorbent vessels in periosteum is also, for the most part, an inference from the changes of structure it undergoes in disease; yet a few lymphatics have been shown to exist in it.

The uses of this membrane are various. It serves to transmit blood-vessels into the bone itself; to give attachment to muscles, tendons and ligaments; it

sustains and strengthens the whole skeleton; and possesses, as we have seen, some agency in the process of ossification.

Internal periosteum, or *medullary membrane.*—The central canals in the long bones, the cavities in others, and the cells of every size and locality, are lined by a web-like membrane of extreme tenuity, called the internal periosteum, which in its healthy condition is everywhere filled with the medulla or marrow. To see the medullary membrane, the divided end of a bone should be gradually exposed to heat, so as to melt the fat, in which case the enveloping tissue thickens, collapses on itself, and becomes manifest to observation. It may also be seen by exposing a smilar section of bone with its contained medulla to the gradual action of a weak alkaline solution, which by combining with and separating the fat, exposes its envelope.

It is extremely vascular, obtaining its blood from those arteries which furnish the bones with the means of reparation and nutrition.

The contained medulla is an oily substance, much resembling ordinary fat, which is in a more fluid state in the cellular parts of long bones than in their central canals. Its characters, like those of the bone itself, differ at the different periods of life. It is thin and of a reddish tint in infancy; it has more consistence in adult life, and has been compared in this respect to butter; but in old age it becomes again more fluid and of a decided yellow color. A principal use of this substance appears to be the same as that of fat in other tissues—a resource for the nourishment of the system when the usual aliments are not available.

THE SKELETON.

In anatomy this term is proverbially applied to the collective series of bones that constitute the frame-work of the body. There are two modes of articulating these parts; one consists in retaining the ligaments, and is called a natural skeleton; in the other mode the bones are united by wire, forming the artificial skeleton. The whole structure is divided into the head, trunk, superior and inferior extremities.

No exterior views of the skeleton are capable of exposing all its parts; for some are so deep-seated as to be only very partially visible in their natural position, as those of the interior of the face.

Nor in the study of the skeleton can any drawings possibly supersede the careful examination of the bones themselves, which ought to be accessible to every learner: I have thought best, however, to illustrate most of them by plates; yet can assure the student that he who derives his knowledge of these important organs from the latter sources alone, can never fully understand their intimate structure or relative position; a remark that is especially true of the many parts that enter into the composition of the head and face.

BONES OF THE HEAD.

The head is formed of two parts, the cranium and face; the former being composed of six bones, and the face of fourteen; while two are regarded as common to both the cranium and face. Of the six bones of the skull, two are single, viz., the frontal and occipital; the other four are in pairs—the parietal and temporal.

THE OS FRONTIS.

The frontal bone, as its name implies, constitutes the anterior portion of the cranium, and forms, besides the forehead, part of the temporal region, and the roof of the orbitar cavities. It is connected by sutures with the parietal, ethmoidal and sphenoidal bones of the cranium, and with the malar, superior maxillary, nasal and unguiform bones of the face.

It is very convex externally, and correspondingly concave within. It terminates posteriorly in an angle that joins by suture with the parietal bones, and its anterior, inferior margin is arched for the orbits of the eyes. This arch is extended on each side between the two angular processes; the outer one, called the external, the inner one the internal angular process. The arch, which is the superciliary ridge, is sharp at its under edge; but above it the bone becomes tumid, especially at its inner margin, and forms the superciliary protuberance, which is slightly developed in childhood, but becomes prominent in adult age, and more especially among savages. Behind it and within, are the frontal sinuses, of which more will be said in another place.

Just at the inner third of the superciliary ridge, is a notch, sometimes a foramen, called *supra-orbital*, which gives passage to the supra-orbital artery, veins and nerve. At the inner side of this foramen is a small depression made by the tendon of the superior oblique muscle where it plays upon its trochlea.

Extending backwards from the superciliary ridge is the *orbitar process*, concave without and convex within, and in length upwards of an inch and a half; it is extremely thin and diaphanous, and terminates behind by a ragged edge that joins the sphenoid bone. The outer part of the orbitar process is deeply excavated, and gives lodgment to the lachrymal gland.

In a direction obliquely upwards from the external angular process, is a rough angular prominence, which is the commencement of the *temporal ridge*, and in part the origin of the temporal muscle.

The *nasal spine* projects downwards between the internal angular processes, having above and on each side a rough surface for the reception of the root of the nasal bones.

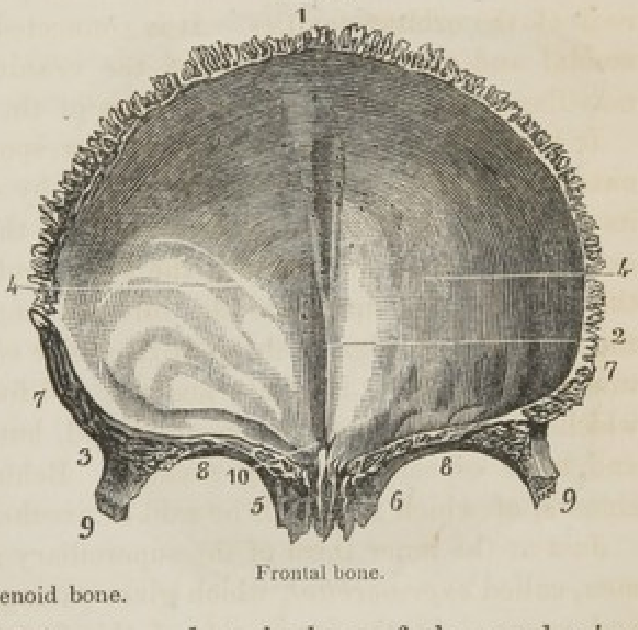
Behind the nasal spine, and between the inner margins of the orbitar processes, is the *ethmoidal fissure*, broken at its edges into cells, which by joining with corresponding concavities in the ethmoid bone, complete the ethmoidal cells. The latter, at the base of the nasal spine, present two rounded openings which communicate with the frontal sinuses.

The os frontis is divided in early infancy into two equal parts, by a median

suture running from the nasal spine to the coronal suture; but when the suture comes to be obliterated in the progress of ossification, its former position is often marked by a corresponding ridge of bone. On each side of this ridge, and giving lateral prominence to the forehead, is the *frontal protuberance*, full and convex in childhood, but much less prominent in the majority of grown persons. It constitutes the principal centre of ossification for the frontal bone.

If we now examine the internal surface of the os frontis, it will be observed strongly marked by the convolutions of the brain. These depressions are most distinct at the sides of the bone, and over the orbital plates, where they are called *digital fossæ*.

Fig. 17.



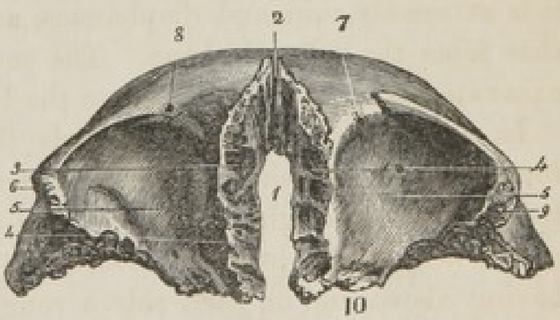
Frontal bone.

Fig. 17 represents an internal view of the frontal bone. 1, 2, groove for the great longitudinal sinus; 3, temporal fossa; 4, 4, concavity of the bone, furrowed for the lodgment of the anterior lobes of the cerebrum; 5, internal angular process; 6, frontal cells, leading to the frontal sinus; 7, point of junction with the parietal bone, called the temporal region; 8, superciliary ridge; 9, external angular process; 10, foramen cæcum.

Fig. 18. View of the frontal bone, looking into the orbits. 1, ethmoidal opening or fissure; 2, spine; 3, 4, frontal cells, leading into the frontal sinus; 5, 5, orbitar plate or process; 6, external angular process; 7, trochlea for tendon of the trochlearis muscle; 8, supra-orbitar foramen; 9, articular surface for the malar bone; 10, same for sphenoid bone.

Immediately behind the ethmoidal fissure, and at the base of the nasal spine within, is a small opening called the *foramen cæcum*, which gives attachment to a process of the dura mater, and occasionally transmits a small vein. From this foramen there extends upwards and backwards a sharp ridge which soon divides into a groove; the former gives attachment to the falciform process of the dura mater; and the groove lodges the great longitudinal sinus.

Fig. 18.



The os frontis gives insertion to the corrugater supercilii and occipito-frontalis muscles of each side.

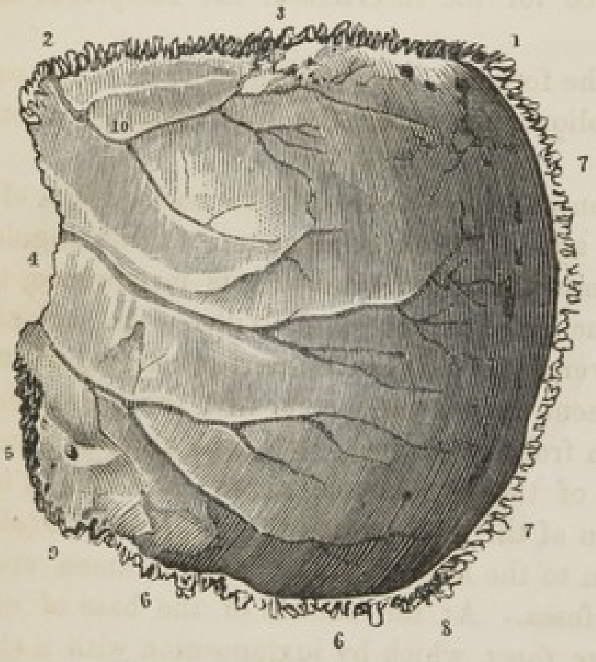
PARIETAL BONES.

The parietal bone is of a quadrangular form, convex externally, and concave within. It is broader before than behind, of a smooth and polished surface, and forms, with its fellow, the summit and part of the sides of the vault of the cranium.

The parietal bones are connected by the sagittal suture, on each side of which, an inch or more from the posterior margin, is the *parietal foramen*, for the transmission of a vein from the scalp to the great longitudinal sinus. It also sometimes conveys a small branch of the occipital artery to the dura mater.

The sagittal margin of this bone is the largest and straightest, terminating anteriorly in the frontal angle, and posteriorly in the occipital angle. Nearly parallel to the sagittal is the temporal margin, much shorter, but more curved, and terminating before in the sphenoidal, behind in the mastoid angle.

Fig. 19.



Internal view of the parietal bone.

Fig. 19, parietal bone. 1, frontal angle; 2, sphenoidal angle; 3, coronal suture; 4, 5, temporal margin; 6, 6, lambdoidal suture; 7, 7, sagittal suture; 8, occipital angle; 9, mastoid angle; 10, middle artery of the dura mater.

Some distance above the temporal margin, is seen a curved line or ridge, which is continuous with the temporal ridge of the os frontis, and like the latter, serves for the origin of the temporal muscle. The parietal bones are smooth and polished in appearance, and have nearly in the centre a very distinct convexity called the *parietal protuberance*, which is the centre of ossification in the growing state.

The internal surface, like the external, is very smooth, and everywhere marked by the diverging channels of the middle artery of the dura mater. It also contains numerous irregular fossæ for the convolutions of the brain, more deeply developed at the temporal margin of the bone. When the two sides are articulated, they form a groove the whole length of the sagittal suture for the lodgment of the great longitudinal sinus; and on each side of this are some considerable but irregular excavations for the glands of Pacchioni.

The sphenoidal, or anterior inferior angle, is connected with the sphenoid bone; it is thin and pointed, and deeply channeled for the middle artery of the dura mater. In like manner the mastoid angle is grooved for a very short distance for the passage of the lateral sinus.

Each parietal bone is articulated with five others—the occipital, frontal, temporal and sphenoid, and its fellow of the opposite side.

OCCIPITAL BONE.

This bone forms the posterior wall and part of the base of the cranium, being of a mixed oval and angular form, convex externally and concave within.

Viewed from behind, its upper surface is smooth, like the rest of the arch of the cranium, from the action of the occipito-frontalis muscle; but below this surface the bone becomes rough, and is marked by the *upper semicircular ridge*, which crosses in a doubly curved line almost from one mastoid process to the other. It gives origin to the occipito-frontalis muscle, and insertion to the trapezius and sterno-mastoid. The central part of this ridge is full and prominent, and is called the *occipital protuberance*, and running from it to the foramen magnum is a sharp ridge called the *spine*, or *crest*, which serves for the attachment of the *ligamentum nuchæ*.

About an inch below is the *lower semicircular ridge;* between which and the upper arch, is a rough, pitted surface for the insertion of the complexus and splenius capitis muscles.

Between this second arch and the foramen magnum, is another rough surface, which receives the superior oblique muscle of the neck and the rectus posticus major and minor.

The *foramen magnum* forms a conspicuous feature of this bone. It is of a rounded or oval form, about an inch and a quarter in diameter, with an angular, smooth margin. It serves to transmit the spinal cord and its membranes, the vertebral and spinal arteries, and the accessory nerve of Willis. On each side of the foramen magnum and converging towards its anterior margin, are two oblong, convex *condyles*, which present an articular surface for the corresponding parts of the atlas vertebra. In front of the condyle is the *anterior condyloid foramen*, for the transmission of the hypoglossal nerve; and behind is a smaller and less constant perforation of the bone, called the *posterior condyloid foramen*, for the passage of a vein to the lateral sinus. This foramen opens into the upper part of the jugular fossa. At the outside of the base of each condyle is a large notch, the *jugular fossa*, which by juxtaposition with a similar fossa in the temporal bone, forms the *posterior foramen lacerum*, for the course of the internal jugular vein, and the pneumogastric, glosso-pharyngeal and accessory nerves.

In front of the foramen magnum, and forming the anterior termination of the occipital bone, is the *basilar process*, having in its centre a rough surface for the attachment of the upper and middle constrictor muscles of the pharynx.

The internal face of the occipital bone presents the following appearances. In its centre is the *internal occipital protuberance*, from which are given off four ridges, which constitute the *occipital cross:* the upper one is superficially grooved for the longitudinal sinus, and each of the horizontal limbs is excavated for the corresponding lateral sinus. The inferior ridge, which terminates at the foramen magnum, is more elevated and sharper than the others, and serves for the attachment of the lesser falciform process of the dura mater. Between the limbs of the cross, the bone is smooth, hollowed and sinuous for the accommodation of the cerebellum and the posterior lobes of the cerebrum.

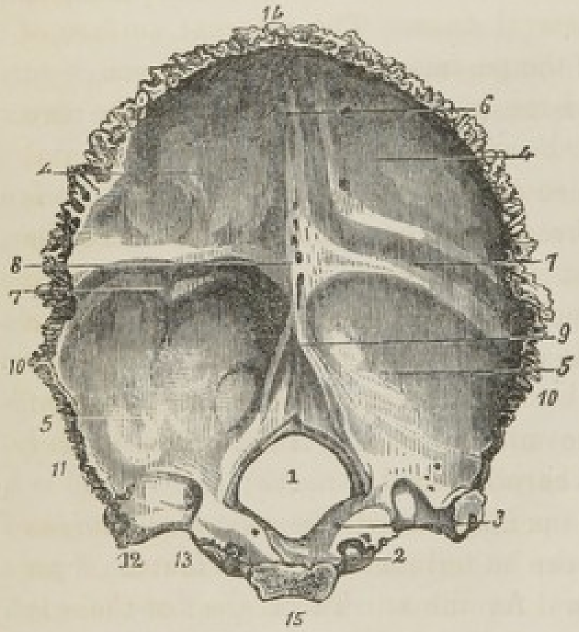
At the lowest part of the bone, on each side of the foramen magnum, is a short deep channel, continuous with that of the temporal bone, for the terminal end of the longitudinal sinus just before it passes through the jugular fossa.

The basilar process, as prolonged in front of the foramen magnum, is concave, for the support of the medulla oblongata; and this surface, at its anterior extremity, becomes continuous with the clivus of the sphenoid bone.

There are four angles to the occiput; the superior, which is received between the parietal bones; the two lateral, terminating at the mastoid portion of the temporal bone; and the inferior, which is the end of the basilar process.

The occiput is connected with six bones—the parietal, temporal, sphenoid and atlas. Its surfaces, especially the external one, are marked by many inconstant foramina for the transmission of blood-vessels to the diploic structure.

Fig. 20.



Occipital bone.

Fig. 20 is an internal view of the occipital bone. 1, foramen magnum; 2, basilar process, excavated for the medulla oblongata; 3, anterior condyloid foramen; 4, concavity, *cerebral fossa*, for the posterior lobe of the cerebrum, on each side; 5, concavity for lodging the lobe of the cerebellum; 6, superior limb of the occipital cross, grooved for the longitudinal sinus; 7, 7, transverse ridge of the occipital cross; 8, the internal occipital protuberance, with a slight depression for the torcular Herophili; 9, inferior limb of the cross, which bifurcates below; 10, angle at which the occipital joins the temporal bone; 11, the lesser lambdoidal suture, which extends between 10 and 13; 12, groove for the lateral sinus, which terminates at 13, in the jugular fossa; 14, superior angle of the occiput; 15, anterior end of the basilar process, which articulates with the body of the sphenoid bone.

TEMPORAL BONES.

The *os temporis* of either side forms a large part of the lower and lateral surface of the cranium, and in some measure contributes to its base. It is composed of three dissimilar parts, called the squamous, mastoid and petrous portions.

The *squamous portion*, forming the upper and anterior expansion, is semicircular at its margin, which is thin and broad for articulation with the parietal bones. Its outside is smooth from the action of the temporal muscle, and it sends off below a flattened, incurved process of an inch in length, called the *zygomatic process*, which goes directly forward to join a similar production from the malar bone. At the base of the zygomatic process below, is the *tubercle*, to which is attached the external lateral ligament of the lower jaw; and from the tubercle and extending inwards is the *articular ridge* bounding the *glenoid cavity* in front. This cavity, which receives the condyle of the lower jaw, is bounded behind by the basal surface of the petrous portion of the bone, from which it is separated by the *glenoid fissure*, or *fissura Glasseri*. This fissure consists of a series of very small foramina connected by intervening slits in the bone, which give passage to the corda tympani, the anterior artery of the tympanum, and the laxator tympani muscle.

The inner side of the squamous portion presents a number of elongated concavities for the convolutions of the brain; and at the anterior and inferior margin, is a bifid channel for the middle artery of the dura mater.

The *mastoid portion* is behind, thick and strong, and tapering downwards into a rounded end or edge: this is called the mastoid process. Its surface is rough for the attachment of the occipito-frontalis, splenius, sterno-mastoid, trachelo-mastoid and digastric muscles. If divided, the mastoid portion is found to be full of cells which communicate with each other and with the cavity of the tympanum. At the base of this process is a groove an inch in length called the *digastric fossa*, from the circumstance of its lodging the digastric muscle. In the suture between the mastoid portion and the occipital bone, is the *mastoid foramen*, for transmitting a vein to the lateral sinus. The internal surface of the mastoid portion is deeply grooved for the passage of the lateral sinus.

The *petrous portion* of the temporal bone is joined at its base to the two other portions, whence it projects forwards and inwards, and in a horizontal direction, into the cavity of the cranium, so as to form part of its base. It is triangular in shape, and consequently presents three surfaces. The *anterior surface* has a principal point of interest in the groove leading to a foramen called the *hiatus Fallopii* or Vidian foramen, for the transmission of the Vidian nerve. This surface is also marked by the convolutions of the brain. Directly beneath the hiatus Fallopii is another and smaller foramen for the reception of the lesser superficial petrosal nerve. The anterior part of this surface is very thin, and bounds the terminal end of the carotid canal.

The *posterior face* has a large, oblique opening called the *meatus auditorius internus*. When closely observed, it is seen to terminate about a fourth of an inch from the surface of the bone, in several foramina. The largest of these is the aqueduct of Fallopius, for the passage of the facial nerve; but the lesser foramina give transit to the auditory nerve in its course to the labyrinth of the ear. Behind this, in the direction of the mastoid process, the bone is slit and a foramen is formed leading to the vestibule, whence its name of the *aqueduct of the vestibule*. It transmits a small artery and vein of the vestibule.

Above and somewhat behind the meatus internus, is a small foramen entering a fissure of the bone, which serves to conduct a vein from the interior of the petrous bone.

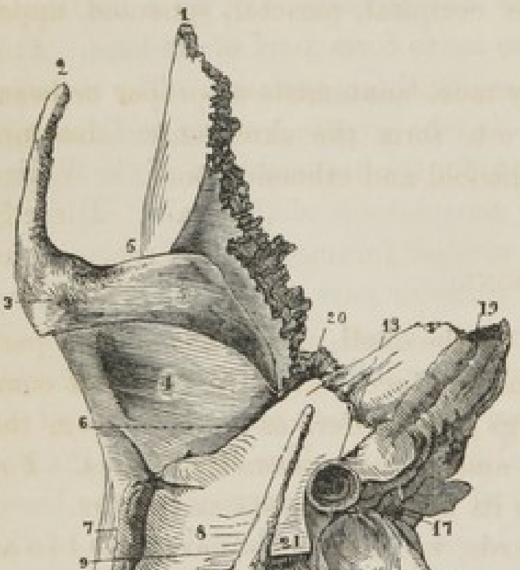
The *inferior* or *basal surface* of the petrous portion is rough, and remarkably sinuous. A sharp, angular spine that proceeds from it vertically downwards, is the *vaginal process*, which is sometimes considerably elongated, so as to deepen the glenoid fossa and form a barrier for the carotid artery as it enters the canal of that name. It is sometimes bifurcated, so as to present a double process, separated by a concave edge. At the base and outer side of the vaginal process, is the *styloid process*, round, slender, and upwards of an inch in length. It gives origin to the three styloid muscles. The styloid process is cartilaginous in infancy, and partially so during many years of early life; from which cause, and from its delicate conformation, it is often deficient.

Between the styloid and mastoid processes is the *stylo-mastoid foramen*,

through which the facial nerve escapes in its course to the side of the face. About half an inch in advance of this foramen, and at the base of the vaginal process, is a large foramen called the *carotid canal*, the size of a quill; which after a curved course through the petrous bone, opens at its anterior and terminal end. This canal gives passage to the carotid artery from the side of the neck to the interior of the cranium; and also serves to transmit and protect the carotid plexus of nerves.

Between the vaginal process on the outside, and the opposite and inner margin of the bone, is the *jugular fossa*, which joins a corresponding excavation of the occipital bone to form the *posterior foramen lacerum*, for the passage of the jugular vein and the eighth pair of nerves. A projection of bone called the *jugular ridge* forms a partial septum in the fossa, and terminates behind in a spinous projection called the *jugular process*. The ridge and process separate the internal jugular vein from the eighth pair of nerves; the former lying at the outer side.

Fig. 21.



Basal view of the petrous bone.

Fig. 21 is a basal view of the petrous portion, drawn by my son, J. S. Morton, from an adult bone. 1, anterior angle of squamous portion; 2, zygomatic process; 3, tubercle; 4, glenoid cavity; 5, articular ridge; 6, fissure of Glasser; 7, meatus auditorius externus; 8, plane surface for lodging part of the parotid gland; 9, styloid process; 10, mastoid process; 11, stylo-mastoid foramen; 12, digastric groove; 13, tympanic foramen; 14, jugular fossa; 15, jugular ridge; 16, jugular process or spine; 17, aqueduct of the cochlea; 18, basal orifice of the carotid canal; 19, terminal orifice of the carotid canal; 20, bony orifice of the Eustachian tube; 21, vaginal process.

It will thus be seen that the jugular fossa is bounded before by the vaginal process; behind by the jugular process; the latter is generally prolonged in the forward direction, and has at its anterior and basal margin, an irregular foramen called the *aqueduct of the cochlea*, from its communication with the internal jugular vein. It transmits a vein from the cochlea to the cavity of that name.

Behind the vaginal process, between it and the foramen stylo-mastoideum, is the *tympanic foramen*, for transmitting the tympanic branch of the pneumogastric nerve.

At the outer extremity of the petrous bone is the *meatus auditorius externus*, leading to the cavity of the tympanum. It is rounded or oval, more than a

quarter of an inch in diameter, having its margin marked by a rough ridge or ring of bone called the *auditory process*, which gives attachment to the cartilage of the ear. Below this external opening of the ear and on the under surface of the petrous bone, is a large, smooth, plane surface, continuous with the glenoid cavity, from which it is separated by the fissura Glasseri, already mentioned. If the fissure be traced to its termination, where the squamous and petrous portions meet, the angle thus formed between the bones presents a foramen which is the orifice of the *Eustachian tube.* The latter is divided by a thin plate of bone into two canals; the upper one lodges the tensor tympani muscle, and the lower forms part of a channel of communication between the cavity of the tympanum and the posterior fauces.

The upper margin of the petrous bone is irregularly angular, and marked by a slight groove for the *superior petrous sinus;* and it also gives attachment to that process of the dura mater called the tentorium.

The temporal bone articulates with the occipital, parietal, sphenoid, upper maxillary and malar bones.

The preceding six bones are described by most anatomists as proper or peculiar to the cranium; two others which serve to form the skull, enter also into the structure of the face; these are the sphenoid and ethmoid bones.

SPHENOID BONE.

The *sphenoid bone* is placed at the base of the skull, and forms a large part of the septum between the cranial cavity and the face. Its form has been compared to that of a bat with extended wings; but it derives its name from the manner in which it is wedged between and among the surrounding bones. For the purpose of description it is divided into its body, processes and wings.

The body presents a small surface upwards, which is deeply excavated so as to form the pituitous fossa, *ephippium*, or *sella turcica*, from its resemblance to a Turkish saddle. It gives lodgment to the pituitary gland; and has continuous with it, in the lateral and backward direction, a groove for the carotid artery as it ascends into the cranium from the end of the petrous bone. The sella turcica is bounded in front by a slightly grooved ledge of bone, the *processus olivaris*, that sustains the optic nerve, and behind by an elevated lamella of bone, prominent at the corners, which last are called the *posterior clynoid processes.*

From the posterior clinoid processes, the posterior surface of the body of the bone is extended downwards in a smooth but slightly concave manner, called the *clivus*, which is continuous with the basilar process of the sphenoid bone. The clivus supports the pons Varolii.

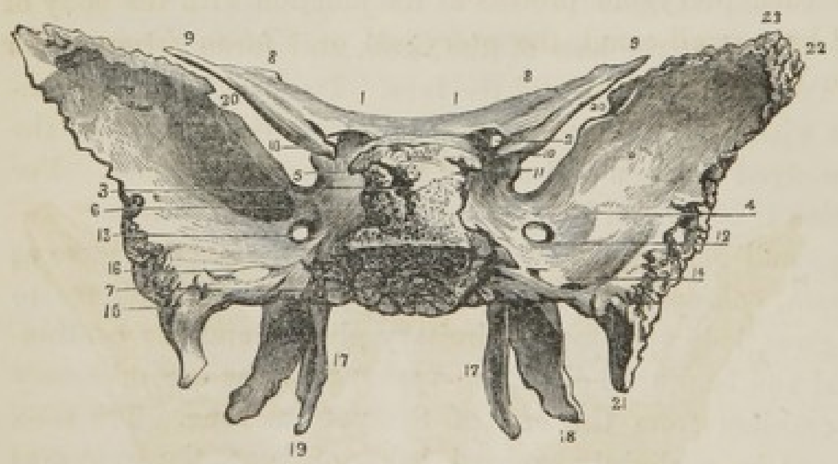
The anterior face of the body is placed between the pterygoid processes, and gives off a broad, sharp spine, called the *azygos process*, which is directed obliquely downward and forward to be received into the base of the former, and is continued forward to join the nasal plate of the ethmoid bone. On each side of the azygos process are the *sphenoidal cells*, with orifices presenting anteriorly

by which they communicate with the nasal cavity. These cells do not exist in infancy, but are gradually developed with the rest of the skeleton, and often attain a great size in advanced life. They are separated by a delicate partition which joins in front with the central lamella of the ethmoid bone.

The *great wings* of the os sphenoides, arise from the body of the bone, and project outwards, upwards and forwards, so as to present three surfaces—one anterior, one external and one internal. The *anterior surface* is smooth and lozenge-shaped, inclines outwards and forms a part of the external parietes of the orbit. The *external surface* is smooth and slightly hollowed, and forms part of the lateral surface of the cranium and also of the temporal fossa. The *internal surface* runs upwards and forwards, is smooth, and deeply concave for the reception of the middle lobe of the brain. These wings have at their summit a very rough surface for articulation with the frontal bone.

The *lesser wings*, or apophyses of Ingrassias, arise from the upper, anterior part of the body. Each wing is a triangular plate of bone that runs outwards and slightly forwards, until it terminates in a sharp point. Their anterior edge is joined to the ethmoid and frontal bones; but posteriorly they are rounded or pointed into two terminations called the *anterior clinoid processes*, which are perforated at the base by the optic foramen.

Fig. 22.



Posterior view of the sphenoid bone.

1, 8, 9, lesser wings; 2, optic foramen; 3, clivus; 4, 6, concavity of greater wings, for lodging the middle lobe of the brain; 5, 11, posterior clinoid processes; 7, basilar or cuneiform suture; 10, anterior clinoid process; 12, 13, foramen rotundum; 14, 16, foramen ovale; 15, foramen spinale; 17, 17, internal pterygoid process; 18, external pterygoid process; 19, trochlea of the internal pterygoid process; 20, 20, superior (or anterior) foramen lacerum; 21 to 22, suture for the squamous portion of the temporal bone; 23, suture for the os frontis.

Turning again to the anterior surface of this very complicated structure, we see the *pterygoid processes*, one on each side, projecting downwards from the base of the greater wings. Each of these is again divided into two lamellar portions which are given off at an angle equidistant between the origin and termination of the process. The *internal plate* is the longest and narrowest, and is prolonged into a small hook-like or *hamular process* on which plays the tendon of the tensor palati muscle. At the base of the internal plate is a small fossa from which arises the tensor palati muscle; and the groove between the two plates gives origin to the internal pterygoid muscle. The outer face of the external plate forms part of the parietes of the zygomatic fossa.

The best mode of obtaining a just idea of the *foramina* is to look at the bone from behind. The first of them is the *optic foramen*, for transmitting the optic nerve. It runs forwards and outwards through the lesser wing, at the base of the anterior clynoid process, in order to reach the orbit of the eye. Between the optic foramina is a smooth ledge of bone called the *processus olivaris*, on which rests the commissure of the optic nerves.

The second of these perforations is rather a fissure than a foramen; it is placed between the greater and lesser wings, is triangular in shape, and opens directly into the orbit in front. It is called the *foramen lacerum superius*, or the sphenoidal fissure, and gives transit to the third, fourth and sixth nerves, to the first or ophthalmic branch of the fifth, and to the ophthalmic vein.

Immediately below is the *foramen rotundum* perforating the base of the greater wing in front, and coming out at the lower margin of the orbit. It transmits the second branch of the fifth pair of nerves to the upper jaw.

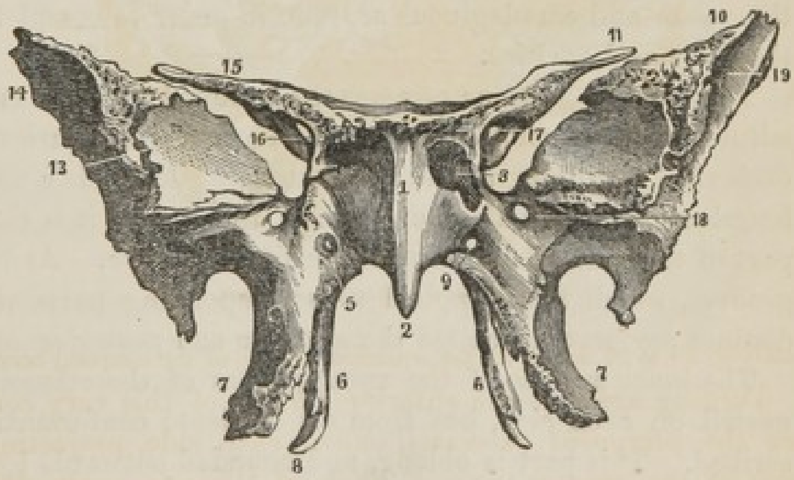
Yet lower down, and also perforating the greater wing, is a larger canal called the *foramen ovale*. It opens in front at the base of the pterygoid process, and conveys the inferior maxillary nerve (third branch of the fifth pair) on its course to the lower jaw.

At the posterior angle of the greater wing, and in close proximity to the foramen ovale, is the *foramen spinale*, for the transmission of the middle artery of the dura mater, which enters the cranium at this point.

Finally, the base of each pterygoid process at its junction with the body of the bone, is perforated by a small canal, the pterygoid or *Vidian foramen*, for the transmission of the Vidian nerve.

1, 2, azygos process; 3, sphenoidal cells; 5, 9, Vidian or pterygoid foramen; 6, 6, internal pterygoid process; 7, external pterygoid process; 8, hamulus, or trochlea of the internal pterygoid process; 10, suture for the os frontis; 11, 15, lesser wings; 14, suture for the squamous portion of the temporal bone; 16, 17, foramen opticum—these two figures mark the superior foramen lacerum of each side; 18, foramen rotundum; 19, temporal fossa, being the external surface of the greater wing.

Fig. 23.



Front view of the sphenoid bone.

The os sphenoides articulates with twelve bones, viz., all those of the head, and with the palate, malar and vomer of the face. It has at least twelve points of ossification—two in each greater wing, two in the lesser wing, and two in the pterygoid process. It gives attachment to twelve muscles: to the four recti, around the optic foramen in each orbit; from the same point also arise the

superior oblique and the levator palpebræ muscles. The temporal muscle is attached to the exterior surface of the great wing; the external pterygoid process gives origin to the external pterygoid muscle, and the fossa between the pterygoid plates to the internal pterygoid; the superior constrictor of the palate comes from the inferior half of the inner pterygoid plate; the fossa and navicularis gives off the circumflexus palati; and the spinous process the laxator tympani.

THE OS ETHMOIDES.

The ethmoid is of a cuboidal form and composed of thin lamellæ which meet in various directions, giving the whole structure a light, cellular or cavernous character. It is firmly embraced between the orbitar processes of the os frontis, and attached to the sphenoid behind. Its most striking features are the cribriform plate, a central lamella, and two lateral scrolls of bone.

The *cribriform plate* fills up the vacancy in the os frontis in front. It is oblong, horizontal, slightly concave, and perforated by many foramina for the transmission of the fibres of the olfactory nerve, which last is lodged in an elongated groove on each side of the crista galli.

The *crista galli* is a thick smooth, angular process that rises from the fore margin of the cribriform plate to the height of half an inch. It gives attachment to the beginning of the falciform process of the dura mater; and immediately in front of it and contiguous to the os frontis, is the *foramen cæcum*, which is usually formed by the junction of both bones.

The crista galli perforates the cribriform plate longitudinally, and forms below the *nasal lamella*—a thin plate of bone that descends vertically to join the vomer and cartilaginous septum, in order to complete the partition between the two nasal cavities.

The *cellular portions* commence at the sides of the cribriform plate, and constitute, as already noticed, an open cavernous structure of great delicacy. From each side, beginning at the upper margin, descends a smooth lamella, the whole length and about half the depth of the bone: it is the *os planum*, and forms part of the inner parietes of the orbit of the eye. At its upper margin are two grooves, which when applied to corresponding parts of the frontal bone, form distinct perforations called the anterior and posterior orbitar foramina.

The inner surface of the spongy mass of the ethmoid, forms the wall of the nostril on each side, but from its intricate conformation it is not readily described. This part is oblong, and bounded outwards by the os planum; it contains the *ethmoidal cells*, which communicate freely together, and also with the frontal sinus and nasal cavity of the corresponding side. Looking at the ethmoid from behind, we see immediately beneath the cells a deep, curved excavation that runs forwards half the length of the bone, facing the nasal lamella. This fossa is the *upper meatus* of the nose; and it is bounded above by a very delicate bony scroll that curves inwards and forms the *upper turbinated bone*. The floor of the upper meatus is formed by a second and much larger scroll

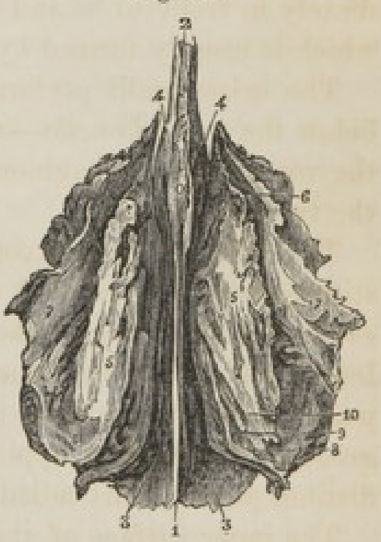
that is convex within and concave without, with a rough, spongy and rounded inferior margin; this is the *middle turbinated bone;* and the long, horizontal sinus embraced within its curvature and open outwardly, is the *middle meatus* of the nose, into which the anterior cells discharge; the posterior cells communicate with the upper meatus.

At the junction of the cribriform plate with the sphenoid bone, thin plates of bone pass down upon the body of that bone, one on each side of the azygos process, diminishing the opening into the sphenoidal cells. "These plates," observes the late Professor Wistar, "are sometimes triangular in form, the bases uniting with the cribriform plate. They have been described very differently by different authors, some considering them as belonging to the os ethmoides, others to the sphenoid bone. To the perfect ethmoid bone there are attached *two triangular pyramids*, in place of the triangular bones; these pyramids are hollow, and the azygos process of the os sphenoides is viewed between them. One side of each pyramid applies to each side of the azygos process; another side applies to the anterior surface of the body of the sphenoid bone, in place of the ossa triangularia; and the third side is the upper part of one of the posterior nares. There are two apertures in each of these pyramids; one at the base opening directly into the nose, near the opening of the sphenoidal sinuses in the bones of adults; and the other in each of the sides in contact with the azygos process." These are the pyramids of Wistar.

These pyramidal bones were described with much accuracy by Bertin, a French anatomist, about a hundred years ago, whence they have also been called the *cornua Bertini.*

Fig. 24 gives a view of the inferior aspect of the ethmoid bone. 1, posterior end of the nasal lamella; 2, its anterior extremity; 3, 3, posterior margins of the cribriform plate, and the fissure, on each side, separating the nasal lamella from the lateral, spongy portions of the bone; 4, 4, anterior portions of the same fissures; 5, 5, middle spongy or turbinated bones; 6, upper meatus of the nose; 7, curved lamellæ or scrolls of bone that bound the upper meatus above; 8, 9, posterior opening of the upper meatus; 10, point at which the superior meatus communicates with the posterior ethmoidal cells.

Fig. 24.



The ethmoid bone.

The ethmoid bone articulates with the frontal and sphenoid of the cranium; and with the nasal, upper maxillary, lachrymal, palate, vomer and lower turbinated bones of the face.

BONES OF THE FACE.

The bones of the face are placed at the anterior and inferior part of the cranium. They are fourteen in number, and contain cavities for the accommodation of the organs of sight, smell and taste, and the organs of mastication. Thirteen of these bones are included in the upper maxillary structure, viz., two

upper maxillaries, two malars, two unguial, two palate, two nasal, and two inferior spongy bones, and a vomer. The lower jaw consists of a single bone, the lower maxillary.

SUPERIOR MAXILLARY BONES.

These bones essentially constitute the upper jaw, and give the whole face its characteristic prominence. They are convex in front, concave at the sides, pointed above, open at the nostril and hollow within; and they assist in forming the orbit, nose, cheek and palate.

The *anterior and lateral surface*, that which presents in a front view, is irregularly concave and convex, having at its lower margin an undulated appearance from the bulging of the alveolar sockets of the teeth. One of these depressions, immediately below the meatus of the nose, and between the first incisor and the cuspid teeth, is sometimes called the *sub-nasal fossa;* and another depression behind the root of the canine tooth, is the *canine fossa.* Above, the surface is hollowed out, and terminates in an angular ridge that forms part of the rim of the orbit of the eye: this ridge expands outwardly into a spinous and triangular surface that articulates with the malar bone, and is therefore called the *malar process.* Behind the last tooth the bone has a rounded termination called its *tuberosity*, or boss; between which and the malar process is a smooth excavation for the play of the temporal muscle. Where the bone joins its fellow in front and in the centre of the nostril is the *nasal spine;* from this point there is an open curvature outwards; and the bone, ascending towards the forehead, terminates in the *nasal process*, roughened above for articulation with the os frontis. The two nasal processes are separated by a triangular opening of which the apex is upwards; this opening, of an inch in length, is occupied by the nasal bones. The external side of the nasal process is grooved, and forms part of the cavity for lodging the lachrymal sac.

From the anterior rim of the orbit, commences a lamina of bone slightly hollowed before, and running backwards in an oblique direction and in a triangular shape: this is the *orbitar process*, which forms the roof of the antrum Highmorianum and part of the floor of the orbit. Between it and the spinous process of the nose is a semicircular deficiency for the os unguis; and at its outer and posterior margin is a groove in the bone that leads to a canal between the lamellæ of the orbitar process; this passage is the *infra orbitar canal*, which opens on the front a quarter of an inch below the orbit, at the *infra-orbitar foramen*, for the transmission of the infra-orbitar nerve and an artery.

Within, this bone is deeply excavated to form the nasal cavity, of which the floor is formed of the *palate process* on each side. These processes are thin and diaphanous, and united in the median line by the *palate ridge*, a sharp, elongated process that terminates in front at the *nasal spine*, and behind at the palate bones, and gives attachment to the inferior edge of the vomer. The palate processes, with the corresponding parts of the palate bones, form the floor of the nose and the roof of the mouth. At their junction in front, imme-

diately behind the nasal spine, is the *foramen incisivum*, which contains a branch and a ganglion of the spheno-palatine nerve.

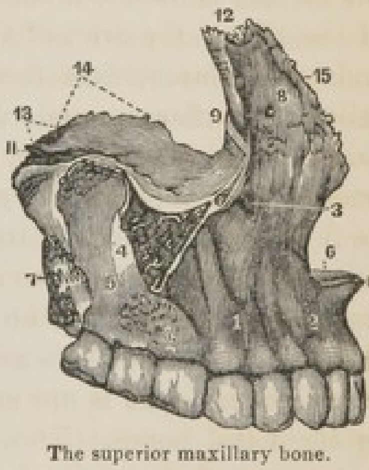
On the inner side of the spinous process is an oblique ledge of bone for sustaining the anterior end of the lower turbinated bone; and behind and on a line with it is an opening the size of a quill leading into the *antrum Highmorianum*, in the body of the bone. This cavity, called also the maxillary sinus, is lined by mucous membrane and furrowed for the passage of the branches of the superior maxillary nerves to their respective teeth.

The under surface of the palate process is concave to form the cavity and roof of the mouth; the *foramen incisivum* is seen opening behind the incisor teeth; while the process itself is articulated with its fellow by the broad and serrated surfaces of the palatal ridge. Behind, the palate process articulates by a sharp edge with a similar production of the palate bone. The front and lateral margin of this process is elevated for the accommodation of the teeth, which are here received into their respective alveolar sockets.

The superior maxillary articulates with the frontal, nasal, unguiform, malar, ethmoid, palate, inferior turbinated and the vomer, and to its fellow of the opposite side.

Fig. 25 illustrates the several peculiarities of the superior maxillary bone. 1, the canine fossa; 2, sub-nasal fossa; 3, infra-orbitar foramen; 4, malar process; 5, maxillary boss; 6, meatus of the nose; 7, suture for the sphenoid bone; 8, nasal process; 9, curved space for the os unguis; 10, nasal spine; 11, posterior orifice of the infra-orbitar canal; 12, summit of the nasal process, which articulates with the os frontis; 13, posterior margin of the orbitar plate, which joins the orbitar process of the palate bone; 14, margin of the orbitar plate that joins the ethmoid bone; 15, anterior edge of the nasal process, which articulates with the nasal bone.

Fig. 25.



The superior maxillary bone.

NASAL BONES.

The *ossa nasi* fill the triangular cavity between the nasal processes of the superior maxillary bone. Each bone has a broad base which tapers upwards to its termination in a rough depression of the frontal bone. The nasal bones are joined by a slightly curved median line; the opposite surfaces being much broader above than below, and slightly serrated. From their junction above and behind, the *spinous process* is given off, and projecting backwards, joins the nasal lamella of the ethmoid. The lateral edges are serrated for articulation with the upper maxillary bone on each side; the inferior margin is sharp, continuous with the cartilage of the nose, and forms an arched margin over the opening of the nares.

These bones are prominent, arched and salient in the Caucasian race; but in the Negro they are often so flat that the nose cannot be seen in profile.

OSSA UNGUES.

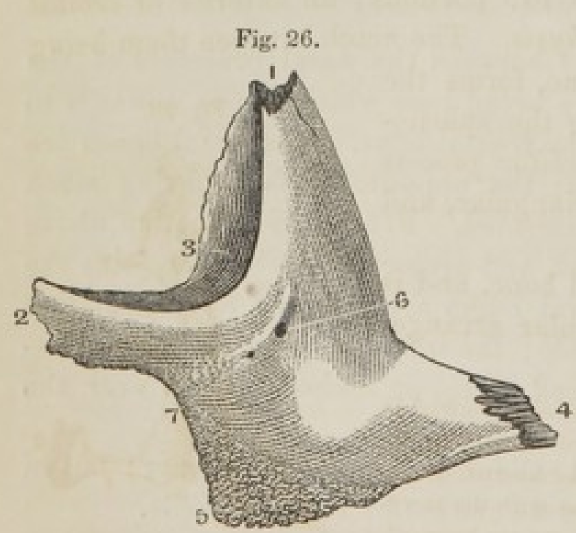
The *os unguis* is so called from its resemblance in size and shape to the finger nail. It is also called the *lachrymal* bone because it lodges the lachrymal sac. It is placed at the anterior and inner margin of the orbit. Its external surface is marked by a dividing ridge, into two portions, one forming part of the orbit by connection with the os frontis and superior maxillary bones; the other joining the nasal process of the superior maxillary to make a fossa for the lachrymal sac. The internal surface is rough, and assists in forming the ethmoidal cells and the nasal duct.

It articulates with the frontal, ethmoid and superior maxillary bones, and gives origin to the tensor tarsi muscle.

MALAR BONES.

The *ossa malarum* or *cheek bones*, are placed, as their name imports, at the fore and lateral parts of the face. They are slightly rounded and smooth in front, and concave behind, with a rhomboidal body and four angular processes. The first of these ascends vertically, joins the os frontis and forms a part of the external parietes of the orbit, whence its name of *superior orbitar* or *frontal process*. Its upper and outer surface is curved, and continuous with the temporal ridge of the os frontis, and aids in the origin of the temporal fascia; it is also excavated behind to enlarge the zygomatic fossa. From the apex of the superior orbitar process within, the rim or marginal ridge of the orbit is continued downwards and inwards until it ends in the *inferior orbitar process*, which articulates with the upper maxillary bone. That portion of the malar bone that assists in the construction of the orbit, is the *orbitar plate*. The obtuse angle at the anterior and lower part of the bone is called the *maxillary process*, from its connection with the upper jaw; and lastly, a fourth process, the *zygomatic*, presents backwards, and receives the corresponding process of the temporal bone. All these surfaces of attachment are strong and deeply serrated. Two foramina are generally observed on the anterior surface of this bone; a larger one for the passage of the temporo-malar nerve, and a smaller one for a minute artery.

Fig. 26.



Malar bone.

Fig. 26, the malar bone of the left side. 1, superior orbitar or frontal process; 2, inferior orbitar process; 3, orbitar plate, or internal orbitar process; 4, zygomatic process; 5, maxillary process; 6, foramen for the temporo-malar nerve; 7, foramen for an arterial twig.

The malar bone articulates with the maxillary, frontal, sphenoidal and temporal bones; and it gives attachment to the following muscles: levator labii superioris, zygomaticus major, zygomaticus minor, masseter and temporalis.

PALATE BONES. OSSA PALATI.

These bones are placed at the posterior nares, where they are continuous with the palate bones, and thus assist to form the floor of the nose and roof of the mouth. Each bone is divided into three parts—the palate, vertical and orbitar plates.

The *palate* or *horizontal plate* looks like an extension backwards of the contiguous palate plate of the upper maxillary; like the latter it is concave above, meets its fellow at the *palate ridge*, where the two are joined by suture, and terminates behind in a sharp semilunar edge; so that where the two bones meet a central projecting point or process is formed, called the *palate spine*, from which the azygos uvula muscle arises. The under surface is slightly concave, with a sharp ridge, to which is attached the tensor palati muscle. Where the palate process joins the superior maxillary bone, is the *posterior palatine foramen*, for the nerve and artery of that name; and the adjacent smaller foramen transmits the middle palatine nerve.

Where the palate plate terminates externally, the *vertical* or *nasal* plate begins; it rises, as its name implies, in a perpendicular direction, forming, within, the parietes of the nasal cavity, and externally concealing in part the antrum Highmorianum. On its inner surface about half way up, is a ledge or *crista*, that supports the posterior end of the lower turbinated bone. The nasal plate terminates below and outwardly in the *pterygoid process*, of a sharp, angular form, and having three distinct grooves; two for articulation with the pterygoid processes of the sphenoid bone, and the third and middle one continuous with the pterygoid fossa of the os sphenoides.

The vertical plate terminates above in an angular, laminated enlargement, which is separated by a large notch into two portions; an anterior or *orbital process*, and a posterior or *pterygoid apophysis*. The notch between them being applied to the body of the sphenoid bone, forms the *spheno-palatine foramen*, for transmitting the spheno-palatine artery, vein and nerve. The *orbitar process* looks outwardly, is small, smooth and triangular, and aids in forming the orbit of the eye.

It is spongy on the side of the ethmoid bone, and is there continuous with the subjacent cellular arrangement.

Fig. 27.

Palate bone.

Fig. 27 is a drawing of the palate bone of the right side, viewed in front. 1, 3, palate process; 2, palate ridge, terminated behind by the palate spine; 4, 5, pterygoid process; 4, groove for the internal pterygoid process of the sphenoid bone; 5, groove continuous with the pterygoid process of the sphenoid; 6, ridge for the lower spongy bone; 7, pterygoid apophysis; 8, orbitar plate; 9, spheno-palatine foramen.

The palate bone is articulated with the sphenoid, ethmoid, superior maxillary, and lower turbinated bones, with the vomer, and with the palate bone of the opposite side. It also gives attachment to four muscles; the tensor palati, and azygos uvulæ, and the internal and external pterygoids.

INFERIOR SPONGY BONES. OSSA TURBINATA.

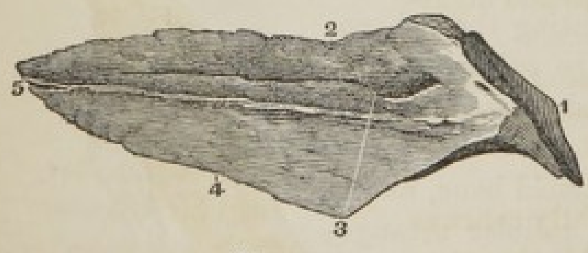
The lower spongy bone is of a light, porous structure, and shaped like a scroll. It is broad in front, where it rests on a ledge of the upper maxillary bone, and tapering behind, where it rests on a similar projection of the palate bone. The anterior of these portions has several small, laminated plates, one of which joins the os unguis within and aids the formation of the ductus ad nasum; another plate assists in closing the antrum. Where this bone faces the septum narium, it is convex and thin, forming, above, the floor of the middle meatus of the nose. Its under edge is straight and horizontal, thicker and more porous than the rest of the bone, and delicately furrowed for the attachment of the mucous membrane. It articulates with the ethmoid, palate, superior maxillary and unguial bones.

VOMER.

This bone derives its name from some resemblance to a ploughshare. It forms an elongated triangle, thin, furrowed on the sides, and nearly destitute of diploic structure. Its upper or sphenoidal margin is the broadest, and has a triangular groove for articulation with the azygos process of the sphenoid bone; and the expanded lateral plates of this groove, embrace the body of the sphenoid. The anterior edge is also grooved, but more delicately, for the reception of the vertical plate of the ethmoid, and for the cartilage of the nose. The posterior border is thin and free, and forms the partition between the posterior nares. The inferior edge is received into the fissure formed between the palate ridge of the maxillary and palate bones.

It articulates with the sphenoid, ethmoid, both superior maxillary and both palate bones.

Fig. 28.



The vomer.

Fig. 28 represents the vomer. 1, posterior grooved margin, for articulation with the azygos process; 2, upper margin, continuous with the nasal lamella; 3, grooves for the anterior palatine nerves; 4, lower margin, to join the intermaxillary ridge; 5, anterior angle.

INFERIOR MAXILLARY BONE.

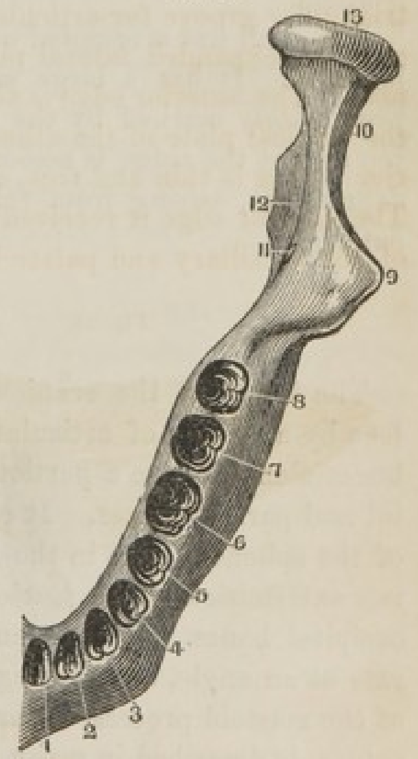
The lower jaw has some resemblance to the half of an elongated oval. It is divided, for the purpose of study, into a *body* and two limbs or *rami*. The body

is horizontal, and is composed in early infancy of two halves, which are afterwards inseparably joined together at a median line in front called the *symphysis*. The latter is marked in front and below by the *anterior mental protuberance*, on each side of which are transverse ridges for the origin of the muscles of the lower lip. An inch from the symphysis on each side, is the *anterior mental foramen*, for the exit of the inferior maxillary nerve, and blood-vessels. At this foramen is the commencement of a ridge that runs backwards and upwards to form the *coronoid process*, a flattened triangle with the apex upwards. It serves for the insertion of the *temporal muscle;* and its anterior thin edge gives origin to the buccinator.

Behind the coronoid process, and much less elevated, is the *condyle* of the jaw. It has at the top a long, narrow surface, for the attachment of cartilage, and is received into the glenoid cavity of the temporal bone. Between the coronoid process and the condyle is a semilunar notch with a thin, sharp edge. These processes join at their bases to form the *ramus*—a broad, strong portion of bone that descends downwards and forwards to join the base of the jaw. Externally it gives insertion to the masseter muscle.

The *angle* is formed by the junction of the base and the ramus: in children it is obtuse; in adults rectangular; and in old age it resumes its obtuse form. The upper or *alveolar margin* of the bone, is furnished with sockets for the teeth; and the roots being deeply set in the alveolar processes, give an undulated appearance to the anterior surface of the bone. The horizontal part of the jaw, or that on which it rests, is called its base, a thick and rounded margin extending from the symphysis to the angle.

Fig. 29.



Lower jaw.

The *inside* of the jaw remains to be examined; and first, a small prominence immediately in the course of the symphysis. This, the *posterior mental protuberance*, is often bifurcated; and below it are two smaller tubercles. At these points and the adjacent surface of the bone on the corresponding side, attachment is given to the genio-hyo-glossus, genio-hyoides, mylo-hyoides and digastric muscles.

Fig. 29 gives a vertical view of the left ramus of the lower jaw. 1 to 8, alveolar processes for the corresponding permanent teeth; 9, coronoid process; 10, cervix or neck; 11, posterior mental foramen; 12, angle of the jaw; 13, condyle.

Above the tubercles is a double, slightly concave surface for the sublingual glands. At the inner tubercle commences an indistinct ridge that soon becomes prominent, running upwards and backwards until it terminates at the margin of the last alveolar socket. To the anterior part of this ridge the mylo-hyoid muscle is attached; and to its posterior part the superior constrictor of the pharynx. Between this ridge

and the base of the jaw is an excavation that will receive the end of the finger: it is for the *submaxillary gland*. Following this ridge behind, it seems lost in a plane surface that produces a sharp triangular process of bone, on the inside of the ramus and at the base of the coronoid process. This angular spine marks the orifice of the *posterior mental foramen*, for the passage of the inferior maxillary nerve and blood-vessels to the teeth and other parts of the jaw. To the spine itself is attached the internal lateral ligament of the jaw; and the thread-like groove that is extended downwards from it, is formed for the mylo-hyoid nerve, and small blood-vessels.

The lower jaw is the first bone of the skeleton to take on ossification after the clavicle. It articulates with the temporal bones by its condyles; and gives attachment to many muscles, viz., levator labii inferioris, depressor labii inferioris, depressor anguli oris, platysma myoides, buccinator and masseter, by the external surface of the bone: by the internal surface, the genio-hyo-glossus, genio-hyoideus, mylo-hyoideus, digastricus, constrictor pharyngis superior, temporalis, and the external and internal pterygoids.

GENERAL REMARKS ON THE BONES OF THE HEAD AND FACE.

We have hitherto analyzed the cranio-facial structure by examining in detail the many parts of which it is composed; and we now proceed by a sort of synthesis to reconstruct this remarkable piece of mechanism, and to examine it as a whole.

The skull has a rounded or oval form, and is a continuous arch on an irregular base. It has a large cavity with thin parietes; and the internal face is proximately marked by the exterior form. The general surface, both on the top and at the sides, is smooth, with occasional prominences and corresponding depressions, arising from relations to the brain within or the muscles on the outside.

SUTURES.

The bones of the cranium are connected to each other and to those of the face by a species of articulation called *sutures;* of which those of the cranial bones alone require a particular notice. The *coronal suture* connects the frontal and parietal bones. It extends from side to side between the upper margins of the sphenoid bone in the temporal fossæ, being deeply serrated except at its two extremities. The *lambdoidal suture* is interposed between the parietal and occipital bones. It commences in the occipital region by two limbs that separate at an angle, and passing to each side terminate on the base of the skull and at the mastoid process. That portion extending downwards from the squamous suture, is described in many books as the accessory lambdoidal suture; but the distinction is perhaps unnecessary. The lambdoidal suture is deeply indented

and serrated throughout, and usually embraces more or less of those isolated portions of bone called ossa trequetra, to be noticed hereafter. The *sagittal suture* is extended in a zigzag line between the coronal and lambdoidal sutures, and thus unites the parietal bones.

The *squamous suture* connects the temporal bone below with the parietal above and the sphenoid in front. It is not serrated like the other sutures, but simply rough and undulated where the different bones come in contact. That part of the squamous suture which is placed between the temporal and sphenoid bones is sometimes called the *spheno-temporal suture;* which, in the Negro, not unfrequently forms a continuous line with the coronal suture.

The *frontal suture* extends from the root of the nose to the sagittal suture, dividing the frontal bone into two equal parts. It is always present in infancy, but generally ossifies in childhood; and in adult age its former position is only marked by a slight elevation of the bone. It not unfrequently happens, however, that the frontal suture is co-existent through life with the other sutures; a condition that appears to be more frequent in female than in male crania.

The *transverse suture* is interposed between the frontal, malar, sphenoid, ethmoid, upper maxillary and nasal bones. The *ethmoid suture* surrounds the ethmoid bone; and the *sphenoid suture* in like manner surrounds the sphenoid bone; and finally, the *zygomatic suture* connects the temporal and malar bones.

Although the sutures present such complex serratures externally, when the connection is viewed on the inside of the skull the bones appear to be joined by a mere unbroken line; and the inner margins of the sutures are said to become sooner ossified and obsolete than those of the surface.

The *uses of the sutures* have given rise to much discussion, and to a variety of opinions. It was long taught that their principal object was to facilitate the process of parturition; a theory which is refuted by the fact that they are as well developed in the skulls of all oviparous animals as in man; for example, in birds, reptiles and fishes. That they give an increased facility to parturition in the mammiferous tribes, is unquestionable; yet this has been but a subsidiary motive in their functions.

Some surgeons, and especially the late Dr. Physick (with whom the idea is said to have originated), suppose that one of the uses of the sutures is to arrest the progress of fractures of the cranium. The results of many comparisons, however, are unfavorable to this explanation, which, at best, could only apply to juvenile bones; for the consolidation that takes place in adult age, connects the several parts of the skull into a continuous structure.

The true use of the sutures undoubtedly is to subserve the growth of bones, which is accomplished by osseous deposition at their margins: hence a suture between two cranial bones, is equivalent to the surface that intervenes between the shaft and epiphysis of a long bone. The periosteum not only covers the two surfaces of the cranial bones, but it dips between them at the sutures, so that each bone is in reality contained in a periosteal sac; nor does this intervening membrane disappear, until the bones have ceased to grow. In other

words, this is an example of *intra-membranous* ossification, which could not be completed without the intervention of sutures. The following facts, derived from the examination of a skull in my possession, will serve to illustrate the question at issue.

The skull alluded to is that of a mulatto boy, who died when about eighteen years of age. The sagittal suture is entirely wanting; in consequence of which the lateral growth of the cranium has ceased in early infancy, (no doubt at the time when the suture became consolidated,) so that the diameter between the parietal protuberances is less than four inches and a half, instead of five, which is about the average in the negro.

The squamous sutures, however, are fully open, whence the skull has continued to expand in the upward direction, until the vertical diameter has reached five inches and a half, which is an inch above the average in the negro. The coronal suture, however, is wanting, excepting some traces at its lateral extremities. The result of this deficiency is seen in the very inadequate development of the forehead, which is low and narrow, but elongated below by means of the various cranio-facial sutures.

The lambdoidal suture is complete, thus permitting of posterior elongation; and the growth in this direction, together with the great vertical diameter above mentioned, has allowed the brain to attain the bulk of seventy-seven cubic inches, which, however, is eight inches short of the negro average.

In this instance, therefore, it is evident, that the cranium has expanded in those parts, and in those only, in which the sutures were open; and *vice versâ;* and since the growth of the brain and cranium are consentaneous, it is not probable that either could be developed without the intervention of the sutures.*

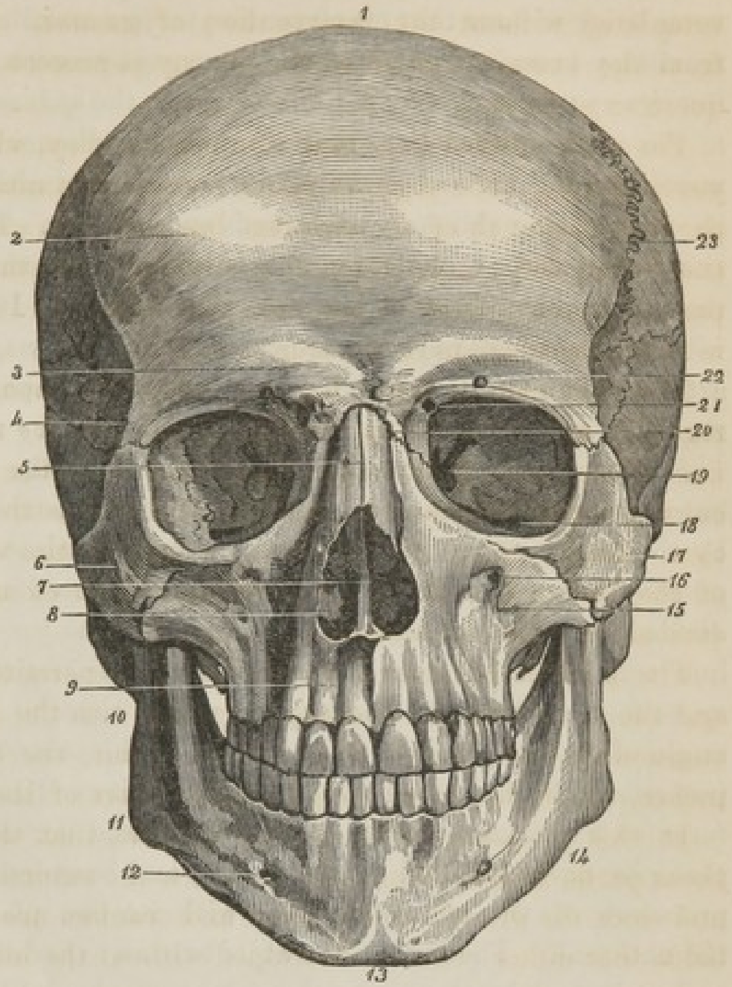
EXTERIOR REGIONS OF THE CRANIUM.

We use the word cranium in this place in the collective sense, to include both the skull and face; and find it divisible into five regions; 1, the facial region; 2, the coronal region; 3, 4, the lateral regions; and 5, the basal region.

1. THE FACIAL REGION is that which is seen in a front, or face view. It embraces the full forehead above, together with the superciliary ridges, the supra-orbitar foramen, and the orbits; and beyond these and laterally, the receding temporal regions. Between the orbits are placed the nasal bones, beneath which are seen in succession, the orifice of the nose, the nasal spine, the alveolar ridges, and teeth of both maxillæ, and the chin. The orbit is bounded on its outside by the malar bone; within by upper maxillary, in which last, just below the edge of the orbit, is the infra-orbitar foramen. The zygoma forms the outer lateral boundary, with which the lower jaw forms a nearly continuous outline, and completes the lower aspect of this region.

* I am moreover convinced, from considerable observation, that the absence of the sutures may be a cause of idiocy, by preventing the growth of the brain, and thereby destroying or impairing its functions.

Fig. 30.



Facial region of the cranium. From Bonamy and Beau.

Fig. 30. Facial views of the head and face. 1, os frontis; 2, frontal protuberance; 3, superciliary ridge; 4, external angular process of the os frontis; 5, ossa nasi; 6, malar bone; 7, septum narium; 8, opening of the nose; 9, sub-nasal fossa; 10, neck of lower jaw; 11, angle of the jaw; 12, anterior mental foramen; 13, symphysis; 14, base of lower jaw; 15, upper maxilla; 16, infra-orbitar foramen; 17, malar bone; 18, spheno-maxillary fissure; 19, superior foramen lacerum; 20, internal angular process of os frontis; 21, trochlear depression; 22, foramen supra-orbitarium; 23, coronal suture.

2. The coronal region. This is embraced in a vertical view of the cranium. It is bounded in front by the superciliary ridges; behind by the superior semicircular ridges and occipital protuberance; and laterally by the temporal ridges; but a casual inspection of the cranium will show that this description is arbitrary, inasmuch as its anterior and posterior limits cannot be included in any single view. The facial region embraces the parietal and frontal protuberances, and the lines of the coronal and sagittal sutures, which last is often marked by a slight longitudinal sinuosity. The coronal region is of extremely variable proportions in the different races of men, being of nearly equal diameters in the American Indian, long and narrow in the negro, and more or less oval in the European. On this subject we shall add some further remarks, when treating of the *norma verticalis* of Blumenbach.

3, 4. The lateral regions are bounded above by the temporal ridge; in front by the margin of the orbit; and behind by the lambdoidal suture. It embraces the temporal and zygomatic arch before, and the mastoid process behind. The *temporal fossa* is bounded above and behind by the temporal ridge, in front by the great wings of the sphenoid, the os frontis, and the superior orbitar process of malar bone. Below it is marked off by the zygomatic arch. This large opening contains the temporal and external pterygoid muscles, and the coronoid process of the lower jaw. The *zygomatic fossa*, which is merely

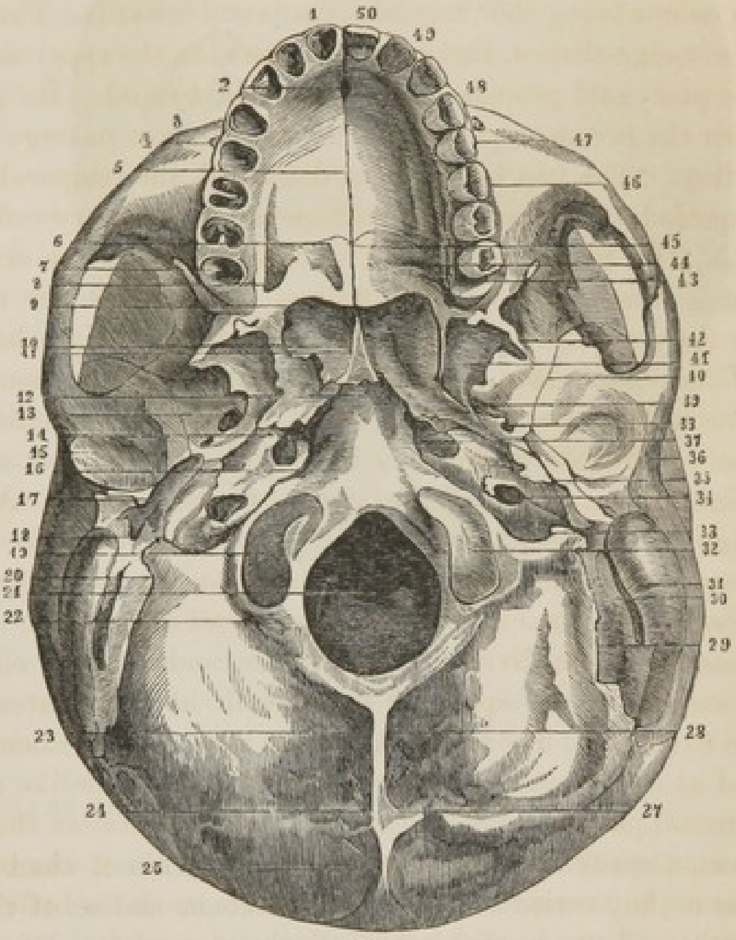
a continuation of the temporal, is all that part below the zygoma, and the transverse ledge of bone that overlaps the pterygo-maxillary fissure: it has the superior maxillary bone in front, and the pterygoid process on its inner side. Two large fissures open into this fossa; one of these, the *spheno-maxillary fissure*, is formed in the orbit between the great wing of the sphenoid bone behind, and the upper maxillary and malar bones in front, and is just above the level of the zygoma, its course being obliquely backwards and inwards. The *pterygo-maxillary fissure* is a wedge-shaped, elongated slit, between the upper maxillary bone in front, and the pterygoid process of the sphenoid behind. Its position is nearly vertical, with the broadest part upwards, and it gives passage to the internal maxillary artery. The two fossæ above described, the temporal and zygomatic, are often regarded as one, and it is perhaps an unnecessary refinement to divide them.

5. The basal region. The *basal region* of the skull is extremely irregular, but is embraced in an oval outline. In front, is the roof of the mouth formed by the palate process of the maxillary and palate bones, and hence called the *palate fossa*. It is deeply concave, and rendered more so by the teeth, and is divided by a median line or ridge, marking the junction of the two sides. This line terminates in front in the *foramen incisivum*, and behind in the palate spine for the origin of the azygos uvulæ muscle. At the outer and posterior angle of the bony palate on each side, is the *posterior palatine foramen*, for the posterior palatine nerves and arteries; and immediately behind it a much smaller foramen for branches of the same vessel and nerve. Above the palate are the *posterior nares*, divided by the vomer, and bounded outwardly by the pterygoid processes of the sphenoid bone, with its two plates, viz.: the internal and the external. The former has at its base an excavation called the *scaphoid fossa*, and at its termination, near the palate, the hook-like or *hamular process*. The external plate expands below, so as to form between the two plates the *pterygoid fossa*, already noticed. At the outer margin of the base of the pterygoid process is the *foramen ovale*, and close to it, and a little further out, the *foramen spinale*. Outside of this again is the glenoid fossa of the temporal bone, divided transversely by the *fissura Glasseri*, and overarched by the excavated base of the zygomatic process, and having at its outer margin the meatus auditorius externus.

The spinous process of the sphenoid bone, its proximate margin in front, and the petrous bone behind, form the *foramen lacerum anterius*, for the passage of the carotid artery, and for lodging a part of the Eustachian tube. Here also the carotid plexus of nerves is joined by the carotid branch of the Vidian nerve. Still further behind, and between the petrous bone and the occiput, is the large fissure called *foramen lacerum posterius*, of which the outer part, marked off by a small spine, is called the *jugular fossa*, and gives passage to the jugular vein: the inner part, or proper foramen lacerum, transmits the pneumogastric nerve. These foramina on each side bound the basilar process externally, which is now observed to run forward in a pyramidal form; its broad end articulating with the body of the sphenoid bone, and its base resting on the margin of the foramen magnum, and on the condyloid processes externally. Between these last

is the foramen magnum; and the basal region terminates behind in the superior semicircular ridge of the occiput, and at the sides in the mastoid processes. These parts have been already so fully noticed as to require no description in this place.

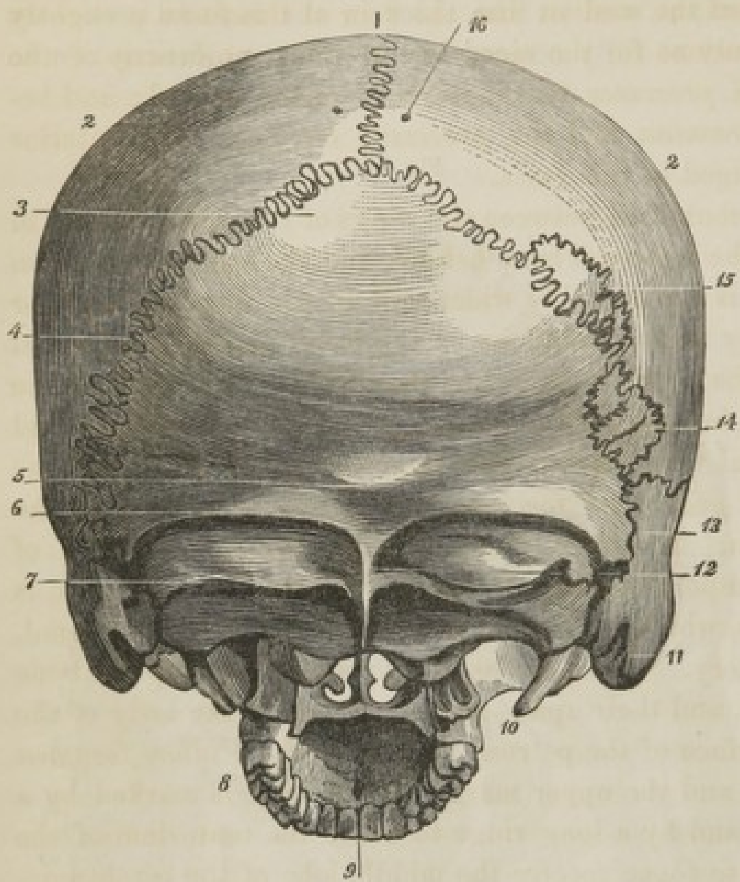
Fig. 31.



Basal view of the cranium. From Bonamy and Beau.

Fig. 31 gives a view of the various parts that enter into the composition of the base of the cranium. 1, 7, alveolar margin of the upper jaw, marked by the alveolar cavities; 2, foramen incisivum; 3, malar bone; 4, infra-orbitar foramen; 5, inter-maxillary suture; 6, suture between the palate processes of the upper maxillary and palate bones; 8, posterior palatine foramen; 9, posterior nasal spine, formed by the junction of the palate bones; 10, posterior nares; 11, the vomer, forming part of the septum narium; 12, basilar process of the occipital bone; 13, foramen ovale of the sphenoid bone; 14, foramen lacerum anterius; 15, glenoid cavity of the temporal bone; 16, occipito-petrous fissure; 17, styloid process; 18, stylo-mastoid foramen; 19, occipital condyle; 20, jugular eminence; 21, foramen magnum occipitis; 22, posterior condyloid foramen; 23, depressions for the attachment of muscles; 24, 28, spine or crest of the occiput; 25, space between the superior and inferior semicircular occipital ridges; 26, external occipital protuberance; 27, inferior semicircular ridge; 29, lambdoidal suture; 30, groove for the digastric muscle; 31, mastoid process; 32, left occipital condyle; 33, foramen lacerum posterius; 34, inferior orifice of the carotid canal; 35, petrous portion of the temporal bone; 36, base of the zygomatic process of the temporal bone; 37, anterior orifice of the carotid canal; 38, foramen spinale of the sphenoid bone; 39, foramen ovale; 40, spheno-temporal suture; 41, pterygoid fossa; 42, external wing of the pterygoid process; 43, dens sapientiæ; 44, palate process of the palate bone; 45, inter-palatal suture; 46, first molar tooth; 47, second bicuspid tooth; 48, first bicuspid; 49, cuspid tooth and second incisor; 50, first incisor tooth.

Fig. 32.



Oblique view of the occiput.

Fig. 32. Oblique view of the occiput. 1, sagittal suture; 2, 2, parietal bones; 3, occipital bone; 4, lambdoidal suture; 5, occipital protuberance; 6, superior semicircular ridge, for the origin of the trapezius and occipito-frontalis muscles; 7, inferior ridge, in which are inserted the superior oblique muscles of the neck; 8, upper maxilla and teeth; 9, foramen incisivum; 10, styloid process; 11, digastric groove; 12, occipital crest; 13, lesser lambdoidal suture; 14, 15, ossa triquetra; 16, parietal foramen.

INTERNAL REGIONS OF THE CRANIUM.

The upper or vaulted part of the cranium, when viewed within, presents a smooth but varied surface for the accommodation of the brain, which marks the locality of its several convolutions by corresponding concavities in the bone. The groove for the longitudinal sinus is slight in front, but broader and deeper between the parietal bones; and it is here, on each side of the sagittal suture, that is seen an irregular oval depression of an inch in length, for the glands of Pacchioni. The surface is further marked by arborescent channels, large and deep at the sides, but diminishing in size towards the vertex, for transmitting the middle artery of the dura mater and its branches. The sutures are observed to present mere indented lines, more or less irregular in their course, but destitute of the serrated arrangement of the outer surface.

The base of the cranium internally is divided into three distinct and very natural regions—the anterior, middle and posterior.

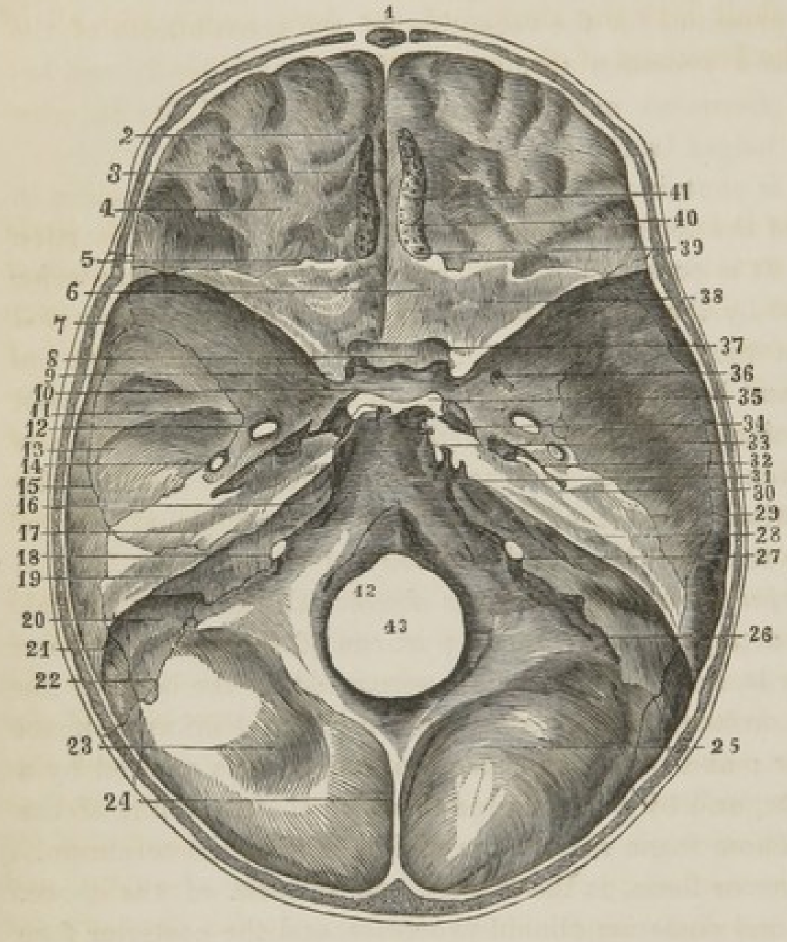
1. The ANTERIOR REGION or *fossa*, has the frontal bone in front, and the same bone and the ethmoides below, forming its floor; while its posterior margin is made by the curved edge of the wings and body of the sphenoid. This fossa has in its middle the oblong depression of the cribriform plate of the ethmoid bone, with its many foramina and the crista galli in front. Above the

latter is the *foramen cæcum*, with a vertical groove which is the incipient longitudinal sinus. On each side of the median line, the floor of this fossa is slightly convex, but with many depressions for the reception of the convolutions of the brain. The *anterior clinoid processes* terminate this region behind; and between them are the *optic foramina* and the *processus olivaris*. The anterior lobes of the cerebrum are lodged in this fossa.

2. The MIDDLE REGION is contained between the wings of the os sphenoides in front, the petrous portion of the temporal bone behind, and the squamous portion of that bone at the side. It is considerably wider and deeper than the anterior fossa, and like it is marked by the convolutions of the brain and the meningeal arteries. In its centre is the *sella turcica* for the pituitary gland, with the clinoid processes in front and behind, and a channel on each side for the carotid artery. Under the sphenoidal wings is seen the *foramen lacerum superius*, the *foramen rotundum*, *foramen ovale* and *foramen spinale*, each succeeding the other in the outward direction. Inside of these, between the internal end of the petrous portion of the temporal bone and the body of the os sphenoides, is the *foramen lacerum anterius*, which is continuous above with the carotid canal, and transmits the carotid artery. The petrous portions of the temporal bone project inwards and forwards, and their apices are separated by the body of the sphenoides. In the front surface of the petrous portion is the *Vidian foramen* for the nerve of that name; and the upper margin of the bone is marked by a groove for the petrous sinus, and by a long ridge to which the tentorium of the dura mater is attached. These fossæ receive the middle lobe of the cerebrum.

3. The POSTERIOR REGION or fossa, is the largest and deepest of the three. It has in front the basilar and posterior clinoid processes, and the posterior face of the petrous portion of the temporal bone; and its posterior boundary is the horizontal portion of the groove for the lateral sinus, to which is attached the tentorium of the dura mater; and the two fossæ are separated behind by the ridge and groove for the occipital sinus. On the posterior face of the pars petrosa are seen the *meatus auditorius internus* and the orifice leading to the aqueduct of the vestibule, and still lower down, and almost concealed, the aqueduct of the cochlea. The double canal, the *foramen lacerum posterius*, for the jugular vein and pneumogastric nerve, is seen like a large fissure between the petrous and occipital bones, and forming the terminus or outlet of the lateral sinus, which from this point winds upwards and then backwards and horizontally to the internal occipital protuberance. At the latter point the longitudinal, lateral and occipital sinuses meet; they trace in the bone their respective grooves, and these are again marked by corresponding elevations, constituting the *occipital cross*, or crucial ridge. The foramen magnum is in the centre of the posterior region, and at its anterior margin on each side is the anterior condyloid foramen. The basilar process that bounds it in front is continuous with the clivus of the sphenoid bone, and hence this surface is sometimes called the occipital clivus. It is concave for lodging the tuber annulare, which, with the cerebellum and medulla oblongata occupies the whole of this region.

Fig. 33.



Internal regions of the cranium. After Bonamy and Beau.

Fig. 33 gives a view of the three interior basal regions of the cranium. 1, frontal sinus; 2, foramen cæcum; 3, crista galli; 4, orbitar process of the frontal bone, marked by the convolutions of the brain; 5, suture between the frontal and sphenoid bones; 6, apophyses of Ingrassias; 7, spheno-parietal suture; 8, olivary process, whereon lies the chiasm of the optic nerves; 9, anterior clinoid process; 10, sella turcica; 11, spheno-temporal suture; 12, foramen ovale; 13, middle fossa of the cranium; 14, foramen spinale; 15, temporo-parietal suture; 16, suture between the petrous and occipital bones; 17, internal auditory foramen; 18, 27, posterior foramen lacerum; 19, upper margin of the petrous bone; 20, 21, 26, lateral sinus; 22, occipito-mastoid suture; 23, 25, inferior occipital fossa; 24, internal occipital crest; 28, superior petrous groove; 29, anterior face of petrous portion of temporal bone; 30, hiatus Fallopii, or Vidian foramen; 31, basilar process, or clivus of the occipital bone; 33, anterior extremity of petrous bone; 34, foramen lacerum anterius; 35, posterior clinoid process; 36, foramen rotundum; 37, optic foramen; 38, lesser sphenoidal wings; 39, ethmoido-sphenoidal suture; 40, cribriform plate of the ethmoid; 41, ethmoidal groove for lodging the olfactory ganglion; 42, anterior condyloid foramen; 43, foramen magnum occipitis.

DIPLOE.

This name is given to the cellular osseous structure that intervenes between the two tables of the skull, and which perfectly resembles the cancellated tissue of the vertebral and other bones.

The diploë is not fully developed until the early periods of life; for until a child reaches the age of four or five years, the proximity of the two tables of the skull leaves but little space for it.

It is more abundant in the occipital than in the frontal bone, and is least conspicuous in the temporal region, where the two cranial tables are almost in contact with each other.

The diploë is perforated by branching canals, which are occupied by veins. These veins arise in the membranous lining of the cancelli, and coalesce into larger and larger trunks, until the vessels attain a considerable magnitude.

Some of these canals terminate in appropriate foramina on the surface of the cranium, and thus become continuous with the corresponding veins. Others open at the base of the skull into the sinuses of the dura mater, and all of them are subservient to the functions of the venous system.

THE FACE.

The contour of the face is familiar to every one, inasmuch as the soft parts harmonize with the bony structure, and soften without concealing its principal features. Viewed in front, the forehead with its frontal protuberances above and superciliary ridges below, constitutes, in a well-formed head, nearly half of the entire facial oval, which is completed below by the inferior maxilla. The zygomatic arches give strength and fullness to the lateral regions, at the same time that they protect the muscles and other soft parts contained within them. The maxillæ, with their teeth, complete the basal structure; while the orbital and nasal cavities penetrate and darken their respective regions.

THE ORBIT lodges the eye and its appendages. Its form is usually compared to that of a quadrangular pyramid; whence it is composed of four sides, a base and an apex. The roof of the cavity is principally derived from the orbitar process of the os frontis, and in small part by the lesser wing of the sphenoid towards its inner extremity. This portion is extremely thin and diaphanous. Posteriorly it is perforated by the optic foramen; anteriorly, and on its outer side is the depression or pit for lodging the lachrymal gland, and its arched margin in front is marked by the infra-orbitar foramen or notch; and yet near the inner angle, is a slight depression to which is attached the pully for the superior oblique muscle. The floor of the orbit is chiefly formed by the malar and superior maxillary bones, but derives a very small surface from the orbitar plate of the palate bone behind. This surface is marked by the infra-orbitar canal, which becomes a foramen, and disappears beneath the margin of the orbit to terminate in the infra-orbitar foramen. This surface forms the floor of the orbit, and the roof of the anterior Highmorianum, and is terminated externally by the *spheno-maxillary fissure*.

The *external wall* of the orbit runs obliquely inwards, and terminates below in the spheno-maxillary fissure, and behind at the margin of the superior foramen lacerum of the sphenoid bone. The *internal orbitar surface* runs in a nearly straight direction backwards until it terminates at the foramen lacerum. It is chiefly formed of the os planum of the ethmoid, but is completed by the os unguis in front, and the os sphenoides behind. In the suture connecting it with the frontal bone, are two foramina, called the anterior and posterior ethmoidal; the first of these conveys the anterior ethmoidal artery and vein, and nasal nerve to the cavity of the nose; the second transmits the posterior ethmoidal vessels into the same part. The *lachrymal fossa* for the lachrymal sac, is seen at the inner and anterior part of the orbit, formed partly by the os unguis, partly by the upper maxillary bone, and ending below in a rounded opening, which is the commencement of the ductus ad nasum.

NASAL CAVITIES.

The NASAL CAVITIES are two fossæ situated in the centre of the face, and separated from each by a vertical septum, the *septum narium*, formed by the vomer below, the nasal lamella of the ethmoid bone above, and by the nasal cartilage in front. This septum presents a smooth, imperforate surface, but the fossa on each side of it is remarkably uneven, owing to the protrusion of the turbinated bones.

The nasal cavities are bounded above by the cribriform plate of the ethmoid and sphenoid bones; below by the floor of the nose, as constituted by the palate processes of the upper maxillary and palate bones; in front, to a partial extent, by the ossa nasi; and externally by the upper maxillary, ethmoid and lower spongy bones.

The double opening in front, and below the ossa nasi, is the *anterior nares;* and a similar, but much smaller opening behind is the *posterior nares.*

The floor of the nasal fossa is formed by its lower boundary—the palate processes of the upper maxillary and palate bones; an elongated, concave surface, above which the lower turbinated bone protrudes into the nostril, with its convex margin towards the septum narium. The passage thus formed is the *lower meatus;* and at its upper, anterior part, that is to say, just under the anterior end of the lower turbinated bone, is the orifice of the ductus ad nasum, that communicates with the lachrymal sac; and on the floor of this meatus, at its inner and anterior end, is the opening of the *anterior palatine canal*, which leads to the roof of the mouth and there forms the foramen incisivum.

Between the lower and middle spongy bones is another channel, extending, like the former one, the whole length of the nostril; this is the *middle meatus.* At the fore part of the meatus is a vertical convexity in the upper maxillary bone, marking the position of the ductus ad nasum; and directly behind these parts the parietes of the meatus is constituted by the diaphanous lamella of the os unguis. Behind the latter bone, and immediately inside of the outer, anterior margin of the middle turbinated bone, is the opening of the anterior ethmoidal cells, from which a canal leads upwards to the frontal sinus.

In the middle meatus, about midway between its two extremities, is the orifice leading into the antrum maxillare. It is variable in size and position, and sometimes so closed by the surrounding bones and mucous membrane, as hardly to admit an ordinary probe.

The *upper meatus*, the smallest of the three, lies between the posterior angle of the middle turbinated bone and a little over-arching scroll of bone called the *cornet of Morgagni.* It is a narrow, deep fissure, with several foramina that communicate with the posterior ethmoidal cells; and it terminates posteriorly in the spheno-palatine foramen.

In the perfect state of these parts, they are covered and strengthened by the mucous membrane of the nose, which at the same time contracts the orifices that lead to the cavities in the contiguous bones.

FORM OF THE HEAD.

The form of the head and face in different nations presents some remarkable dissimilarities, respecting which we shall make a few observations.

The human family is usually divided into five races, the Caucasian, the Mongolian, the Malay, the aboriginal American and the Negro. The skulls of the first and the last of these can be readily distinguished from each other and from the other three; but the latter—the Mongolian, American and Malay—though in the aggregate separated by marked differences, not unfrequently possess a blended character that requires a practised eye to identify them.

1. *The Caucasian race* has a large oval skull and a face small in proportion. The nasal bones are arched and narrow, the zygomæ small and receding, the chin full, and the teeth vertical, with a facial angle of 80 degrees. There is a harmony of proportion in the cranial structure of this race which is comparatively rare in any of the others.

2. *The Mongolian race.*—In the Mongolian nations the skull is oblong-oval, rather flattened at the sides, with a low forehead and very broad and full occipital region. The nasal bones are broad and depressed, the face prominent, the jaws large and the cheek bones broad and flat, and the zygomatic arches expanded. The facial angle 77 degrees.

3. *The Malay race* strongly resembles the Mongolian. The head is high, and squared or rounded, the forehead low, the face very broad and projecting, the teeth salient, the nose flat. Facial angle 75 degrees.

4. *The American race.*—The skull of the American Indian is small and rounded, with a receding forehead, vertical occiput, great width between the parietal bones, large, salient nose, heavy jaws and teeth, and prominent face. Facial angle 75 degrees.

5. *The Negro race* is remarkable for a long, narrow skull, a low forehead and coronal region, full occiput, short flat nasal bones, ponderous maxillæ, large teeth and projecting face. Facial angle 75 degrees.

When the osseous structure in these races is studied in connection with the perfect developments of living nature, the differences are greatly enhanced, and the eye cannot fail to detect them at a glance; but a great obstacle to this investigation arises from that interminable blending of races, which is well represented in this country by the frequent and conspicuous mixture of the white man and the negro.

Internal Capacity.—The internal capacity of the cranium gives the bulk of the brain, and is consequently a measurement of great interest. I have devoted much attention to this question, and by means of an ingenious contrivance, invented by my friend Mr. John S. Phillips, I have succeeded in ascertaining the capacity of several hundred crania, with the following results.

The Caucasian brain gives the largest average of all the races, and especially the European branches of this race. For example, the German and Anglo-Saxon brain yields a mean of at least ninety cubic inches, and a maximum of

one hundred and thirteen cubic inches. The latter is the largest measurement I have met with. The negro brain presents, in the aggregate, the other extreme; for the measurement of forty-six skulls of native Africans of many different and distant tribes, gives a mean of eighty-five cubic inches; nor does the size in any instance augment to one hundred cubic inches. The smallest brain I have met with (leaving idiots and dwarfs out of the question) is that of a negress, which gives but sixty-five cubic inches. Between the Caucasian and the negro are the Mongolian, Malay, and Indian, the first of the three ranking in this respect next the Caucasian; the last, or Indian, being next above the negro.

Some curious facts remain to be noticed: for instance, the brain of the ancient Egyptians gives an average of but eighty cubic inches; the Fellahs of the Nile (their lineal descendants), the peninsular Arabs, the Hindoos, and the old Peruvians, all living in nearly the same latitudes, have the brain of about the same size; in other words, five cubic inches less than that of the negro. It may appear on further investigation, however, that these people had a brain as large in proportion to their physical bulk as the negro; but the absolute proof is wanting. Another question arises,—whether the greater relative magnitude of the posterior or animal portion of the brain may not give the negro his preponderance over these last-named nations, when the entire bulk of the organ is considered?

DIAMETERS OF THE SKULL.

From what has been already stated, it is evident that the cranial diameters differ greatly in different heads of the same race; but the average in the adult European or Anglo-American is as follows:—

The *longitudinal diameter* is measured between the most prominent part of the frontal bone (generally between the superciliary ridges) and the occipital protuberance, and gives six inches and a half.

The *lateral diameter* is measured between the parietal protuberances, and is five inches and a half.

The *vertical diameter* is measured between the occipital condyles below, and the vertex of the cranium above, and gives five inches.

Many other measurements have been resorted to for the purpose of comparison; but it is, perhaps, unnecessary to notice them on the present occasion.

The three diameters above mentioned are greatly diversified in the different races of men; in the aboriginal American, for example, they are often nearly equal; in the negro the long diameter is increased at the expense of the lateral; and the Mongolian skull is marked by a striking vertical diameter.

FACIAL ANGLE.

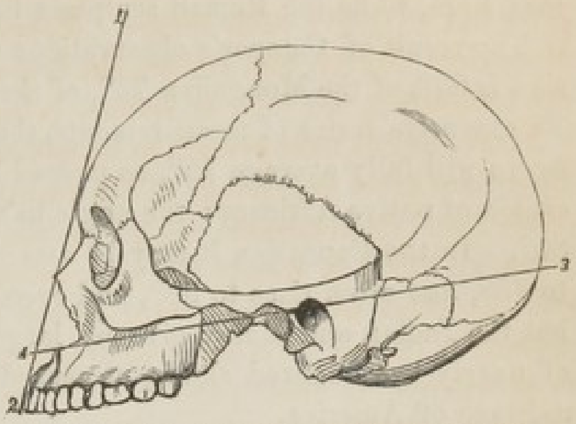
The facial angle was first proposed and applied by the learned Professor Camper. It is measured as follows:—a line, called the *facial line*, is drawn from the anterior margin of the upper jaw or teeth to the most prominent part of the forehead—Fig. 34, 1, 2. A second or *horizontal line* is drawn through the middle of the external meatus of the ear till it touches the lower edge of the

nasal fossa at the nasal spine, from which point it is prolonged until it meets the facial line—Fig. 34, 3, 4. The decussation will occur either at or very near the nasal spine; and the angle thus formed is the facial angle.

Fig. 34. Skull of a woman of a tribe of the Shoshonees, or root-diggers, who inhabit the western slope of the Rocky Mountains. These people constitute one of the lowest castes of the aboriginal race of this country: the configuration of the head is in remarkable keeping with the low grade of intelligence; and the facial angle, as formed between the facial and horizontal lines, is but 70°. This head is of the natural form, not having been subjected to those modifying processes in use among some American tribes. It was presented to me by Col. J. C. Fremont.

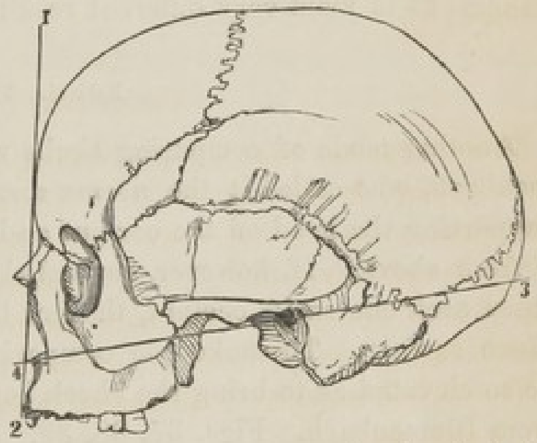
Fig. 35 contrasts in all respects with the preceding. It is that of an embalmed Egyptian woman, taken from one of the tombs at Memphis, by my friend Mr. George R. Gliddon. Among eight hundred human skulls of all nations in my possession, I regard this the most beautiful in outline, and the most harmonious in its proportions. The facial angle measures nearly 82°.

Fig. 34.



The facial angle measured on a Shoshonee Indian.

Fig. 35.

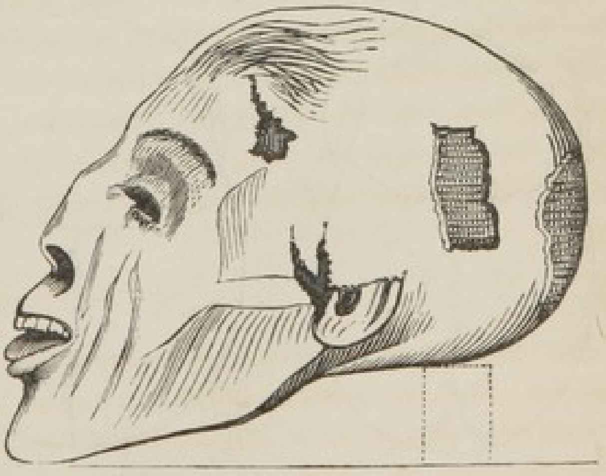


The facial angle measured on an ancient Egyptian head.

The most casual observation on the part of the anatomist will convince him, that the facial angle is no criterion of mental intelligence, nor did Camper himself suppose it to be so. It chiefly shows the projection of the face in relation to the skull, without conveying the least idea of the capacity of the cranium, which is often the same in heads of very different facial angle and diameters.

But although a full angle is no proof of superior intelligence, the converse of this is for the most part true; for a very contracted angle, whether in nations or individuals, is generally accompanied by a low grade of mental development. Thus, in most savage tribes, the face is protruded at the expense of the head; while in the idiot this disparity is often yet more remarkable, and even exceeds that of some of the monkey tribes. To illustrate this remark, I annex an outline draw-

Fig. 36.



Head of an embalmed idiot, from Thebes.

ing of the head of an embalmed idiot, from a tomb at Thebes, where it had probably lain several thousand years, until removed by my friend Mr. Gliddon. In this remarkable instance, the facial angle measures but 65°. Fig. 36.

The maximum angle that can be obtained by the facial lines is 100°; and it is remarkable that the most ancient of the Greek artists have chosen this very maximum, while the Roman sculptors limited theirs to 95°.

The result of Camper's observations was, that the facial angle of the Caucasian is 80°, of the Mongolian 75°, of the negro 70°. I am prepared to say, from an extensive series of measurements, that some of these angles are too low. The negro will fully average 75°, as proved by my observations on upwards of forty crania of native Africans; the angle in this race rarely sinks to 70°, or rises to 80°. In the Caucasian it may be assumed at 80° as a mean, but it rarely falls to 75°, and often rises to 83°, and even to 85°. The Mongolian is about 77°; but the Indian and Malay give no larger angle than the negro. The average of nearly two hundred skulls, measured by me, gives but 75.5° for the aboriginal race of America.

These measurements refer exclusively to the adult and perfect head; for the cranium is so modified by infancy and old age, and also by artificial contrivances, as to yield very different results, which will be noticed hereafter.

NORMA VERTICALIS.

Another mode of comparing skulls was discovered by the late Professor Blumenbach, who called it the *norma verticalis* or vertical method. It consists in supporting the head on the occiput and lower jaw, and then looking down upon it from above. If, however, several skulls are to be compared, they should be stood each one on its occiput, the jaw being vertical and supported against any plane surface. To make the comparison complete, the occipital bones should be so elevated as to bring the cheek bones on a line, as in the following outlines from Blumenbach. Figs. 37, 38, 39.

Fig. 37.

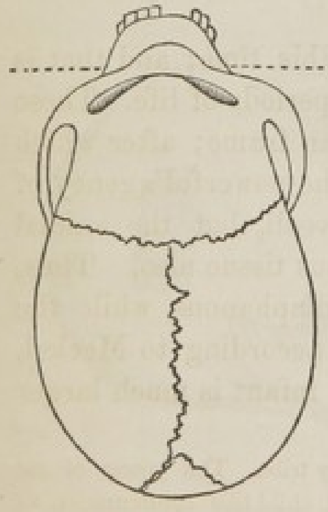


Fig. 38.

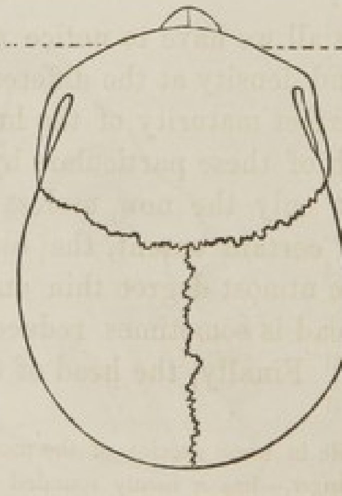
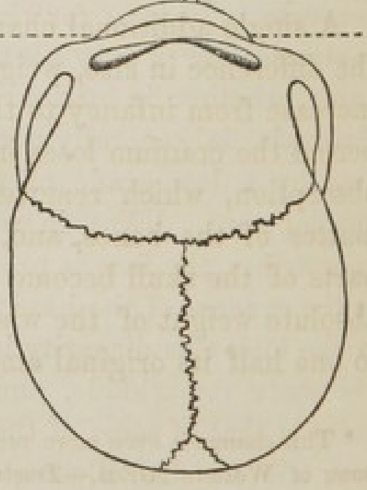


Fig. 39.



One of these, Fig. 37, represents a negro head, elongated and narrow in

front, with expanded zygomatic arches, projecting cheek bones, and protruding maxillæ. The *second* outline, Fig. 38, is that of a Caucasian skull, in which the facial region is nearly concealed by the more symmetrical outline of the whole head, and especially by the full development of the frontal bone. The last outline, Fig. 39, was taken from a Mongolian head, in which the orbits and cheek bones are exposed, as in the negro, and the zygomæ arched and expanded; but the forehead is broader, the face more retracted and the cranium larger.

PERIODICAL CHANGES OF THE FORM OF THE HEAD.—Without entering into all the details of this interesting subject, we shall limit ourselves to a few of the more striking facts. The first of these is the obvious change of form between childhood and old age. During the former period the skull is remarkably wide between the parietal protuberances, and very prominent in the frontal region; these developments, in each instance, marking the centres of ossification. As life advances, these regions recede more or less, and a part of the transverse diameter is merged in the longitudinal, for the occiput becomes elongated, and the interparietal distance shortened.

Again, we often admire the over arching frontal region of the child; but if we watch the phases of development, the forehead will be found to recede, the face to advance, and the whole profile to undergo a change on the approach of adolescence, and which increases in many, and perhaps in most instances, so long as the bones continue to grow. Thus it is that the facial angle of infancy is often equal to 95°, and sometimes to 100°; but the same head in adult age will not measure more than 80°. This change is most conspicuous in savage nations, in whom there is a characteristic tendency to massiveness and elongation of the jaws; and in them the variation of the facial angle is not less than twenty degrees between the fourth and the thirtieth years of life.* To these mutations in the relative size and position of the cranio-facial bones, may be added the changes in the angle of the jaw, which is small in infancy, full in manhood, and again less developed in old age. A further change is caused by the absorption of the teeth, which reduces the lower jaw to a mere bony ring, and the alveolar portion of the upper maxilla to a semicircular plane, without teeth-sockets and consequently without concavity.

A single additional change is all we have to notice at this time; and that is the difference in size, weight, and density at the different periods of life. These increase from infancy to the perfect maturity of the human frame; after which period the cranium loses in each of these particulars by the powerful agency of absorption, which removes not only the now useless alveoli, but the animal matter of the bones, and, to a certain extent, the osseous tissue also. Thus, parts of the skull become to the utmost degree thin and diaphanous, while the absolute weight of the whole head is sometimes reduced, according to Meckel, to one half its original amount. Finally, the head of the infant is much larger

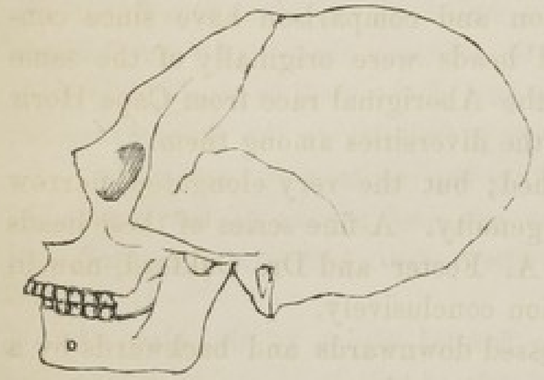
* This change is even more remarkable in some species of the monkey tribe. The young of the orang of Western Africa,—*Troglodytes niger*,—has a neatly rounded and child-like configuration of head; but as adult age comes on, its face becomes greatly elongated, and the whole physiognomy assumes a most brutal form and expression. The same change often takes place in idiots of the human species.

in proportion than that of adult age; and some anatomists have even maintained, that the cranium reaches its full development before the tenth year.

ARTIFICIAL MODIFICATIONS OF THE HEAD.

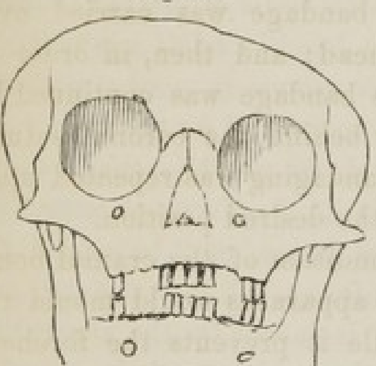
It is well known that some of the ancient nations of Europe and Asia practised the art of flattening the heads of their children. Among these were the Macrocephali, whom Hippocrates has described as moulding the cranium in the upward direction, until it attained a conical or sugar-loaf form. Other tribes, inhabiting the banks of the Danube, adopted other modes of distortion; but the most remarkable prevalence of this custom, and variety in the resulting modifications, have been observed in North and South America. Among the old Peruvians no less than four of these modifications were in such general use, that they were finally prohibited by an edict of the ecclesiastical council of Lima. They were almost equally common among some tribes near the Gulf of Mexico, and in parts of Mexico itself; and the art is still practised by many of the tribes near the mouth of the Columbia river in Oregon.

Fig. 40.



Skull of a Clatsap Indian.

Fig. 41.



Skull of a Cowalitsk Indian.

Fig. 42.

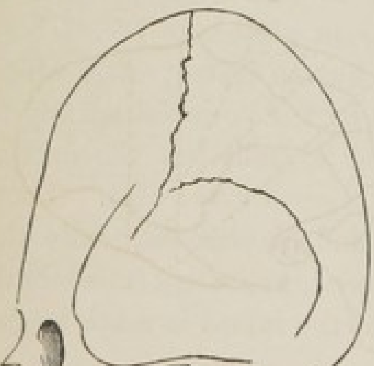


Fig. 40 is an outline of the head of an Indian of the Clatsap tribe, in the Oregon Territory. In this instance the forehead has been flattened by means of a compress drawn across the forehead in infancy, and attached at the opposite sides of a rude cradle. The cranium expands posteriorly and laterally, and the face is protruded by the operation.

Fig. 41 gives a front view of the skull of a Cowalitsk Indian, also an Oregon tribe, in which the deformity has been urged to an extraordinary degree. The increased breadth of the cranium, and its inequilateral shape, are well shown in this instance.*

Fig. 42 illustrates the opposite extreme of conformation, as seen in the skull of an ancient Natchez Indian. The process in this instance has been conducted in the upward direction, and produced the conical form. To accomplish this shape, hard compresses have been applied to the forehead and occiput, and kept in place by means of a bandage carried round the head.

* This skull and the preceding one were presented me by my friend Dr. J. K. Townsend, who obtained them himself in Oregon.

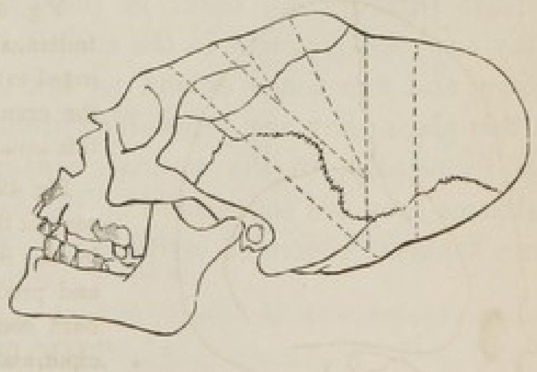
Some ancient Peruvians attained a refinement of this art, by means of which they gave the head a cylindrical and at the same time an elongated and perfectly symmetrical conformation. I at first found it difficult to conceive that the original rounded skull of the Indian could be changed into this fantastic form; and was led to suppose that the latter was an artificial elongation of a head remarkable for its natural length and narrowness. I even supposed that the long-headed Peruvians were a more ancient people than the Inca tribes, and distinguished from them by their cranial configuration. In this opinion I was mistaken. Abundant means of observation and comparison have since convinced me, that all these variously-formed heads were originally of the same rounded-shape which is characteristic of the Aboriginal race from Cape Horn to Canada, and that art alone has caused the diversities among them.

The simple forms were easily accomplished; but the very elongated, narrow and symmetrical variety, required more ingenuity. A fine series of these heads recently sent me by my friends Mr. W. A. Foster and Dr. Oakford, now in Peru, has enabled me to decide this question conclusively.

It is evident that the forehead was pressed downwards and backwards by a compress, (probably a folded cloth,)—or sometimes by two compresses, one on each side of the frontal suture; a fact that may explain the cause of the ridge which usually replaces that suture from the root of the nose to the coronal tract. To keep these compresses in place, a bandage was carried over them from the base of the occiput over the forehead; and then, in order to confine the lateral portions of the skull, the same bandage was continued by another turn over the top of the head, immediately behind the coronal suture, probably with an intervening compress; and the bandaging was repeated upon these parts until they were immovably confined in the desired position.

Every one who is acquainted with the pliable condition of the cranial bones at birth, will readily conceive how effectually this apparatus would mould the head in the elongated or cylindrical form; for, while it prevents the forehead from rising, and the sides of the head from expanding, it allows the occipital region an entire freedom of growth; and thus without sensibly diminishing the volume of the brain, merely forces it into a new though unnatural direction, while it preserves, at the same time, a remarkable symmetry of the whole structure. The annexed outline, Fig. 43, of one of these skulls, will further illustrate my meaning; merely premising that the course of the bandages (represented by dotted lines), is in every instance distinctly marked on the skull itself by a corresponding concavity of the bony structure, excepting on the forehead, where the action of a firm compress has left a plane surface.

Fig. 43.



Two interesting facts have resulted from inquiries into this custom; viz :

1, that artificial modification does not diminish the capacity of the cranium, or bulk of the brain; and 2, that the process, contrary to our preconceived opinions, appears to produce no bad effect on the intellect; inasmuch as those people who practice it are known to have been, and some of them still are, among the shrewdest of our aboriginal tribes.

THE FONTANELS.

The head at the full period of utero-gestation, presents some peculiarities necessary to be mentioned; and among these the most remarkable are the *fontanels*. The fontanels are deficiencies in the bones of the head, and are invariably found in certain localities. The *anterior fontanel*, *fonticulus major*, is placed between the os frontis in front (at this period usually composed of two parts) and the parietal bones behind. It is of a quadrangular form, and the largest of these openings. The *posterior fontanel*, *fonticulus minor*, is between the parietal and occipital bones, of a triangular shape, with its base behind. It is often nearly closed at the birth of the child.

There are four lateral fontanels, two on each side. The anterior of these is placed at the junction of the parietal and sphenoid bones. The posterior fontanel occupies the upper and angular part of the mastoid portion of the temporal bone, where it joins the parietal and occipital bones.

The use of these openings is twofold—they materially assist the process of parturition by enabling the bones more readily to overlap each other; and they subserve, as we have seen, an important purpose in the growth of the cranial bones. Their production is as follows: ossification, as already explained, begins in or near the centre of the bones, and extends by degrees to the circumference, the remotest parts being the last completed, and these parts are the angles of junction. The fontanels, therefore, represent the unossified parts, which remain more or less open until the child reaches the age of four years.

OSSA TRIQUETRA.

The ossa triquetra, or *Wormian bones*, are isolated portions surrounded by distinct sutures, and occur in the course of the normal sutures themselves. They are most frequent in the occipital region in the track of the lambdoidal suture, and sometimes extend as low down as the superior semicircular ridge. In this place they are generally symmetrical. They also occur, though much less frequently, in the coronal, squamous and sagittal sutures; and in rare instances they are constituted of the external table alone. Each os triquetrum has a separate centre of ossification. Fig. 32.

THE TRUNK.

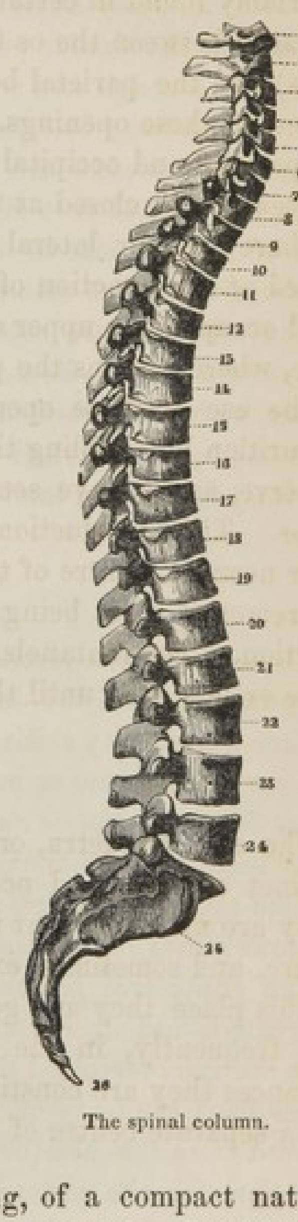
The trunk consists of the *spine*, *thorax* and *pelvis;* and the first of these, the spine, is constituted of a series of bones extending from the occiput to the termination of the os coccygis. The bones thus arranged are called *vertebræ*,

and form two irregular pyramids, placed base to base. The upper and longer pyramidal series is composed of *true vertebræ;* and the lower and shorter series is made of *false vertebræ;* so called because they change their form, in the progress of growth, from several parts to a single piece. The true vertebræ are twenty-four in number; viz., seven cervical, twelve dorsal and five lumbar. The false vertebræ are usually regarded as five—one sacral and four coccygeal.

THE VERTEBRAL COLUMN.

The spine, when seen in front, presents a straight line; but a profile view shows that it is composed of four distinct curvatures. The first of them is seen in the neck, which is convex in front, and consequently concave behind; the second is that of the dorsal vertebræ, which are concave in front for the enlargement of the thorax and the better accommodation of the contained viscera; the third curvature is that of the dorsal vertebræ, convex in front; and the fourth is seen in the deep concavity of the sacrum, which is prolonged below by the coccygeal bones.

Fig. 44.



The spinal column.

The true vertebræ present, in their articulated state, a continuous convexity in front, and a spinous and irregular surface behind; but the sacral series possess these characters in a much smaller degree. As a general rule each vertebra presents a body, a ring and several processes; but these also are much varied in the different classes. In the progress of development, a vertebra consists of three pieces—the body and the two sides of the ring; but early in life these several parts become consolidated into a single bone.

Fig. 44. Lateral view of the spinal column. 1 to 24, true vertebræ; 25, sacrum; 26, coccyx.

TRUE VERTEBRÆ.

Each bone of this series is characterized by a body, processes and medullary foramen.

The *body* varies from a rounded to an oval form, and is concave above and below. This concavity exists in different degrees in different vertebræ, and is always augmented by a marginal *annulus*, or bony ring, of a compact nature, and varying from an eighth to a quarter of an inch in diameter. It is thicker in front than behind, and serves the double purpose of strengthening the body and giving the socket form to these surfaces. The body itself is of a light spongy texture, and has many foramina, some for the attachment of liga-

ments, others for the passage of blood-vessels. Of the latter class, two in particular are seen on the posterior face of the body, within the medullary canal; they give exit to the veins of the diploic structure within.

From the body of each vertebra behind, a bony projection, called the *lamina*, is given off, which, joining its fellow of the opposite side, forms the medullary foramen, and thus contributes to the great *spinal canal.* These lamina, or bony bridges, as they are also called, are notched above and below; and when arrayed in contact with the contiguous vertebræ, form large *intervertebral foramina* for the passage of the spinal nerves and blood-vessels. The lower notch is deeper than the upper, and the portions of the bridge between them is flattened.

From the vertebral laminæ behind, four *oblique processes* arise, two above and two below. They have smooth, plane, or slightly concave surfaces for articulation with the similar processes of the proximate vertebræ. They have a sharp edge, and a rough and rounded dorsum for the attachment of ligamentous fibres.

From the bony bridges, and between the oblique processes on each side, the *transverse processes* are given off, variable in length and diversified in use. From the central part of the bridge behind arises the seventh or *spinous process*, of unequal size in the different vertebræ, but slanting more or less downwards in the entire column.

The vertebræ are separated in one sense, and connected in the other, by means of a dense, elastic, fibro-cartilaginous tissue called the *intervertebral substance*, to be described in another part of this work.

It has been remarked that the true vertebræ are divided into three classes—cervical, dorsal and lumbar, which we next proceed to examine and compare.

THE CERVICAL VERTEBRÆ.

These, as before stated, are seven in number, and are interposed between the occipital bone and the dorsal vertebræ. The body is small, having on its upper surface a concavity arising from the elevation of the lateral margins; but the inferior surface is concave in the middle and slightly convex at the sides. On its posterior face, the *diploic canals*, two and sometimes three in number, are conspicuously seen, and other vascular and ligamentous foramina are numerous. The oblique processes correspond to their names; the upper ones present backwards, the lower ones forwards.

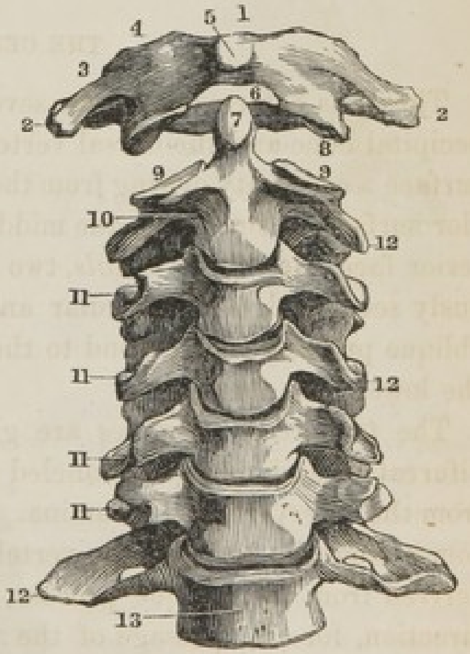
The *transverse processes* are given off between the oblique, are short and bifurcated, and deeply channeled above for the cervical nerves, in their course from the intervertebral foramina. An accessory limb of the transverse process comes from the body of the vertebra, and when this meets, exteriorly, the part derived from the oblique process, the *vertebral foramen* is formed in a vertical direction, for the passage of the vertebral artery and vein, and the vertebral plexus of nerves. Another, but smaller foramen, not unfrequently exists in this place, and serves for the transmission of an accessory vertebral vein. The spinous processes, which increase in length from the fourth to the seventh vertebra, are short, cleft at the end, and are nearly horizontal.

Atlas.—Four of the seven cervical vertebræ answer to the foregoing description, but the remaining three possess characteristics altogether peculiar. The first of these is the *atlas*, which directly articulates with and supports the head. It has no body, but in place of it there are two arches connecting the oblique processes: the *anterior arch* is marked in front by a tubercle for the attachment of the longus colli muscle; and on the opposite and inner surface is a smooth, pitted surface for the action and articulation of the processus dentatus of the second vertebra. The *posterior arch* is much the larger of the two, and smooth behind from the action of the muscles that pass to the head, but having in the centre a *tubercle* in place of a spinous process; and on each side of the tubercle is a marginal elevation of the bone marking the origin of the rectus posticus minor muscle. The superior oblique processes are large, and less inclined than in the other vertebræ, with a long, narrow articular facet for the occipital condyle; the lower one is rounded for junction with its fellow.

At the inner base of the oblique processes is a tubercle on each side for the attachment of the *transverse ligament* of the atlas, as it passes behind the processus dentatus of the axis. The transverse processes are formed of two crura that unite externally: between them is the vertebral foramen; and from this a groove is continued in the upper surface of the bone and behind the oblique process, for conveying the vertebral artery in its passage to the foramen magnum and cranium. The central foramen is larger in this bone than in any other vertebra; but the medullary portion of it only includes the space between the transverse ligament in front and the bony arch behind.

Fig. 45 is an anterior view of the cervical vertebræ. 1, atlas; 2, transverse process of the atlas; 3, foramen for the vertebral artery; 4, articular surface for the occipital condyle; 5, tubercle of the atlas; 6, spinal canal; 7, odontoid process of the vertebra dentata; 8, 9, oblique processes of the atlas and axis; 10, body of the axis; 11, grooves in the transverse processes, for the spinal nerves; 12, transverse processes; 13, body.

Fig. 45.



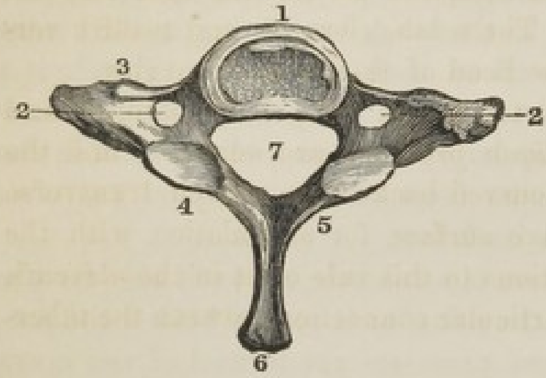
Cervical vertebræ.

Vertebra dentata, or *axis*. This is the second exception to the general vertebral conformation: its chief peculiarity consists in the tooth-like process, *processus dentatus*, that rises from the body of the bone in front, nearly vertical, but curved a little backwards. On its anterior face is a smooth oval spot for articulation with the ring of the atlas; and opposite to this, on the posterior side of the process, is another facet on which the transverse ligament of the atlas plays. On each side of the process, near its apex, is a rough, inclined surface, to which is attached the *oblique ligament*, of which the other end is fastened to the atlas and to the occipital bone; and from the apex itself another,

the *vertical ligament*, runs upwards to the occiput. The oblique processes present four slightly inclined and nearly plane surfaces; the transverse processes are short, seldom cleft, and the vertebral foramen is directed upwards and outwards. The spinal foramen is large and round; and the spinous process is robust, bifid, and excavated on its under surface.

The *seventh cervical vertebra* differs from the four above it, and has some characters in common with the contiguous dorsal vertebra. It has a larger body than the other cervicals, and a longer spinous process, which is tuberculated at the end. The transverse processes are also longer, and have a foramen for the transmission of the vertebral vein.

Fig. 46.



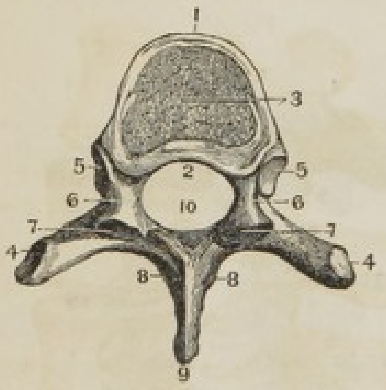
Seventh cervical vertebra.

Fig. 46 represents the lower surface of the seventh cervical vertebra. 1, body; 2, foramen for the vertebral vein; 3, 4, oblique processes; 5, lamina, or bony bridge; 6, spinous process; 7, spinal foramen.

THE DORSAL VERTEBRÆ.

The *dorsal vertebræ*, in other words the vertebræ of the back, are twelve in

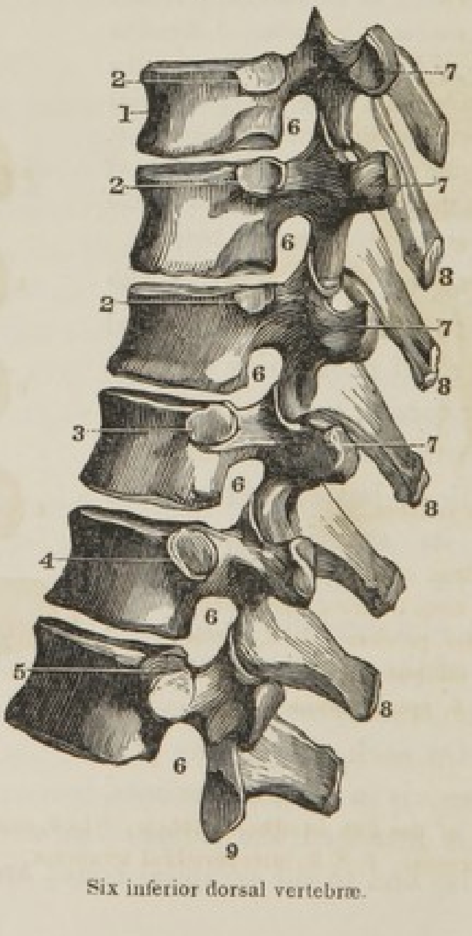
Fig. 47.



Dorsal vertebra.

Fig. 47, upper surface of the sixth dorsal vertebra. 1, annular or marginal ring; 2, spinal face of the vertebra; 3, body; 4, 4, transverse processes, with facet for articulating with tubercle of the rib; 5, articular facet for head of the rib; 6, laminæ or bony bridges; 7, oblique processes; 8, 8, junction of the laminæ to form 9, the spinous process; 10, spinal foramen.

Fig. 48.



Six inferior dorsal vertebræ.

Fig. 48 gives a lateral view of the six inferior dorsal vertebræ. 1, body of the vertebra; 2, 2, 2, rib-depressions formed in contiguous vertebræ; 3, 4, 5, the three last dorsals, in which the pit for the head of the rib is formed entirely in its respective vertebra; 6, 6, inter-vertebral foramina; 7, 7, articulating facets of the transverse processes, for receiving the tubercles of the ribs; 8, 8, spinous processes; 9, oblique process.

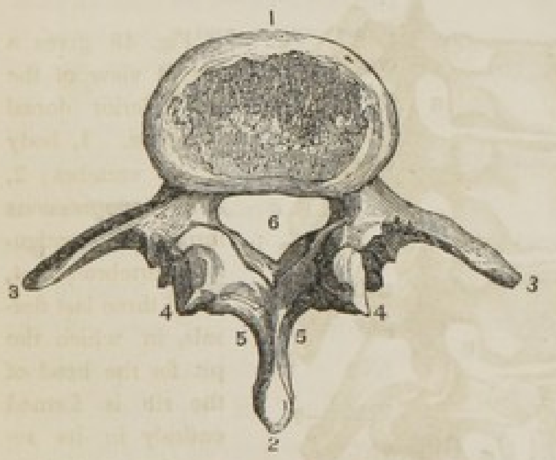
number. They are readily distinguished from all the other bones of the spine by the following characters: their bodies, which are intermediate in size between those of the cervical and lumbar series, are more convex in front, more compressed at the sides; which last present two facets on each side for the articulation of the heads of the ribs. These facets are partly formed in one bone, partly in the other, so that the articulating surface is only completed by the apposition of two contiguous vertebræ. There are four exceptions, however, to this rule; thus, the first vertebra has a complete pit for the first rib, and also forms part of that for the second. The tenth, eleventh and twelfth vertebræ also have each a perfect facet for the head of their respective ribs.

The *spinous processes* of the dorsal vertebræ are long, very oblique, and slightly tuberculated at the end; the *oblique processes* are vertical; and the *transverse processes* are long, robust, and curved backwards. Each transverse process is terminated by a smooth, concave surface for articulation with the tubercle of the corresponding rib. Exceptions to this rule exist in the eleventh and twelfth vertebræ, in which there is no articular connection between the tubercle of the rib and the transverse process.

THE LUMBAR VERTEBRÆ.

Lumbar vertebræ.—These portions of the spinal column are by far the largest of the series. This remark applies first to the body, which is elongated laterally, and marked on its articular surfaces by a very strong bony annulus. The

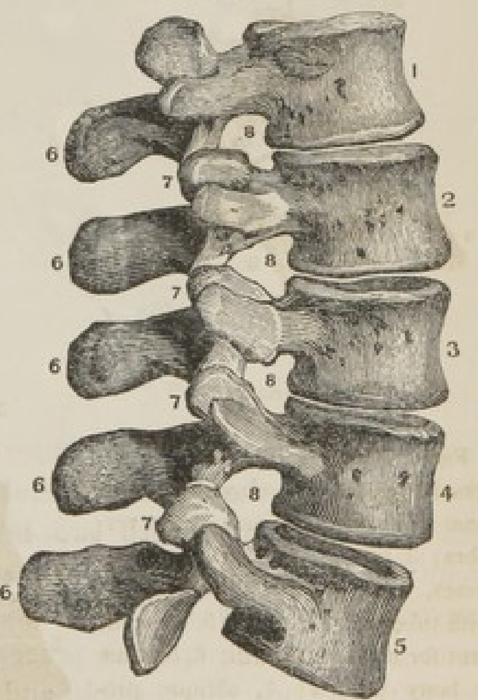
Fig. 49.



Lumbar vertebra.

Fig. 49. Inferior surface of the third lumbar vertebra; 1, annulus or ring, forming the margin of the body; 2, spinous process; 3, 3, transverse processes; 4, 4, oblique processes; 5, 5 junction of the laminæ; 6, spinal foramen.

Fig. 50.



The five lumbar vertebræ.

Fig. 50. Lateral view of the five lumbar vertebræ; 1 to 5, consecutive vertebræ; 6, 6, spinous processes; 7, 7, oblique processes; 8, 8, 8, intervertebral foramina.

spinous processes are broad and flat, and nearly horizontal. The transverse processes are long, slender and pointed, and the diploic and other foramina strongly developed; especially the intervertebral, which, being smallest in the cervical vertebræ, are here of the largest dimensions.

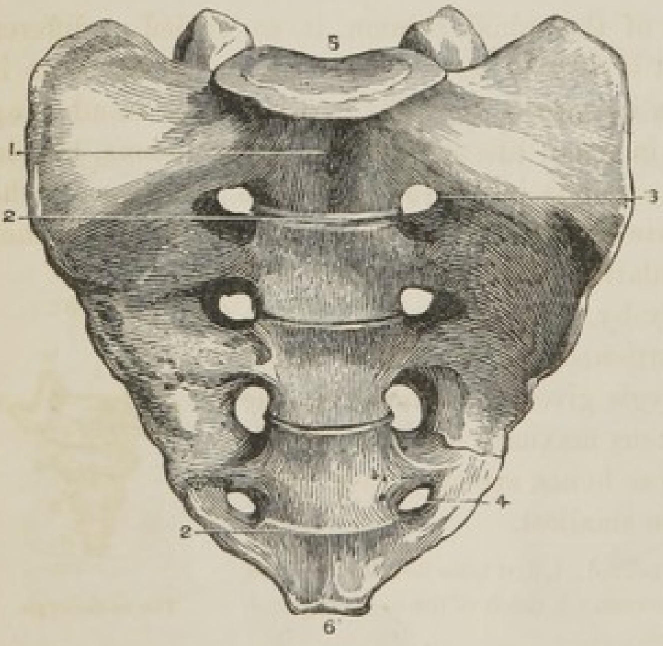
THE PELVIS.

The trunk of the body is terminated below by a large cavity, of a basin-like form, composed of the sacrum and os coccygis behind, and the ossa innominata at its anterior and lateral parts.

THE SACRUM.

This bone, as we have seen, constitutes the principal part of the lesser pyramid of the vertebral column. It is composed of five distinct pieces in early life, but in adult age these are united together, and are by very general usage regarded as a single bone. They are arranged in a triangular form, the base being articulated to the last lumbar vertebra.

Fig. 51.



The sacrum.

Fig. 51. The sacrum seen in front. 1. First bone of the sacrum, to which the four inferior pieces follow consecutively; 2. Lines of separation between the different parts; 3, the upper, and 4, the lower sacral foramina; 5, surface for articulation with the last lumbar vertebra; 6, articulating surface for the coccyx.

The *anterior surface* is concave in both sexes, but much more so in women; it shows the outlines of the five vertebral portions, marked off by four slight linear ridges; having, at the outer margin, the four *anterior sacral foramina* for the passage of the anterior sacral nerves. The *posterior surface* is convex at the sides and centre, with two lateral depressions running the length of the bone; in these depressions are seen the four *posterior sacral foramina*, for the corresponding nerves of the cauda equina. Between these foramina is a ridge or crest, with four spinous processes, which diminish in size from above downwards; they are short, thick, and rounded; the last one overhangs the spinal canal, which is here open, and continues so to the end of the bone. This opening is angular above and wider below, at which place it is often marked on each side by a tubercle, the rudiment of a fifth spinous process. Again, this sacral

portion of the spinal canal is sometimes open the whole length of the sacrum. On the outer side of the foramina is a row of tubercles, that look like a continuation of the transverse processes, and serve for the origin of the sacro-iliac ligaments.

The *upper border* has a large oval surface for articulation with the last lumbar vertebra. The oblique processes are large, and of a lunated shape, with a groove at their base, which assists in forming the intervertebral foramen for the fifth lumbar nerve.

The *lateral surface* presents an irregular, rough surface for articulation with the ilium; but below, this margin becomes thin, and contributes to form the great sacro-sciatic notch. The sacrum below is of a rounded triangular form, but is truncated at its inferior extremity; and at the latter place is also seen a notch which, in conjunction with another in the os coccygis, forms a foramen for the thirtieth spinal or fifth sacral nerve.

The texture of the sacrum is very light and spongy.

THE OS COCCYGIS.

This bone, the terminal point of the spinal column, is so varied at different ages, that by some anatomists it is divided as a single piece, by others as including four separate bones. In infancy it is wholly cartilaginous; in adult age formed of distinct pieces; and in after life it becomes a continuous, blended structure. The superior bone expands into two transverse processes; it has also two cornua, which articulate with those of the sacrum. Between these cornua is the surface for articulation with the sacrum. On each side of it, formed conjointly by both bones, is the intervertebral foramen, already mentioned, for the fifth sacral nerve. The side of the os coccygis gives attachment to the coccygæus, levator ani and gluteus maximus muscles, and to the sacro-sciatic ligaments. These bones are extremely light, and last of the series is much the smallest.

Fig. 52.

The os coccygis.

Fig. 52. The os coccygis, as seen from behind; 1, first bone forming the base, which articulates with the sacrum; 2, 2, cornua; 3, notch of the os coccygis; 4, second bone; 5, third bone; 6, fourth bone.

THE OS INNOMINATUM.

Although the *os innominatum* is an undivided bone in adults, it is composed of three distinct parts in children; and by the usage of anatomists this division is adopted in descriptions of the bone at all periods of life. These constituent portions are, the *ilium*, *ischium*, and *pubis;* the first forms the upper and lateral part of the pelvis; the second completes the pelvic region below; and the third forms its boundary in front.

The *os ilium*, the largest of the pelvic bones, is broad and thin; its external surface, or *dorsum*, is chiefly concave, with an elevation of the bone behind and before. It is bounded above by the *crista*, a rounded, semicircular margin, thinner in the middle than at the ends. This crista, which is an epiphysis in

early life, gives attachment, at its outer margin, to the obliquus externus muscle; at its inner lip it gives origin to the transversalis; and between the two arises the internal oblique. The crista terminates anteriorly in the *anterior superior spinous process*, from which originate the sartorius and tensor vaginæ femoris muscles and Poupart's ligament; an inch lower down, and in front, is the *anterior inferior spinous process*, for the origin of the rectus femoris muscle. The bone between these processes has a lunated notch. The sacral end of the crest terminates in the *posterior superior spinous process;* and two inches below this is the *posterior inferior spinous process.*

In front, and below the last named point, is the *sciatic notch*, for the passage of the pyriformis muscle, the sciatic nerve, and several blood-vessels. Let us now examine the dorsum between the several points above mentioned. A flat surface extends between the posterior superior spinous process for the origin of the glutæus magnus muscle; and from the posterior inferior process commences an arched line, marked by a perceptible roughness on the bone, and terminating at the anterior superior spinous process in front. All the space between this line and the crista of the ilium gives rise to the glutæus medius muscle; and all the space below it, to the margin of the acetabulum, is for the origin of the glutæus minimus. The inferior and thickest part of the dorsum ends in, and contributes to form, the cup-shaped cavity called the acetabulum.

The *costa* or *venter* is the inner surface of the ilium; and the concavity that occupies four-fifths of its surface is the *iliac fossa*, in which is lodged the iliacus internus muscle. The fossa is bounded below by a part of the *linea ileo-pectinea*, which runs downwards and forwards to join a similar linear ridge of the os pubis. The posterior portion of the costa is marked by a rugged, semilunar excavation, which joins this bone to the sacrum; and behind this surface, and in the denuded bone, continuous with it, is another rough depression for the attachment of the interosseous ligaments.

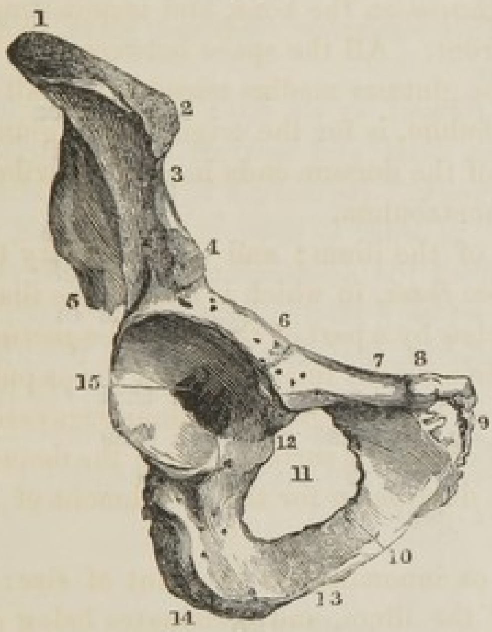
The *ischium* is the second bone of the os innominatum in point of size: its *body* descends from the inferior margin of the ilium, and terminates below and in front in a smaller and tapering portion called the *ramus*. The body is rough externally for the attachment of muscles, and forms, at its upper margin, a share of the acetabulum with its *notch* below. The internal surface is concave and smooth, and terminates behind in the *spinous process*, a sharp tooth-like projection, from which arise the coccygæus, gemellus, and levator ani muscles. It also gives attachment to the anterior sacro-sciatic ligament. The spinous process slopes above into the *sciatic notch;* below, into the tuberosity of the ischium; and between the latter and the spine is a smooth channeled surface for the play of the obturator internus muscle. The rough ridge forming the margin of this channel is for the attachment of the great sacro-sciatic ligament.

From the body of the ischium the tuberosity begins and curves downwards and forwards, being thickest at its origin. Its upper rough surface is divided into two; the uppermost of them presents outwards, and gives origin to the semi-membranosus muscle; and the lower surface affords origin to the semi-tendinosus and the long head of the biceps flexor cruris. To the outer ridge below this is attached part of the adductor magnus.

The *crus* or *ramus* of the ischium is flattened and triangular, with a sharp, gently curved inner margin, that is continuous with a similar edge on the body of the bone, thus forming two-thirds of the great *thyroid* or *obturator foramen.* The ramus of the ischium terminates above in that of the pubis, about an inch below the symphysis.

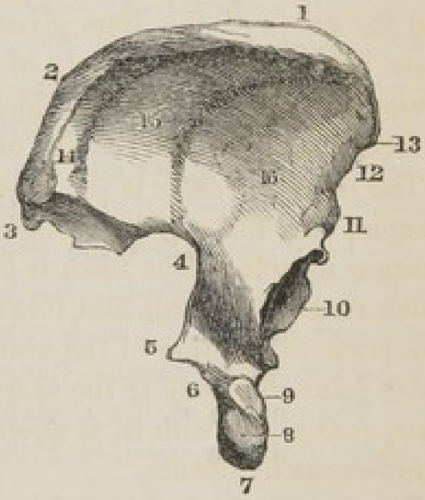
Os pubis.—This, the smallest part of the triple bone, terminates the os innominatum in front. It is composed of two portions, the *body* and *ramus*. The former is placed in apposition with the ilium above and the ischium below: its upper surface is nearly horizontal, tapers towards the symphysis, and is marked by two ridges. The first of these, the *crista*, is internal and continuous with the linea ilio-pectinea of the ilium; it is straight and sharp, and running diagonally with respect to the parent bone, terminates at the *spine* of the pubis, a rounded process at its anterior margin.

Fig. 53.



Os innominatum.

Fig. 54.



Os innominatum.

Fig. 53 represents the principal features of the os innominatum, as seen in a front view. 1, crista of the ilium; 2, anterior superior spinous process; 3, interspinous notch; 4, anterior inferior spinous process; 5, posterior inferior spinous process; 6, ilio-pectineal eminence; 7, crista of the pubis; 8, spine of the pubis; 9, symphysis pubis; 10, junction of the rami of the pubis and ischium; 11, thyroid or obturator foramen; 12, cotyloid notch; 13, ramus of the ischium; 14, tuber ischii; 15, acetabulum, with the fossa in its bottom.

Fig. 54 gives a lateral view of the os innominatum. 1, crista ilii; 2, posterior superior spinous process; 3, posterior inferior spinous process; 4, great sciatic notch; 5, spine of the ischium; 6, trochlea for the obturator internus muscle; 7, tuber ischii; 8, rough surface for the origin of the biceps flexor cruris and semi-tendinosus muscles; 9, surface for the origin of the semi-membranosus muscle; 10, acetabulum; 11, anterior inferior spinous process; 12, interspinous notch; 13, anterior superior spinous process; 14, origin of the gluteus magnus muscle; 15, origin of the gluteus medius; 16, origin of the gluteus minimus.

From the spine of the pubis, there runs backwards a rounded ridge of bone that terminates at the margin of the acetabulum; between this ridge and the linea ileo-pectinea an angle is formed, with its apex at the spine. The femoral vessels pass over the smooth base of the triangular surface, together with the

iliacus internus and psoas muscles. The bone is truncated in front by a rough, oval surface of an inch and a half in length, which, by articulating with the proximate surface of the opposite bone, forms the *symphysis pubis*. Below the symphysis the bone is contracted for an inch of its length into a branch called its *ramus*, which is blended with the similar prolongation of the ischium. It is slightly hollowed in front, and gives origin to the adductor longus and adductor brevis muscles. Within and behind, the os pubis presents a sharp edge for the *thyroid foramen*, having at its upper part a channel for the passage of the obturator vessels. The base of the bone forms part of the *acetabulum* for lodging the head of the femur.

The *thyroid foramen* is formed in nearly equal proportions by the ischium and pubis. It is of an irregular oval form, with a sharp, angular margin, which, in the subject, gives attachment to a strong membrane called the thyroid ligament, that covers and shuts the entire foramen, excepting only the groove above for the blood-vessels and nerve. This *obturator ligament* gives rise to the internal and external obturator muscles.

The acetabulum.—This large cavity is formed, as we have seen, by each of the parts of the os innominatum; thus, the ilium and ischium each contribute two-fifths, and the pubis one-fifth of the cavity. Its margin is high and sharp, especially at the upper and posterior part, in order to protect and restrain the head of the femur in that direction. In front the acetabulum has a deficiency at the bony rim called the *notch*, across which a strong ligament is extended which is continuous with another, the *cotyloid*, that is attached to the whole acetabular margin. The bottom of the cavity is rough, deeper than the rest, and perforated by several foramina; it lodges a mass of fat in a membranous sac. The surface of the acetabulum exterior to the margin, is rough for the attachment of the capsular ligament of the joint.

THE MALE AND FEMALE PELVIS COMPARED.

If the pelvis be reconstructed by its several bones, it will be observed that the linea ileo-pectinea and the projecting base of the sacrum, divide it into two unequal regions; the lower is called the *true* or *lesser pelvis*, the upper the *false* or *greater pelvis*. This line also constitutes in itself the *brim* of the pelvis, and the area included within it is the *inlet* or *superior strait*. The greater pelvis is bounded on the sides by the iliac fossæ and partially behind by the top of the sacrum. It is consequently incomplete in the denuded bones both before and behind; but the deficiency is supplied in the one instance by the last lumbar vertebra and very strong ligaments, and in the other by the abdominal muscles.

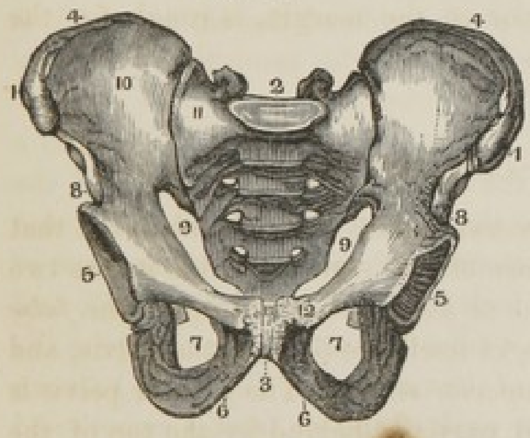
The *lesser pelvis* has the sacrum and os coccygis behind; the pubic bones and thyroid foramina in front; and the ischium and small surfaces of the ilium and pubis laterally. Its upper margin, or *brim*, is of an ovoidal form, and the *superior strait* of variable diameter in the two sexes. As these measurements possess a pre-eminent interest relatively to parturition, we shall only give the average diameters of the *superior strait* in the female pelvis. The *longitudinal*

diameter,* measured from the symphysis pubis to the *promontory* or anterior and upper rim of the sacrum, gives four inches: the *transverse diameter*, which crosses the former at right angles from the brim on one side to the corresponding point on the other, measures five inches; and the *oblique diameter*, drawn from the sacro-iliac symphysis to the inner wall of the acetabulum of the opposite side, measures also five inches.

The *inferior strait* of the lesser pelvis is bounded behind by the terminal bone of the os coccygis, laterally by the tuberosities of the ischium, and in front by the symphysis pubis. The three diameters of this passage in the female, are the following: between the points just indicated as forming the *longitudinal* or antero-posterior diameter, four inches; but this measurement may be varied an inch by the flexibility of the coccygeal bones in early life. The *transverse diameter*, drawn from one tuberosity of the ischium to the other, gives four inches. The *vertical diameters* of the lesser pelvis are three; thus, the *posterior depth*, between the sacrum and the coccyx, is four inches and a half; the *middle depth*, which is equivalent to that of the lateral walls, three inches and a half; and the *anterior depth*, that of the symphysis pubis, an inch and a half.

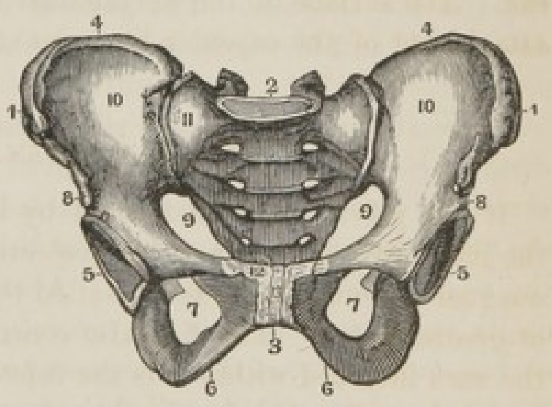
These diameters are different in the male pelvis, as are also all its proportions. The male bones are stronger, and the cavity, though deeper, is narrower, and the iliac bones are much less expanded. In the female, the superior and inferior strait, and the ilia are larger, the sacrum more concave, the tuberosities more distant from each other, and the span of the pubic arch greater: consequently the whole pelvic cavity possesses a much greater capacity in the female than in the male.

Fig. 55.



Male pelvis.

Fig. 56.



Female pelvis.

The male and female pelvis are compared in Figs. 55 and 56; 1, anterior superior spinous process of the ilium; 2, base of the sacrum; 3, angle of the pubis; 4, crista of the ilium; 5, acetabulum; 6, ramus of the ischium; 7, thyroid or obturator foramen; 8, anterior, inferior spinous process of the ilium; 9, 9, the superior strait; 10, iliac fossa; 11, sacro-iliac symphysis; 12, spine of the pubis; 13, symphysis pubis.

* Called also sacro-pubic, conjugate and antero-posterior.

THE THORAX.

The thorax is a conical cavity forming the upper half of the trunk of the body. It is composed of the spine behind, the sternum in front, and the ribs intermediately.

THE RIBS.

The ribs constitute a series of slender, curved, and flattened bones, interposed between the sternum before, and the vertebral column behind. They are convex externally, and by consequence concave internally; an arrangement that accomplishes a double object, first, by giving capacity to the thorax, and secondly, by their exterior arched structure protecting the contained parts from the effects of blows and other injuries.

The ribs are twelve in number on each side: of these, the seven upper ones are articulated with the sternum, and are called *true ribs;* the five below are called *false ribs*, because their cartilages do not severally reach the sternum; and the last two false ribs, being free at their extremities, are sometimes called *floating ribs.*

The spinal end is rounded and tuberculous; but from this point it becomes flattened, and continues so to its junction with the sternal cartilages. The upper edge is rounded, the lower one sharp; and on the inner side of the latter is a groove running nearly the length of the bone, for the transit of the intercostal artery and nerve.

Of the true ribs, the first is the smallest, and they increase in length to the eighth; after which the order is reversed, the first false rib being the longest, the last the shortest. The general course or direction of the entire series is downwards and forwards, with a double curvature, at the same time that they are placed parallel to each other.

The vertebral end of each rib is rounded into a *head*, with two facets, and a dividing ridge; the facets are received into the depressions on the bodies of the vertebræ; the ridge itself is connected with the intervertebral substance; and the proximate surface is rough, for the attachment of the capsular ligament of the corto-vertebral articulation. About an inch from the head of the rib, and on its posterior surface, is the *tubercle*, with a smooth facet for junction with the corresponding part of the transverse process of the vertebra. The space between the head and tubercle is called the *cervix*, or neck of the rib, and is smooth and rounded. Close to this articular tubercle is another, also on the posterior margin, for the attachment of ligaments, and slips of the longissimus dorsi muscle.

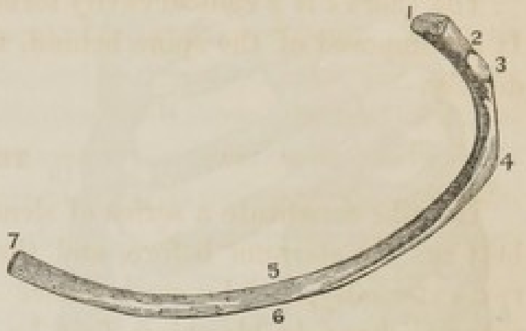
At a little distance from its vertebral extremity, the rib is suddenly bent upon itself, forming the *angle;* the distance between the angle and the head increases from the first to the eleventh rib, being about an inch in the former, and in the latter more than two inches. This part of the rib is marked on its posterior surface by a rough oblique ridge, for the insertion of a tendon of the sacrolumbalis muscle.

Each rib becomes broader and flatter as it approaches the sternum, where its

terminal extremity is marked by an oval pit for the reception of the sternal cartilage.

Fig. 57. One of the true ribs. 1, head of the rib, with its double articulation; 2, neck; 3, tubercle; 4, angle; 5, upper margin; 6, lower margin; 7, sternal extremity.

Fig. 57.



The preceding characters are deficient in some ribs, and modified in others. The *first rib*, for example, is more curved and flatter than the others. It has no angle, and its head presents but a single face for articulation with the first dorsal vertebra. On its upper surface is a shallow groove, marking the passage of the subclavian artery, near which is a roughness for the insertion of the scaleni muscles.

The eleventh rib has no tubercle for articulation with the transverse process of the vertebra, its attachments being merely ligamentous; and its cartilage is only loosely connected with that of the rib above. Its head articulates exclusively with the eleventh dorsal vertebra.

The twelfth rib is short and straight. It has no articulation with the transverse process, and is joined by its head to the last dorsal vertebra. It has no groove for the intercostal artery.

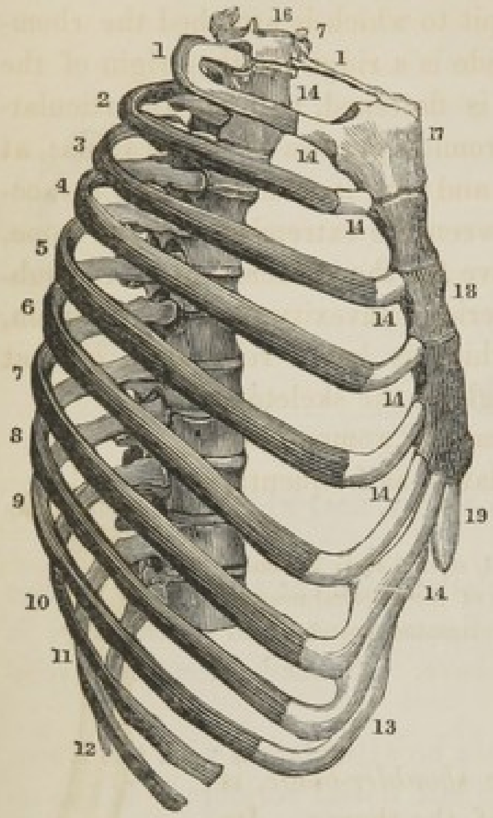
THE STERNUM.

The *sternum* is the anterior boundary of the thorax, and is chiefly kept in its place by the ribs. It is formed of two flat parallel plates of bone, with a very light intervening cellular structure. It is large above, and pointed below, whence the ancients compared it to a gladiator's sword. The anterior surface is flat, the posterior slightly concave; but the whole bone has an arched form, arising from the adjustment of its several parts. Each side of the bone is marked with seven pits for receiving the cartilages of the corresponding true ribs. These depressions are distant from each other above, but become gradually nearer as they descend, until they are nearly in contact.

The sternum is composed of three pieces, as follow. The upper portion, called the *manubrium*, or handle, is a triangle, with its base upwards, and a truncated termination below. The upper surface is thick, with a lunated depression in the centre, on each side of which is an articular face for the end of the clavicle. Immediately below is the pit for the cartilage of the first rib, and still lower down, half the pit for the second costal cartilage. The anterior surface is slightly convex in the centre, but depressed on each side; the posterior surface presents a superficial excavation for the front of the trachea.

The second sternal bone has its *body* long, flat, and nearly equilateral. On its sides are complete pits for the cartilages of the third, fourth, fifth, and sixth pairs of ribs; and the fossæ for the second and seventh cartilages are partly formed in this bone.

Fig. 58.



Ribs and sternum.

The third piece of the sternum is called *cartilago ensiformis*, from some resemblance to the point of a sword. It ossifies very slowly; is mere cartilage in early life; and in adult age has often a cartilaginous margin round a bony centre. It finally becomes complete bone, and consolidates with the proximate piece into a single shaft. At its side is half the pit for the seventh costal cartilage. The ensiform bone is also variable in size and position: occasionally it curves inwards, causing a concavity at the end of the sternum; in other instances, it curves outwards, or even to one side. Sometimes it is perforated in the centre, and not unfrequently bifurcated at the end.

Fig. 58 gives a lateral view of the ribs and sternum. 1 to 12, the twelve ribs; 13, cartilages of the false ribs; 14, 14, cartilages of the true ribs; 16, first dorsal vertebra; 17, first bone of the sternum; 18, second sternal bone; 19, third part of the sternum, or ensiform cartilage.

COSTAL CARTILAGES.

The cartilages of the ribs connect them with the sternum, giving them greater freedom of motion, and enlarging the cavity of the chest. They increase in length from the first to the seventh, and these cartilages which belong to the true ribs are articulated directly with the sternum. The cartilages of the false ribs diminish in length from the first to the last; the three superior ones of this set joining the cartilage of the seventh true rib; the two last, the eleventh and twelfth cartilages, are not attached to the others, but are placed between the abdominal muscles, by which they are chiefly sustained.

These cartilages, after middle life, frequently present osseous points and patches, and sometimes become completely ossified in old age.

THE UPPER EXTREMITIES.

These consist of the shoulder, arm, forearm and hand; and the shoulder itself is formed of two bones, the *clavicle* and *scapula*.

THE CLAVICLE.

The *clavicle* has been aptly compared to the italic letter *ſ*: it is placed between the sternum and scapula, at the upper, anterior part of the chest, giving form and protection to this region, independently of its share in the motive apparatus of the shoulder. The sternal end of the clavicle is full and rounded,

with an articular surface for junction with upper margin of the sternum; and on the under margin of the bone is a rough pit to which is attached the rhomboid ligament. On the opposite and upper side is a ridge for the origin of the sterno-mastoid muscle. The outer extremity is flattened, and has an articulating face where it comes in contact with the acromion process of the scapula: at the opposite or posterior margin is a tubercle, and near it a ridge for the coraco-clavicular ligament. The upper surface, between the extremities of the bone, is smooth; but the inferior margin has a groove for the attachment of the subclavius muscle. The clavicle presents an anterior convexity next the sternum, and a concave surface at its scapular half, which is but a reiteration of that arched and protective form conspicuous throughout the skeleton.

This bone is longer, straighter and more delicate in women than in men; and its texture is so light and cancellated, as frequently to subject it to fracture.

Fig. 59.

Clavicle.

Fig. 59. Under surface of the clavicle of the left side; 1, sternal end; 2, attachment of the rhomboid ligament; 3, rough surface for origin of the pectoral muscle; 4, fossa for the subclavius muscle; 5, articular face for the acromion scapulæ.

THE SCAPULA.

This bone, called in common parlance the *shoulder-blade*, is attached to the upper and posterior parietes of the thorax. Its form is triangular; and it is divided into an anterior and posterior surface, three angles and three margins.

The *anterior face* is concave, and furrowed by the sub-scapularis muscle which covers the whole surface, and is interposed between it and the ribs. This surface is sometimes called the *venter* of the scapula. The posterior face or *dorsum* is divided into two unequal surfaces by the *spine;* an elevated ridge that commences by a smooth triangular plane (formed by the trapezius muscle), at the upper part of the base of the scapula, from which point becoming rapidly broader, it terminates externally by overarching the shoulder-joint: this part of the spine is the *acromion scapulæ*, a triangular projection, convex above and concave below, with an anterior, articular face for the external end of the clavicle. The supra and infra-spinatus muscles, in their course to the os humeri, pass under the arch of the acromion. The inferior margin of the spine gives origin to the deltoid muscle; and the superior edge serves for the insertion of the trapezius. All that portion of the dorsum below the spine, is the *fossa infra-spinata*, and is occupied by the infra-spinatus muscle; the surface above the spine is the *fossa supra-spinata*, for lodging the supra-spinatus muscle.

The three *margins* or *costæ* of the scapula, are the anterior, posterior and superior. The *anterior* or *axillary margin* presents two narrow plane surfaces that meet at an angle which extends from the glenoid cavity above to the inferior angle of the bone. That part of it contiguous to the glenoid cavity, forms a rough ridge for the origin of the long head of the triceps muscle. Upon the

posterior surface the bone is smooth and nearly flat, and gives origin to the teres minor; but the inner or anterior face is gently grooved for the teres major.

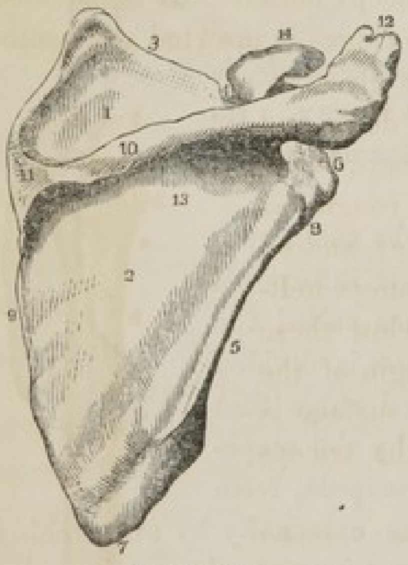
The angle below is marked exteriorly by a flat surface from which also the teres major has a partial origin, and from which the latissimus dorsi muscle derives an accessory slip.

At the upper end of the anterior margin is the *glenoid cavity* for the head of the humerus; an oval, slightly concave surface. At its upper end is a small flat surface for the origin of the tendon of the long head of the biceps muscle; and from the margin of the glenoid cavity the bone becomes thinner, forming the *neck*, or *cervix scapulæ*.

From the cervix arises a long, robust beak-like spine called the *coracoid process*, which is curved over the humeral articulation. In the perfect bone, the end of this process is marked by three plane surfaces; from one of these arises the short head of the biceps muscle; from the second, the coraco-brachialis; and into the third is inserted the pectoralis minor muscle.

Irregularly continuous with the coracoid process, is the *superior margin* or *costa;* it terminates at the *superior angle*, and in its course has a *notch*, sometimes a foramen, for the passage of the supra-scapular nerve and blood-vessels.

Fig. 60.



The scapula.

The *posterior* or vertebral margin is called the *base;* it is slightly curved and extends the whole length of the scapula between its superior and inferior angles, and gives insertion to three muscles; to the rhomboideus major below the spine; to the levator scapulæ above the spine; and to the rhomboideus minor between the two.

Fig. 60 is a posterior view of the scapula. 1, fossa supra-spinata; 2, fossa infra-spinata; 3, superior costa and angle; 4, coracoid or supra-scapular notch; 5, anterior costa, or axillary margin; 6, glenoid cavity; 7, inferior angle; 8, origin of long head of triceps; 9, base, or internal costa; 10, spine; 11, triangular facet made by the trapezius; 12, acromion; 13, base of the spine; 14, coracoid process.

The scapula is a light, thin bone, especially at the fossæ above and below the spine, at which parts there is no diploic tissue, but in place of it a thin, diaphanous plate of bone, which in old persons is not unfrequently perforated by large openings from the action of the contiguous muscles. The scapula is perforated by many nutritious foramina for the passage of blood-vessels, the largest being between the base of the spine and the cervix.

THE OS HUMERI.

This, the *arm-bone*, is interposed between the shoulder and the forearm, and divided into a head, condyles and shaft. The *head* is hemispherical, and smooth for articulation with the glenoid cavity of the scapula. It is placed obliquely

in reference to the body of the bone, and has at its base a channel called the *neck*, which is rough for the attachment of the capsular ligament.

Immediately in front of this part of the bone, and on the inside of the bicipital groove, is a prominent tubercle into which the subscapularis muscle is attached. On the outside of the groove is another and larger tubercle, having three unequal surfaces; into the anterior of these the supra-spinatus muscle is inserted; into the middle surface, the infra-spinatus; and into the posterior one, the teres minor.

Fig. 61.

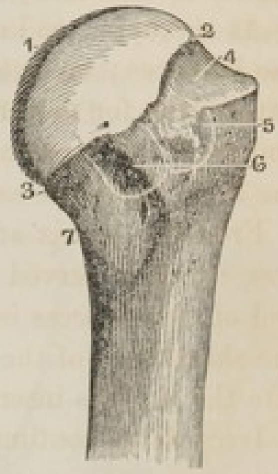


Fig. 61. Posterior view of the upper end of the os humeri of the right side. 1, head of the bone; 2, 3, neck of the bone; 4, 5, 6, mark the three facets of the greater tubercle, for muscular attachments, viz., 4 for the supra-spinatus muscle; 5 for the infra-spinatus; 6, the exterior one, for the teres minor: 7, commencement of the shaft of the bone.

The groove that separates these tubercles is seen to arise at the head of the bone and extend for several inches along the median line of the shaft; it is the *bicipital groove*, for lodging the long head of the biceps muscle. It is bounded on each side of a ridge; into the anterior of these ridges is inserted the pectoralis major muscle; the posterior or internal one gives attachment to the broad tendons of the latissimus dorsi and teres major. On the external surface of the os humeri, below the insertion of the pectoralis major, is a triangular roughness of the bone for the attachment of the deltoid muscle; and on the opposite and inner side of the bone is a roughness indicating the insertion of the coraco-brachialis. Below these parts the bone is smooth and expanded for the origin of the brachialis internus muscle. The whole posterior surface is smooth and rounded for the accommodation of the triceps extensor cubiti.

Fig. 62.

Fig. 62, the right humerus, seen in front. 1, head of the bone; 2, greater tubercle, and 3, its anterior facet, for the supra-spinatus muscle; 4, bicipital groove; 5, insertion of pectoralis major; 6, lesser tubercle of the humerus, for attachment of subscapularis muscle; 7, neck of the bone; 8, ridge for attachment of latissimus dorsi muscle; 9, triangular ridge for attachment of the deltoides; 10, origin of the brachialis anticus; 11, origin of extensor muscles of the hand; 12, external condyle; 13, articular face for the radius; 14, 15, trochlea for the play of the ulna; 16, internal condyle; 17, lesser sigmoid cavity.

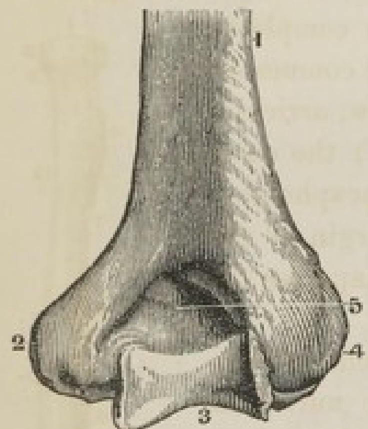
The inferior extremity of the humerus is flattened in an angular form, with a terminal, smooth, articular surface, and two strongly marked processes, one on each side, called the *condyles*. The *external condyle*, the smaller of the two, is the termination of a long ridge on the corresponding side, that gives origin to the extensor muscles of the forearm and hand.

The *internal condyle* is prominent and angular, and gives origin to the flexor

muscles of the wrist and hands. This condyle sends down a ligament—the internal lateral a ligament—to the ulna; the external condyle another to the radius—the external lateral ligament.

The articular face of the humerus projects obliquely from between the condyles; it has two lateral protuberances and an intermediate concavity, the surfaces of which are smooth. The internal protuberance is grooved in the middle in a pulley-like form; it is the larger of the two, and receives the head of the ulna. Directly above this surface, and on the front of the humerus, is the *lesser sigmoid cavity* for the play of the coronoid process of the ulna. It is sufficiently large to receive the end of the finger; but at its outer margin is a much smaller pit for receiving the rounded margin of the head of the radius in the flexions of the forearm. On the opposite or posterior side is the *greater sigmoid cavity*, continuous with the articular surface and adapted to the reception of the olecranon process of the ulna when the arm is extended.

Fig. 63.



Lower end of the humerus.

Fig. 63, lower and posterior view of the humerus of the right side. 1, shaft of the bone; 2, external condyle; 3, trochlea for the play of the olecranon process; 4, internal condyle; 5, greater sigmoid cavity.

At the fore and inner side of the bone, below its middle, is the medullary foramen, slanting towards the condyles, for transmitting the nutritious vessels to the internal structure.

THE FOREARM.

The *forearm* is formed of two bones, the *radius* and *ulna;* the latter is so called because it is used as a measure; the former receives its name from a supposed resemblance to the spoke of a wheel.

THE RADIUS.

The *radius* is placed at the outside of the forearm. It has a long slender shaft with a head at one end and a condyle at the other. The *head* is circular, and slightly concave at the top for articulation with the humerus by the outer tubercle of the joint. Below the head the radius is contracted into the *cervix* or neck for the play of the annular ligament. The internal and lateral surface of the head is broad and smooth where it rotates in the lesser sigmoid cavity of the ulna. Directly below the head and on the inner margin, is the *tubercle* for the insertion of the biceps muscle; and from this point a ridge runs downwards and outwards, into which the supinator radii brevis is inserted.

The shaft of the radius is gently arched outwards its whole length; rounded on the external side, and flattened before and behind. The inner margin is sharp for the attachment of the interosseous ligament. The *anterior surface* lodges, at its upper concave part, the flexor longus pollicis; its flatter part below sup-

ports the pronator quadratus muscle. The *posterior surface* is rounded above by the supinator radii brevis. The *condyle* or lower end of the radius is flattened in front and convex behind, and bounded externally by the *styloid* process, which gives off from its apex the external lateral ligament.

At the side and base of the styloid process, is a fossa for the tendons of the extensor ossis metacarpi pollicis, and extensor primi internodii muscles; and behind, or on the back of the process, is a wider channel for the tendon of the extensor carpi radialis longior and brevior. In the middle of the condyle behind is a well marked ridge with an interposed oblique furrow for the tendon of the extensor indicis; and between this ridge and the ulnar margin, is a broad, excavated surface, which is completed by the ulna, for the tendons of the extensor digitorum communis. The carpal surface of the radius presents a large, hollow, articular surface, divided by a very slight ridge into two facets; the outer one receives the corresponding convexity of the os scaphoides; the inner one that of the os lunare. The internal margin of the condyle has also an articular surface of a lunated shape for the play of the opposite side of the ulna.

The anterior surface of the radial shaft has a sub-central foramen running obliquely upwards, for the passage of the nutritious vessels to the interior of the bone. The radius ossifies from three centres—one for the shaft and one for each extremity.

Fig. 64.

Radius.

Fig. 64, a posterior view of the radius of the right side. 1, head of the bone; 2, annular articulating surface for the ulna; 3, neck; 4, tubercle; 5, nutritious foramen; 6, insertion of supinator radii longus; 7, internal edge for the attachment of the interosseous ligament; 8, articular face for the ulna; 9, anti-carpal face of the bone; 10, styloid process; 11, grooves made by the extensor tendons in their course to the hand.

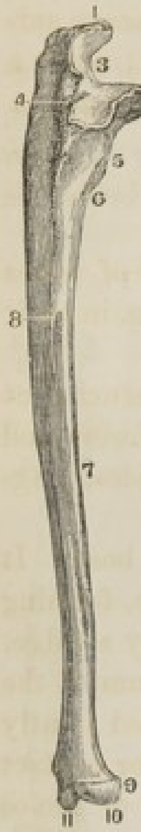
THE ULNA.

This bone is placed nearly parallel to the radius, but is reversed in its proportions, being large above and small at its carpal end. The *head* of the ulna forms the greater part of the articular surface between the forearm and the humerus; it is deeply excavated to form the *greater sigmoid cavity*, which receives the pulley-like surface of the os humeri. On the outer side of the head, and continuous with the cavity just mentioned, is a much smaller and more superficial one, the *lesser sigmoid cavity*, for the lateral articular face on the head of the radius.

The back of the ulna at this part is formed into a very strong, curved process, the *olecranon*, which is received into the greater sigmoid cavity of the humerus. The olecranon is rough for the attachment of the triceps muscle; and below is a flat, triangular surface that supports the arm in the leaning posture. In front of the greater sigmoid cavity of the ulna is the *coronoid process*, which, in the motions of the arm, is received into the lesser sigmoid cavity of the humerus; and at the base of this process is a rough surface for the insertion of the brachialis anticus muscle.

The carpal end of the bone is also covered with cartilage; and between it and the bones of the wrist an interarticular cartilage is placed, which is continuous with that on the end of the radius. At the inner side of the head, is the *styloid process*, into which is inserted the internal lateral ligament of the wrist. The back of the ulna at this part has a groove for the tendon of the extensor carpi ulnaris.

Fig. 65.



Ulna.

Fig. 66.

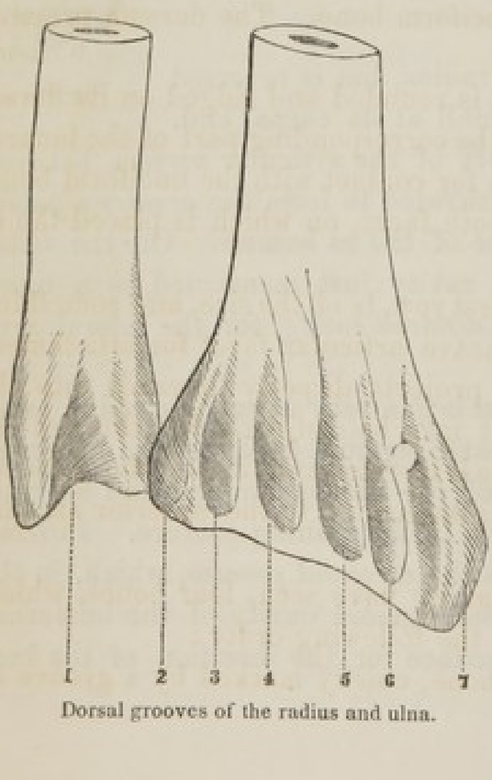
Upper end of ulna.

Fig. 65, lateral view of the ulna of the right side. 1, olecranon process; 2, coronoid process; 3, greater sigmoid cavity; 4, lesser sigmoid cavity; 5, tubercle of the ulna for attachment of brachialis anticus muscle; 6, 7, angle for the interosseous ligament; 8, nutritious foramen; 9, articular face for the radius; 10, capitulum, or little head of the ulna; 11, styloid process.

Fig. 66, front view of the upper articular face of the ulna of the right side. 1, olecranon; 2, 3, greater sigmoid cavity; 4, tubercle for insertion of brachialis anticus; 5, commencement of interosseous angle.

The ulna is irregularly triangular, and presents three ridges extending the length of the bone. The first and most strongly marked of these ridges commences on the radial side, at the lesser sigmoid cavity, and terminates a short distance above the carpal end of the bone: its sharp edge gives attachment to the interosseous ligament, and affords origin, at its upper part, to the supinator radii brevis muscle. A *second ridge* begins at the base of the coronoid process on the inner margin of the bone, and passes downwards until it terminates in the styloid process, becoming more and more rounded in its progress. It gives origin from its upper two thirds to the flexor digitorum profundus, and at its lower end to the pronator quadratus muscle. The *third ridge* has its rise at the base of the olecranon, runs down on the posterior side of the bone, and curving towards its radial margin, is gradually lost on the surface above the carpal joint. At the radial side of this ridge, and below the olecranon, is a triangular depression for the insertion of the anconeus muscle.

Fig. 67.



Dorsal grooves of the radius and ulna.

Fig. 67. This drawing shows the course of each of the extensor tendons in its respective groove on the dorsum of the ulna and radius. I have drawn some of the ridges (which are very differently developed in different individuals), more strongly than they exist in nature. 1, groove for the extensor carpi ulnaris; 2, extensor digitorum communis; 3, indicator; 4, extensor pollicis major; 5, extensor carpi radialis brevior; 6, extensor carpi radialis longior; 7, extensor pollicis minor and extensor ossis metacarpi pollicis.

The bones of the forearm are parallel to each other when the thumb is turned outwards; and they retain the same relative position if placed across the chest, provided the thumb is turned upwards. The space between the radius and ulna being filled up by the interosseous ligament, an elongated, slightly concave surface is formed, on which, in front, lie the flexor muscles of the hand; while a similar surface on the back of the forearm, gives support to the extensor muscles.

CARPUS.

The wrist is composed of two arches placed side by side, composed of bones remarkable for their unequal forms and sizes, and somewhat resembling, in their articular relations, the cyclopean masonry of the primitive ages.

These two rows of bones are placed in the following order: commencing at the radial edge, we find, in succession, the scaphoides, lunare, cuneiforme and pisiforme, in the first row; and in the second, the trapezium, trapezoides, magnum and unciforme.

The *os scaphoides* is so named from its supposed resemblance to a boat. It is convex above, more than half the convexity, that on the outer side, forming the surface for articulation with the radius. A groove, bordered by a ridge, separates the radial surface from another which is rather on the dorsum of the bone, and which receives, on its rounded margin, the concavity formed jointly by the trapezium and trapezoides in front. Its inner side is smooth for contact with the lunare; and its concave surface in front receives the head of the os magnum.

The *os lunare* has, as its name implies, a lunated form, being strongly convex above for articulation with the radius, and concave in front where it assists the scaphoides to form a lodgment for the head of the os magnum. It articulates by a semilunar surface with the contiguous part of the os scaphoides, and on the inner side by a triangular facet with the cuneiform bone. The dorsum presents a small, irregularly convex surface.

The *os cuneiforme*, or wedge-shaped bone, is rounded and ridged on its dorsal surface. The base has an articular face for the corresponding part of the lunare; it is slightly concave on the anterior surface for contact with the unciform bone, and its palmar surface presents a small smooth facet, on which is placed the os pisiforme.

The *os pisiforme*, the minor bone of the first row, is of the size, and something of the form, of a pea. It has a single concave articular facet for attachment to the cuneiform bone, so that the pisiform projects directly forwards into the ulnar side of the palm of the hand, where it may be distinctly felt through the integuments. The flexor carpi ulnaris muscle is inserted into it, and the abductor minimi digiti arises from it. It also gives attachment to the anterior annular ligament of the wrist.

The second row of bones also embraces, as we have seen, four bones, which, counting from the radial side, are placed in the following order:

The *trapezium* is an extremely irregular bone, chiefly marked by a groove on

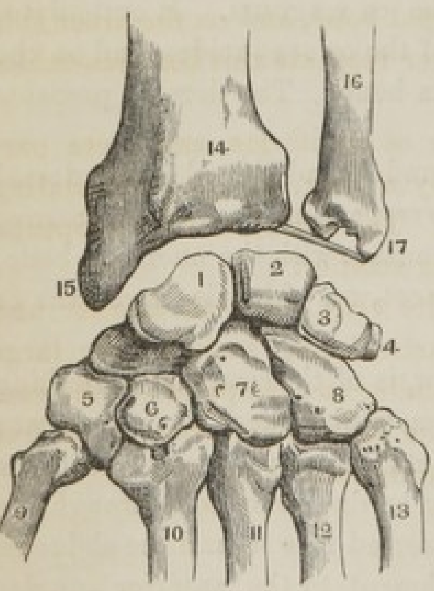
its palmar surface for the insertion of the flexor carpi radialis muscle. It has in front a surface partly convex, partly concave, for the reception of the base of the metacarpal bone of the thumb. On the inner side of this is another and double one for articulation with the trapezoides and the second metacarpal bone; and behind and above is a concave surface for the outer end of the os scaphoides. The palmar surface is made prominent by a *tubercle* that overhangs the groove for the tendon of the flexor carpi radialis, and greatly deepens the concavity of the wrist. The trapezium affords origin to the abductor and flexor ossis metacarpi pollicis; and the annular ligament is attached to the tubercle.

The *trapezoides* is irregular in shape, but may be compared to a truncated pyramid, of which the base forms part of the dorsum of the carpus. This dorsal surface is plane, and nearly rectangular at its metacarpal margin; but the palmar surface is small, rough and irregular. It articulates by a double surface with the second metacarpal bone; with the trapezium on the outside, with the magnum internally, and with the scaphoid bone above. It gives an origin to a single small muscle, the flexor brevis pollicis.

The *os magnum*, the largest of the carpal bones, is composed of an irregular pyramidal body and a rounded head. The body has five sides: one of them is slightly concave, and contributes to the dorsum of the wrist; another oblique and prominent, forms the palmar surface; a third side, the head, articulates into the fossa formed conjointly by the scaphoides and lunare; a fourth surface brings it in contact with the trapezoides, and a fifth, and larger one, with the os unciforme. The os magnum affords one of the origins of the flexor brevis pollicis muscle.

The *os unciforme* presents a large triangular body, from which, at its inner margin, rises a broad, sharp, hook-like process, that gives attachment to the annular ligament. It has five surfaces; the largest of these is external, for contact with the os magnum; a second is internal, for the cuneiform bone; the anterior surface is angular, with a double face, and receives the contiguous parts of the fourth and fifth metacarpal bones. Of the two free surfaces, the dorsal one is rugged and angular: the palmar face is characterized, as before stated, by the unciform process, at the side and base of which is a large, smooth channel for the play of the tendons of the flexor muscles of the fingers.

Fig. 68.



The carpus.

Fig. 68, the carpus and contiguous bones. 1, scaphoides; 2, lunare; 3, cuneiforme; 4, pisiforme; 5, trapezium; 6, trapezoides; 7, magnum; 8, unciforme; 9, metacarpal bone of the thumb; 10, same of the index finger; 11, 12, 13, third, fourth and fifth metacarpal bones; 14, radius; 15, its styloid process; 16, ulna; 17, its styloid process.

THE METACARPUS.

The *metacarpus* is a series of five bones interposed between the carpus and the fingers. Each of these bones is divided into a head, shaft and base. Those for the fingers are parallel to each other; that for the thumb is placed at an angle from the rest. The whole series presents a slightly convex surface on the back, and a corresponding concavity on the palmar side. They are connected together at their bases on the carpal bones, and at their shafts and heads, by ligamentary and muscular structure.

The *metacarpal bone of the thumb* is the shortest and strongest of the series, and is less rounded and more flattened than the others. Its carpal end articulates by a slight concavity with the trapezium. The phalangeal end is convex to receive the first bone of the thumb; and on each side of the palmar face is a tubercle on which is placed a sesamoid bone.

The *second metacarpal bone* sustains the index finger. It is the longest of its class: its carpal end is bifid, to receive the double surface of the trapezoides; and laterally it has a smooth articular face for the trapezium on the one side, and the magnum on the other. The palmar surface of the base presents, close to the joint, a rough surface for the insertion of the flexor carpi radialis; and directly opposite, on the dorsum, is a surface for the attachment of the extensor carpi radialis. The palmar surface of the shaft is divided by a longitudinal groove into two concave surfaces for the interosseous muscles.

The *third metacarpal bone* is next in size to the second. Its base is received upon the os magnum, but projects on the radial side into a rounded process for the insertion of the extensor radialis brevior muscle. The same side of the base has a large articular face for the second metacarpal bone, and on the inner side a smaller facet for the fourth metacarpal. In other respects this bone resembles the rest of its class.

The *fourth metacarpal bone* is based upon the os unciforme, and more partially on the magnum; in the former instance by a long, oblique, articulating surface; and in the latter by a very small facet. This bone, in other respects, only differs from its preceding congeners by being smaller.

The *fifth metacarpal bone*, the smallest of its class, is both smaller and shorter than the fourth. Its base has a double articulating surface; the large oblique face rests on the os unciforme, and the smaller one is applied to the contiguous part of the fourth metacarpal bone. The base is elevated at its free margin into a tubercle for the tendon of the extensor carpi ulnaris.

THE PHALANGES.

The *phalangeal* or *finger bones* are arranged in five rows, beginning with the thumb. The latter has two phalanges, and each of the fingers has three; the bone next the metacarpus being the first phalanx. Each phalanx has a shaft and two extremities. The bones of the *first phalanx* are smooth and convex on

the dorsum; the palmar surface is gently concave, and the margin where the two surfaces meet is angular. The basal end has a simple concavity which receives the head of the corresponding metacarpal bone; but the other and smaller end presents a pulley-like joint for articulation with the second phalanx.

The *second phalanx* is smaller in all respects than the first; but the general conformation is similar. The basal end rests by a double articular face on the proximate end of the first phalanx; and the lower end is slightly concave for the reception of the third phalanx.

The *third phalanx*, the smallest of the three, has a broad base for contact with the second row, and a semilunar flat termination, which is rough on the palmar surface. Between its extremities the bone conforms, though on a small scale, to the conformation of the others of this series.

The thumb, as already observed, has but two phalanges. The first of these is shorter and more robust than those of the fingers; and its second, or terminal phalanx is proportionably broad and strong. At the articulation of the first phalanx with the metacarpal bone of the thumb, are placed two sesamoid bones, one on each side of the palmar surface; and even the fingers are sometimes furnished with the same patella-like appendages.

THE LOWER EXTREMITIES.

The *lower extremity* is formed of three parts, the thigh, leg and foot; of these the thigh has one bone, the leg two, the foot twenty-six.

OS FEMORIS.

The *femur*, or *thigh-bone*, is the longest in the skeleton, extending from the acetabulum to the tibia, inclining inwards as it descends. Like other long bones, it is divided into two extremities, connected by an intermediate shaft. The *head* presents a smooth, hemispherical surface for articulation with the acetabular cavity; and on its summit is an irregular depression for the attachment of the ligamentum teres. The head is fixed to the shaft by means of an intermediate and smaller part called the *neck*, which is rough for the attachment of the capsular ligament of the joint. The neck, which is upwards of an inch in length, is directed upwards and inwards towards the pelvis, at an angle of thirty-five or forty degrees, being obtuse in some persons, but in some females, on the other hand, presenting a right angle. The foramina in this part of the bone are for the passage of nutritious blood-vessels, and the attachment of ligamentous fibres. Around the base of the neck where it joins the shaft of the femur, is a ridge for the attachment of the capsular ligament.

From the base of the neck arises the *trochanter major* at the upper and outer part of the femur, a little lower than the head, and in the axis of the shaft, of which it is, in fact, an upward elongation. It is convex without, concave within, and has at its top an oblique, truncated margin, in the centre of which is a smooth spot to mark the insertion of the pyriformis muscle. Directly below

is a double facet which receives the tendon of the glutæus medius; and in front is an oblong, rough surface for the insertion of the glutæus minimus. The posterior face of the trochanter is made smooth by the play of the glutæus maximus muscle, in its course to shaft of the bone. The inner side of the trochanter has a deep concavity, into which are inserted the rotary muscles that come from the pelvis; and from the contiguous border of this process a ridge is continued downwards to terminate in the trochanter minor. This, the *intertrochanteric ridge*, gives insertion to the quadratus femoris muscle.

The *trochanter minor* is on the posterior surface of the bone, at the junction of the neck with the base of the great trochanter. It is a mammillated process that gives insertion to the common tendon of the iliacus internus and psoas magnus muscles.

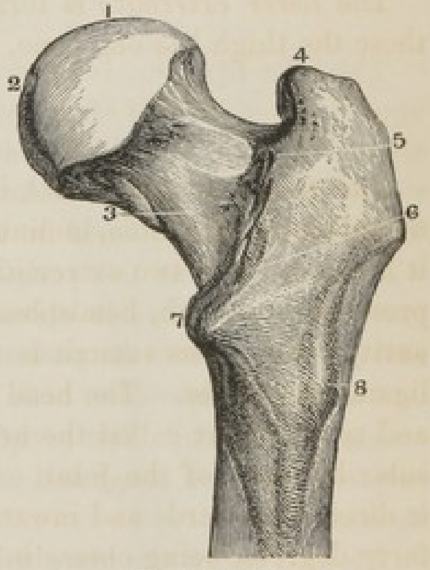
The shaft of the bone becomes cylindrical at the base of the trochanters, whence it is extended to the condyles, smooth and gently convex in front; rough and slightly concave behind. At the upper and posterior part of the bone commences the *linea aspera*, which extends downwards from the greater trochanter to within a fourth of the distance to the condyles, where it divides, and sends a ridge to each of them. The linea aspera above the bifurcation is from a quarter to half an inch in width, with a slight depression between its margins. The *external margin* gives insertion, at its upper half, to the glutæus maximus muscle; from its lower half arises the biceps flexor cruris; and the vastus externus has its origin from the whole length of the ridge on the same side. The *internal margin* gives insertion to the triceps adductor femoris, and origin to the vastus internus.

Fig. 69.

Os femoris.

Fig. 69. Front view of the right femur. 1, head of the bone; 2, depression for ligamentum teres; 3, 4, neck; 5, trochanter major; 6, trochanter minor; 7, 8, shaft; 9, external condyle; 10, 11, articular faces for the tibia; 12, trochlea for patella; 13, internal condyle.

Fig. 70.



Head of femur.

Fig. 70. Head of the femur of the right side viewed posteriorly; 1, head of the bone; 2, depression for round ligament; 3, cervix; 4, trochanter major; 7, trochanter minor; 4, 5, 6, 7, intertrochanteric ridge; 8, commencement of linea aspera.

Near the middle of the bone is the nutritious foramen for the medullary vessels. As the shaft approaches the lower end of the bone, it becomes wider and flatter, and terminates in the internal and ex-

ternal condyles, which are separated by a depression in front and a deep fossa behind.

The *external condyle* is the broader and more prominent; it is marked externally by a large tubercle for the attachment of the lateral ligament; and directly beneath is a fossa for the origin of the tendon of the poplitæus muscle. To its inner surface is attached the anterior crucial ligament; and from its upper and posterior part arise the external head of the gastrocnemius muscle, and the tendon of the plantaris.

The *internal condyle* is the longer of the two. Its inner side has a tubercle for the attachment of the lateral ligament; and beneath the tubercle is a furrow for the origin of the internal head of the gastrocnemius muscle. On the outer face of this condyle is a fossa for the attachment of the posterior crucial ligament. The condyles are smooth for articulation with the tibia and patella; and the latter plays on the trochlea in front of the bone. The many foramina at this end of the femur, answer for the passage of vessels to the cancellated structure within, and for the attachment of ligamentous fibres.

If the os femoris be divided longitudinally, it is seen to be compact in the centre, from which it gradually merges, at each extremity, into the usual cancellated structure. It ossifies by five points, one for each end, one for each trochanter, and one for the shaft.

THE TIBIA.

This, the *leg-bone*, is formed of a shaft and two enlarged extremities. The upper end, or *head*, is of an oval shape at top, with two slightly concave surfaces, separated by a central ridge and fossa. These surfaces are for articulation with the femoral condyles, but the internal one is the larger and deeper of the two. They are much deepened in the undenuded state by the semilunar cartilages, which are thick at the periphery, and thin and open in the centre. The *spinous ridge* or process is elevated between and separates the articular surfaces, and is rather nearer the posterior margin of the bone. It has a pit on its apex; and a deeper depression both in front and behind for the anterior and posterior crucial ligaments. The periphery of the top of the tibia is angular, and the subjacent surface rough and uneven for the attachment of the capsular and other ligaments.

An inch below the margin in front is the *tubercle* of the tibia, a triangular prominence for the attachment of the ligament of the patella; and on its inner side is a slightly concave surface that gives attachment to the tendons of the sartorius, gracilis and semi-tendinosus muscles, and to the aponeurosis of the vastus internus. On the posterior side of the head are two tuberosities; an internal one for the insertion of the semi-membranosus muscle, and an external one which has an articular face for junction with the fibula. At the base of the latter tuberosity, internally, is a concavity for the poplitæus muscle.

The lower end of the tibia is enlarged, and of an irregularly quadrangular form. The tarsal surface presents a double concavity from the presence of a

slight prominence that extends from the anterior to the posterior margin. The internal concavity is greatly deepened by the *malleolus internus;* the external one is relatively small; and both form an articular surface for the rounded top of the astragalus. On the outer side of the tibia is a groove that is in contact with the lower end of the fibula, which bone is sometimes, but not always, attached to a true articular face on the outer margin of the tibia. The tibia is prominent before and behind for the attachment of the ligaments that connect it with the fibula and astragalus. The *malleolus internus* is marked behind by a channel an inch in length for the passage of the tendons of the tibialis posticus and flexor longus digitorum muscles; and this process is laterally rough for the attachment of the deltoid ligament.

The shaft or body of the tibia is triangular, the anterior angle commencing at the tubercle above, and continuing three-fourths of the way down. It lies immediately beneath the integuments, and is sharp and gently curved. It is called the *spine* or shin. Three surfaces result from the triangular form of the tibia. The *internal side* is smooth and subcutaneous; the *external side*, facing the fibula, is hollowed above for the origin of the tibialis anticus, and below for the extensor longus pollicis and extensor longus digitorum. The two posterior angles are rounded, and the intervening space is flattened, and gives rise to the flexor longus digitorum and tibialis posticus. The internal angle of the bone gives attachment to the *interosseous ligament*, which is interposed between the tibia and fibula.

About four inches below the head, on the posterior surface, is seen the *medullary foramen*, which commences by a groove, and pursues a downward direction.

Fig. 71.

Tibia.

Fig. 72.

Tibia.

Fig. 71. Front view of the right tibia. 1, central ridge and fossa; 2, 3, articular surfaces for the femur; 4, external condyle, and immediately below it, the articular facet for the fibula; 5, tubercle, or tuberosity; 6, fossa for tibialis anticus muscle; 7, anterior angle or shin; 8, shaft, which commences at 6; 9, articular surface for the malleolus externus; 10, articular surface for the astragalus; 11, malleolus internus.

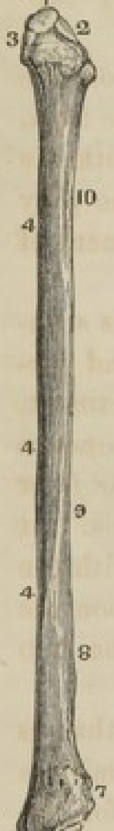
Fig. 72. Posterior view of the upper end of the right side. 1, central ridge and fossa, forming the apex of the bone; 2, articular face for internal condyle of the femur; 3, same for external condyle; 4, fossa for attachment of posterior crucial ligament; 5, 6, rough surfaces for attachment of internal and external lateral ligaments; 7, articular facet for head of fibula; 8, nutritious foramen.

THE FIBULA.

The *fibula*, the second bone of the leg, is placed at the outside of the tibia, the shafts of the two being separated about an inch above, and half that distance below. It is a very long and slender bone, with two enlarged extremities. The upper end, or *head*, joins the tibia; it is rough on the outer side for the attachment of the external lateral ligament of the knee joint: above and behind this is an angular process for the insertion of the biceps flexor cruris; and at the inner posterior side is a tubercle for the origin of the tendon of the soleus muscle.

The front of the fibula is angular and sharp, with an irregularly plane or convex surface each side. The *outer surface*, which is smooth, but more or less channeled, gives origin from its upper third to the peroneus longus muscle; from its middle third to the peroneus medius; and the inferior third is spirally marked from front to back by the action of these two muscles.

Fig. 73.



Fibula.

The *internal* or tibial face of the fibula presents two surfaces, a narrow anterior one, and a broader one which is behind; and the intervening or connecting ridge gives attachment to the interosseous ligament. The anterior of the surfaces thus formed affords origin to the extensor proprius pollicis and extensor digitorum communis muscles; and from the surface behind arises the tibialis posticus. The *posterior face* gives origin to two muscles; from its upper third to the soleus, and below this to the flexor longus pollicis.

The lower end of the fibula is swelled and flattened, to form the *malleolus externus*, which is rough outside, and elongated below for attachment of ligaments that connect it with the adjacent tarsal bones. On its posterior side, opposite to the astragalus, is a deep channel for the peronei muscles in their passage from the bone above. The inner face of the malleolus is smooth for articulation with the astragalus; and above this the bone is somewhat contracted for its reception into the groove on the outer face of the tibia; at which point is also sometimes formed a small articular face.

Fig. 73. Front view of the right fibula. 1, styloid process; 2, articular facet for the head of the tibia; 3, roughness for the external lateral ligament; 4, 4, 4, shaft; 5, malleolus externus; 6, articular face for the astragalus; 7, point of junction with the tibia; 8, 9, 10, internal angle for attachment of interosseous ligament.

THE FOOT.

The foot is divided into three series of bones, the tarsus, metatarsus and phalanges; and these embrace, exclusive of the sesamoids, twenty-seven pieces.

THE TARSUS.

The *tarsus* consists of seven bones, which, like those of the carpus, may be classed into two rows. The first or posterior row consists of two bones only,—the astragalus and os calcis; the second row contains the five remaining tarsal bones, viz., the os naviculare, the cuboides and the three cuneiform bones.

1. The ASTRAGALUS is an irregularly cuboidal bone interposed between the tibia above and the os calcis below, thus supporting the one and being supported by the other.

Its superior surface, or *head*, is arched from back to front and slightly concave in the same direction, forming a pulley-like facet for articulation with the tibia. The outer side of the head is smooth and excavated for connection with the malleolus externus of the fibula. The inner side is partly smooth for the play of the internal malleolus, and partly fitted and rough for the attachment of ligamentous fibres.

The *lower surface* of the astragalus is of irregular conformation. It is separated into two parts by a deep fossa that passes obliquely outwards and forwards, widening in its course, and serving to lodge the interosseous ligament. Of these facets the *posterior* is much the larger, of an oblong form, and concave for the reception of the proximate surface of the os calcis. The *anterior facet* is of an elliptical shape and rests upon the lesser apophysis of the os calcis. At the inner and anterior margin of the bone, and seemingly continuous with the facet just described, is a second smooth, convex surface that rests, not upon the os calcis, but upon a fibro-cartilaginous ligament extended between the two bones.

The *front* of the bone is formed into a rounded, oblong convex head that is received into the concavity of the os naviculare; that the posterior extremity is marked by two angular processes with a smooth furrow between them, for the play of the tendon of the flexor longus pollicis muscle.

The astragalus articulates above with the tibia and fibula; below, with the os calcis; before, with the os naviculare. Fig. 73, A, 1, 2.

2. The OS CALCIS or *calcaneum* is the largest portion of the tarsus. It is of an oblong form, smooth at the two ends, excavated above for the astragalus, and uneven and tuberculated beneath for the attachment of ligaments and tendons.

The *heel* is the flattened, backward projection of the bone; its posterior surface presents two facets divided by a ridge,—an upper one, smooth for the play of the tendo-Achillis, and a lower one to which that tendon is attached.

The *upper surface* presents two articular facets for the reception of the proxi-

mate parts of the astragalus, and they are separated by a groove corresponding to that in the latter bone. The inner face is much the smaller, and is sometimes called the *lesser apophysis.* The posterior or external face is convex behind and irregularly concave before; it receives the body of the astragalus and consequently sustains nearly all the superior cumbent weight.

The outer side of the os calcis is smooth and greatly convex, with a slight horizontal furrow for the tendon of the peroneus longus. The inner face, on the contrary, is smoothly excavated for the lodgment of the *massa carnea,* and for the passage of blood-vessels and nerves to the foot. Directly beneath the lesser apophysis is a groove, less than an inch in length, for the tendon of the flexor longus pollicis.

The *basal surface* of this bone is somewhat convex, being broad behind and narrowing as it advances. It is bounded posteriorly by two tubercles, one large and internal, the other much smaller and external. The former gives origin to the flexor digitorum sublimis and abductor pollicis muscles, and also to the aponeurosis plantaris. The lesser tubercle joins the greater one in affording origin to the abductor minimi digiti muscle and the aponeurosis plantaris. The forepart of this surface of the os calcis also presents an anterior tubercle for ligamentous attachments.

The *anterior end* of this bone is its greater apophysis, and is concave for articulation with the proximate surface of the os cuboides. Fig. 73, A, 3.

3. The OS NAVICULARE, or *scaphoides,* is of an irregular elliptical form, rough above and internally for the attachment of ligaments, and deeply concave behind for the reception of the head of the astragalus. Its inner and inferior margin is a mammillated process, giving origin to the tendon of the abductor pollicis, and insertion to the tibialis posticus. It also affords attachment to some strong ligaments. The anterior surface of the navicularis is divided into three triangular, slightly concave surfaces for the three cuneiform bones; and its outer margin presents a lunated facet for apposition with the proximate part of the os cuboides.

4. The OS CUBOIDEUM, or *cuboides,* possesses an irregular squared form that constitutes about an inch in length of the outer border of the tarsus. Its upper surface is nearly plane and presents obliquely downward and outwards. The anterior surface is divided into two smooth facets for articulation with the fourth and fifth metatarsal bones. The posterior extremity articulates by a concavo-convex surface with the greater apophysis of the os calcis. The inner plane side of the bone has a rounded facet that supports the contiguous cuneiform bone. The basal aspect presents a strongly marked ridge, its *tuberosity,* running inwards and forwards with a sulcus on either side; the *anterior sulcus* or groove, the more distinct of the two, gives passage to the tendon of the peroneus longus, which also notches the outer margin of the bone. The internal or posterior fossa is bounded behind by an angular protuberance, whence arises the adductor pollicis muscle. Fig. 73, A, 8.

5. The CUNEIFORME EXTERNUM is a wedge-shaped bone with an oblong, smooth, slightly concave dorsum, whence it tapers to an elongated edge, and is

completely received between the cuboid and middle cuneiform bones. It has four articular surfaces: one for the naviculare behind, a second for the third metatarsal bone in front, a third externally for the cuboides, and a fourth and internal facet that joins the middle cuneiform bone. Fig. 73, A, 7.

6. The CUNEIFORME MEDIUM is the smallest and most symmetrical of the series. Its dorsum is regularly oblong and from this part its sides approximate in such manner as to form a perfect wedge between the other cuneiform bones. It has a slightly convex surface behind that is received into the central facet of the naviculare, and a triangular plane in front for the second metatarsal bone. On the outside it articulates chiefly by a posterior facet with the external cuneiform; and on the inside it has an oblique surface of attachment for the internal cuneiform. Fig. 73, A, 6.

7. CUNEIFORME INTERNUM, the internal cuneiform bone. This, the largest of the three wedge-shaped bones, forms the inner and anterior margin of the tarsus, and differs from them in being inverted so as to present its edge to the dorsum of the foot. Its internal and basal surfaces are continuous and uneven, and present two small tubercles below for the origin of the abductor pollicis muscle. Just above these is a depression for the tendon of the tibialis anticus. Behind, this bone is gently concave to receive the corresponding part of the naviculare; in front, it has a triangular face for the metatarsal bone of the great toe; but the external side presents, besides a rough surface for ligamentous attachments, two articular facets; one anteriorly for the inner side of the second metatarsal bone; the other behind for articulation with the cuneiforme medium. Fig. 73, A, 5.

Fig. 73, A.

Bones of the foot. From Sappey.*

Fig. 73, A. Dorsal view of the bones of the foot. 1, top of the astragalus; 2, head of that bone; 3, os calcis, projecting at this part to form the heel; 4, os naviculare or scaphoides; 5, first or internal cuneiform; 6, second or middle cuneiform; 7, third or external cuneiform; 8, cuboides; 9, the metatarsus; 10, first phalanx of the great toe; 11, second phalanx of the same bone; 12, first phalanx of the four other toes; 13, second phalanx; 14, third phalanx.

THE METATARSUS AND PHALANGES.

This structure is composed of five bones that bear a close resemblance to the metacarpus of the hand. Each metatarsal bone has a shaft terminated at either end by a condyloid enlargement. Fig. 74, A, 9.

The *first metatarsal bone* is much the largest of the series and is at the inner side of the foot to support the great toe. It is rounded above, flattened on its plantar surface, and concave externally for the corresponding interosseous muscle. Behind it has a large triangular facet for articulation with the internal

* Manuel d'Anatomie, Fig. 45.

cuneiform bone; and beneath this surface is a tubercle for the attachment of the peroneus longus muscle. The anterior end or head of the bone is rounded for receiving the first phalanx, and this articulation terminates below in a trochlear surface for the two sesamoid bones. Fig. 74, B, 1.

The *second metatarsal* is the longest of the set. It is large and squared at its tarsal end, where it presents three articular facets for the corresponding cuneiform bones. It then tapers in a flattened form to its head, which receives the associated phalanx. Fig. 74, C, 1.

The *third metatarsal* closely resembles the second, excepting at its tarsal end, which articulates only with the middle cuneiform bone, and has an articular surface on each side for the proximate metatarsals.

Fig. 74, B.

Fig. 74, C.

Tarsal and phalangeal bones.

The *fourth metatarsal* is something smaller than the former, and has at its metatarsal end a single facet by which it is received upon the os cuboides. It has also lateral facets where it comes in contact with the associated metatarsal bones.

Fig. 74, B. Metatarsal and phalangeal bones of the great toe. 1, metatarsal bone; 2, first phalanx; 3, second and last phalanx.

Fig. 74, C. Metatarsal and phalangeal bones of the second and longest toe. 1, metatarsal bone; 2, 3, 4, the three phalangeal bones.

The *fifth metatarsal* is the shortest, stoutest and flattest of the four outer bones of this series. It articulates posteriorly with the os cuboides, and ends outside of the joint in a robust, elongated tubercle.

THE PHALANGES.

These bones consist of a shaft and two enlarged articular extremities.

The *great toe* has but two phalangeal bones. The *first* is remarkable for its size and flatness; the *second* is also broad and flat, and rough and lunated at the end for supporting the nail. Fig. 74, B, 2, 3.

The *first phalanx* of each of the other four toes has a slender, cylindrical shaft about an inch in length, terminated at each end by an articular face, one for the metatarsal, the other for the second phalangeal bone.

The *second phalanx* is flat and short, that of the little toe being not more than the fourth of an inch across.

The *third phalanx* is very small, with an articular face behind for the second phalanx, and a broad rough surface in front and above for the reception of the nail. Fig. 74, C, 2, 3, 4.*

* Owing to an inadvertence the patella has been transposed from p. 105* to p. 105.

THE PATELLA.

This is a rounded bone that covers the knee-joint in front, and articulates by a trochlear surface with the condyles of the femur. Its upper margin is broad, slopes obliquely downwards, and receives the united tendons of the four recti muscles that extend the leg. Its lower margin is pointed and angular, and gives off the ligamentum patellæ. The inner surface is doubly concave for articulation with the condyles of the os femoris, and the anterior face is convex, and perforated with foramina.

Fig. 74.

Patella.

Fig. 74. The patella, broad above for the attachment of the tendon of the quadriceps femoris; and pointed below for the ligamentum patellæ.

ODONTOLOGY.

DESCRIPTION OF THE TEETH.

The teeth have generally been classed with the bones; but they differ so much both in structure and mode of development from true bones, that they are by some anatomists regarded as part of the dermoid tissue, and by others as appendages of the digestive system.

They differ from bone in several remarkable particulars: thus, they are bare, and destitute of periosteum; they have an interior papilla of a nervous and sensitive nature; and the tooth itself is composed of two different substances, one resembling bone, and the other wholly unlike it, called enamel. Again, the nutritive changes that take place in bones are unknown in the teeth, which are only renewed by a second dentition; and, moreover, the ossiform part of a tooth contains a greater proportion of earthy matter than bone, while the enamel has no gelatin. The manner of development is also wholly different in these structures; so also are their physiological relations. Nevertheless, they are more nearly allied to the osseous system than to any other, and for that reason, as well as for the fact that they constitute an integral part of the perfect head, a description of them is introduced in this place.

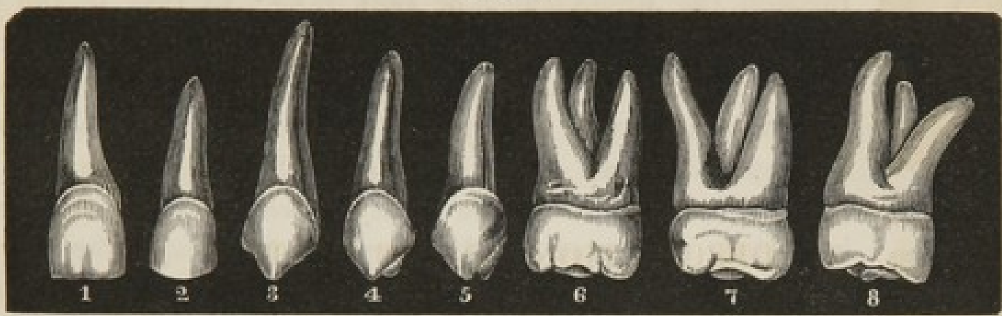
Forms of the teeth.—Every tooth has three parts: a *body*, or the portion projecting above the gums and covered with enamel; the *root* or *fang*, which is received into the alveolar socket; and the *neck*, which connects these parts together. The *crown* of the tooth is sometimes used as synonymous with the body; but it should be more definitely restricted to the pointed and grinding surface. The body of each tooth contains a *central cavity*, *cavitas pulpæ*, that is elongated into the fang, and is the seat of sensation and nutrition: if examined under the microscope, it presents an infinity of small orifices which are the openings of the dentinal canals.

The perfect state of *permanent dentition* presents *thirty-two teeth*, sixteen being appropriated to each jaw. They are divided into four classes—*incisors*, *cuspidati*, *bicuspids* and *molars*. Each jaw contains four incisors, two cuspid or canine teeth, four bicuspids and six molars. Figs. 75, 76.

The *incisor teeth* have a broad, chisel-shaped body, based on a rounded neck terminating above in a sharp and slightly serrated cutting edge. They are

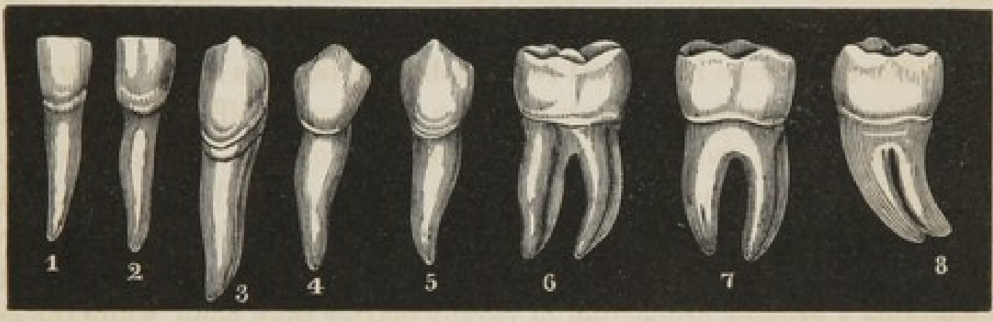
convex in front, concave behind, and gently rounded at the sides, where they come into contact with each other. The upper central incisors are the largest of their kind; but the other six are nearly of an equal size among themselves. They have a single, elongated root of a conical form, which is compressed or flattened on the lateral surfaces. Figs. 75, 76, 1, 2.

Fig. 75.



Permanent teeth of the upper jaw.

Fig. 76.



Permanent teeth of the lower jaw.

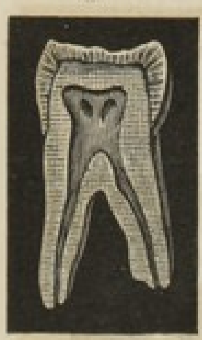
The *cuspidati*, or canine teeth, are round and strong, with a very long tapering root. The body is convex in front and slightly excavated behind, and terminates in a point having on each side a partial serrature. The cuspid teeth are much alike in both jaws; but in common language, those above are called eye-teeth, the lower ones stomach-teeth. Figs. 75, 76, 3.

The *bicuspids*, or false molars, have a rounded body terminating on its grinding edge in two points, one before, the other behind, with a rough groove between them. They have a single, long, flattened root, marked longitudinally by a sulcus, which, in the bicuspids of the upper jaw, ends in a bifurcation of the fang. Figs. 75, 76, 4, 5.

The *molars* are placed behind all the other teeth. The crown has a squared or cuboid form, with four points on the triturating surface separated by channelled depressions. The first two molars are the largest; those of the upper jaw having three roots, those of the lower but two. Those above have two fangs in front, and on a line with the jaw, while the third root projects inwards at an angle. The two fangs of the lower series are placed one before and the other behind, and longitudinally with respect to the bone. Figs. 75, 76, 6, 7. The last molar is the *dens sapientiæ*, or wisdom tooth; smaller than its fellows, late in its development, and early in decay. It has seldom more than one fang;

but this is composed of a blending of two roots in the lower jaw, and of three in the upper. Occasionally the extremity is bifurcated. Figs. 75, 76, 8.

Fig. 77.



The body of the tooth is hollow, constituting what is called its *cavity;* and if a vertical section be made, as in Fig. 77, it will be seen that this cavity is prolonged in an attenuated form through the whole length of each fang; so that in the large molars of the upper jaw, there is a triple communication between the cavity and the alveolar socket. This *cavitas pulpæ* is occupied, as its name imports, with the pulp of the tooth, which is supplied with an artery and nerve through the canal in each root. That portion of the cavity which is next to the enamel, is slightly excavated for the reception of a papilliform process of the pulp, which has been by some regarded as a proper nervous ganglion.

Fig. 78.

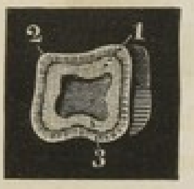


Fig. 78 is a transverse section of a molar tooth of the natural size. The cut is made through the body of the tooth; 1, dentine; 2, enamel; 3, cavity.

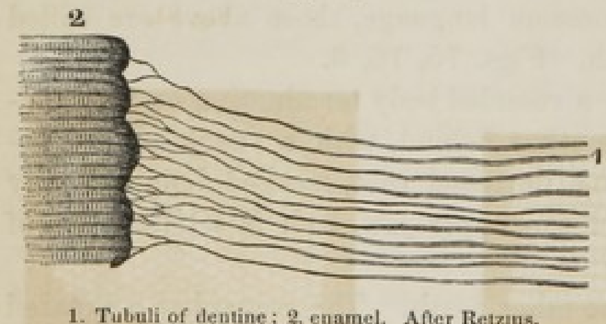
STRUCTURE OF THE TEETH.

Every tooth is composed of three parts, so different from each other as to be obvious to the unassisted eye; viz. the dentine, the enamel and the cement.

DENTINE.—This substance, which is also called the ivory of the tooth, forms by far the greater part of its body and fangs. It is harder than ordinary bone, contains less animal matter, and is destitute of medulla and blood-vessels. It is of a yellowish-white color, of a fibrous structure, and its fibres, when examined under the microscope, are seen to be distinctly tubular.

These tubuli, or dental canals, open by circular orifices into the cavity of the tooth, from which point they traverse its body in a curvilinear form, and terminate in pointed cul-de-sacs either near the exterior margin of the dentine, or at the enamel itself. Fig. 79.

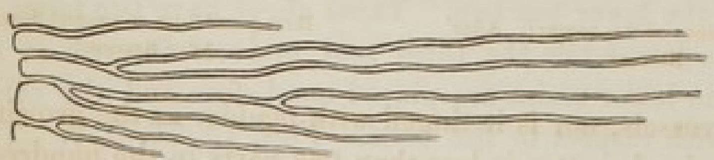
Fig. 79.



1. Tubuli of dentine; 2, enamel. After Retzius.

In other instances these tubuli bifurcate, which arrangement is most usual towards their termination, as in Fig. 79; but in other examples the bifurcation takes place in the body of the canal, as in Fig. 80. They are too small to convey the blood-corpuscles, but are filled with a fluid that has the appearance of serum; and

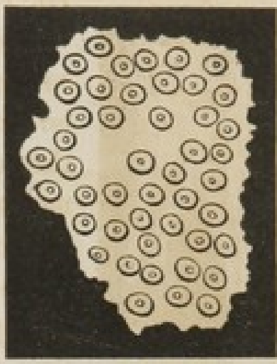
Fig. 80.



Branching dental tubuli. From Retzius.

it is therefore inferred that they receive and convey this fluid which is designed for the nourishment of the tooth, on the principle of imbibition or endosmosis. The dentine further differs from bone in having neither Haversian canals nor lacunæ.

Fig. 81.



Transverse section of dental canals. After Retzius.

Fig. 81 represents a transverse section of a number of tubuli very highly magnified.

Chemical analysis shows the dentine to be composed of the following substances:—

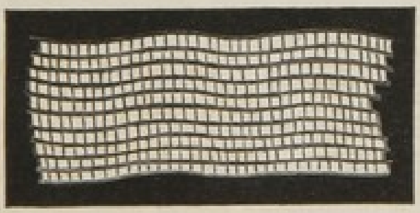
Phosphate of lime - - - -	61.95
Phosphate of magnesia - - -	1.05
Carbonate of lime - - -	5.30
Fluoride of calcium - - -	2.10
Soda and common salt - - -	1.40
Chondrin and water - - -	28.

The CEMENT, or crusta petrosa, covers all the surface of the tooth that is not invested by the enamel; where the latter ends on the body of the tooth, the cement begins; and increasing as it descends, becomes thickest on the fangs. Fig. 85, 1. It has the characters of true bone, with corpuscles of Purkinje and the stellated, connecting tubuli; and although in the healthy state it is destitute of Haversian canals, these readily form in it when, as often happens, it becomes increased by exostosis around the root of the tooth. Its chemical constituents are similar to those of bone.

The ENAMEL covers the body of the tooth from the grinding surface to the gum, being thicker on the former, and gradually tapering to an edge below. Fig. 85, 3, and Fig. 82. It is opaque, white, brittle, yet extremely hard. It is formed of hexagonal fibres that radiate from the body of the tooth in gently undulating lines, traversed by others that have a transverse direction. Fig. 83. The hexagonal form of the enamel-fibres is represented in the transverse section, Fig. 84.

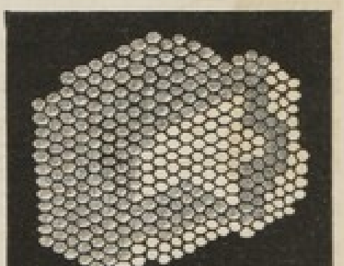
Fig. 82.

Fig. 83.



Undulating lines of the enamel. After Retzius.

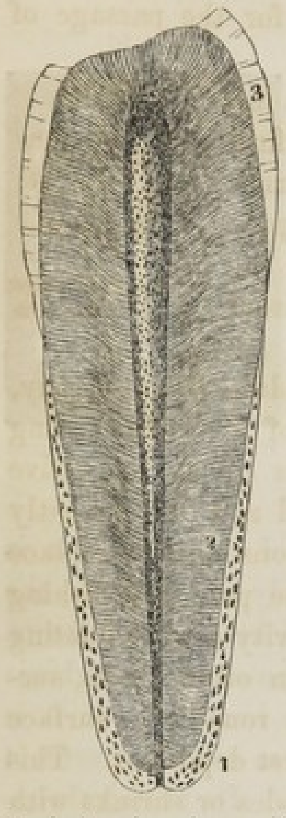
Fig. 84.



Hexagonal form of enamel-fibres. After Retzius.

The enamel has no blood-vessels, nor is it tinged with madder in the growing state. The proportion of animal matter is less than two parts in the hundred; and the complete analysis affords the following results:

Fig. 85.



Vertical section of a cuspid tooth. After Retzius.

Phosphate of lime - - - -	85.3
Carbonate of lime - - - -	.8
Phosphate of magnesia - - -	1.5
Animal matter, soda and water -	0.2

Fig. 85 represents a magnified vertical section of a cuspid or canine tooth, and its several constituent parts; 1, the crusta petrosa, or cement; 2, dentine; 3, enamel; 4, the cavity of the tooth, in which the black points show the orifices of the dental tubuli.

The *alveoli*, or teeth-sockets, are cavities in the maxillary bones for the reception of the teeth. They are hollow processes of a conical form set in the cellular structure of the bone, and adapted with perfect exactness to the fangs of their respective teeth. This articulation, which is called *gomphosis*, admits of no motion in the healthy condition of the parts. The alveoli, and the fangs embraced in them, are covered by a very delicate vascular periosteum.

Blood-vessels and nerves.—The teeth of the upper jaw have their arteries from the alveolar and infra-orbitar branches of the internal maxillary artery. The teeth of the lower jaw are supplied by the *inferior dental* artery, also a branch of the internal maxillary. The *nerves* of the upper teeth are derived from the second branch of the trigeminus; those of the lower jaw, from the third or inferior maxillary branch of the same nerve, which enters the jaw, together with the dental artery, at the posterior mental foramen.

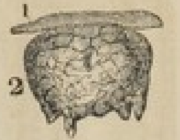
ORIGIN AND DEVELOPMENT OF THE TEETH.

This process, which in physiological language is called *odontogeny*, commences at a very early period of fœtal life; indeed, its incipient state dates with the seventh week. About this period the jaw is marked by a deep groove which is gradually divided by membranous septa into *alveolar cells*, corresponding in number to the deciduous teeth. The margin of the gum is elevated into a partially indented crest, called the *dental cartilage*, of a pale color, and firm, fibrous structure. The follicles thus formed contain in the first instance merely a reddish fluid that gradually assumes a yellowish-white color; until about the seventh week, the germ of the first deciduous molar assumes the form of a granular papilla, the nucleus of the pulp; and according to the recent observations of Mr. Goodsir, these germs are distinctly seen in all the follicles of the deciduous teeth at the end of the eleventh week: but it is not until the fourth month that the dental sacs assume their complete form, and the papillæ become true pulps and present a perfect mould for the incipient teeth.

The pulp is enclosed in a double sac: the outer one is vascular, spongy, is continuous with the gums, and by lining the alveolar sockets forms its perios-

teum. It is attached at the top of the tooth to the *dental cartilage* (Fig. 86); and at the fangs to the dental nerves and blood-vessels, for the passage of which it is perforated.

Fig. 86.



1, dental cartilage; 2, sac of the tooth.

The internal membrane, or *tunica propria*, is that which immediately embraces the dental pulp; it is thin, but of a firm consistence and extremely vascular. It is united to the external sac at the margin of the gum, and again at the base of the pulp where the blood-vessels enter. In the intermediate space the sacs are distinct, unattached, and filled to repletion with a viscid fluid.

The first appearance of the proper tooth is about the middle of pregnancy, when a thin layer of dentine is deposited on the surface of the pulp, having the diameter and the several characteristic coronal points of its respective tooth; or, more strictly speaking, the points are first formed and subsequently united by successive deposits of dentine. Constant depositions now take place in the direction of the fangs, the tooth elongating and the pulp diminishing until the dental structure is completed, with a central cavity communicating externally by means of orifices at the ends of the fangs. In other words, successive depositions of dentine take place, layer by layer, round the surface of the pulp; and the most external layer is that which is first deposited. This of course is on the outside of the pulp, and the latter recedes or shrinks with every new layer, until the whole structure of the tooth is completed.

The formation of enamel commences simultaneously with that of the dentine. It is usually regarded as the product of the *enamel-pulp*, a delicately spongy tissue on the internal face of the inner sac, and which so surrounds the crown of the tooth as to be completely moulded upon its prominences and depressions.

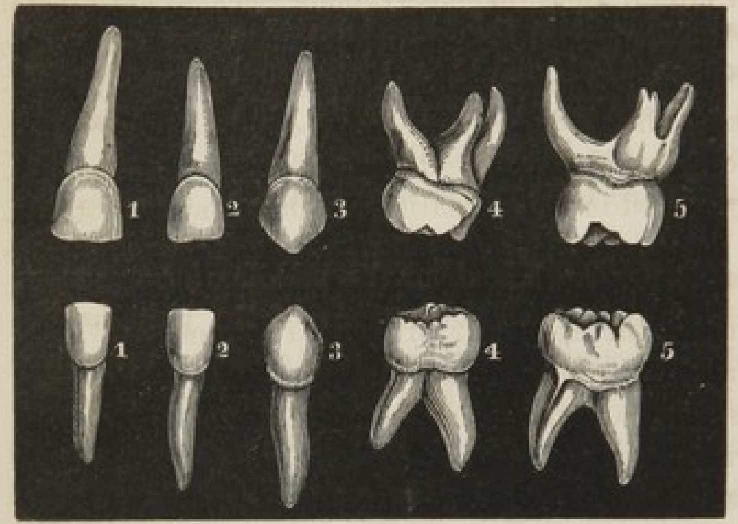
The basis of the enamel first appears in the form of a thin whitish fluid that subsequently assumes a chalky consistence, and finally becomes the true enamel, covering the whole body of the tooth; but it is so delicate, even at a short period before the deciduous teeth are protruded, that it may be cut with a knife; and in the full-grown fœtus may be readily separated from the dentine.

The *cement* is formed last of all, probably by a secretion from that part of the inner sac which embraces the fang and acts as its periosteum.

The body of the tooth being thus formed, with its enamel above and its yet imperfect fangs below, the next process of dentition is its protrusion through the gum. This takes place at very different periods in different children; but as a general rule it may be said to commence at the age of six months, and to end by completion at two years and a half; at which period the entire set of deciduous teeth is twenty in number, ten in each jaw; viz. eight incisors, four cuspids and eight molars. The order of their appearance is as follows: first, the lower incisors; second, the upper incisors; third, the first inferior molars; fourth, the first upper molars; fifth, the lower cuspid or canine teeth; sixth, the upper canines; seventh, the second molars.

The following table is more in detail, and gives at least an approximation to the period of protrusion in the different deciduous teeth.

Fig. 87.



Deciduous teeth of the left side. After T. Bell.

From 6 to 8 months, the four central incisors.

From 7 to 10 months, the four lateral incisors.

From 12 to 16 months, the four first molars.

From 14 to 20 months, the four cuspids or canines.

From 24 to 30 months, the four last molars.

Fig. 87 represents the deciduous teeth of the left side of the jaws. 1 and 2, incisors; 3, cuspidati; 4 and 5, molars.

The twenty teeth thus developed in the infant jaw, resemble in form and structure the teeth of the permanent set, excepting that they are much smaller, fewer in number, and protrude in a different order.

Fig. 88.

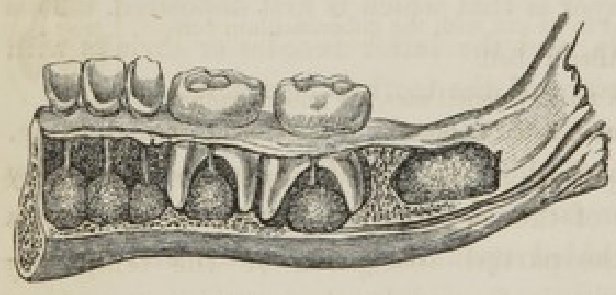


Fig. 88 shows the five perfect deciduous teeth of the lower jaw, with the germs of six permanent teeth yet embraced within their sacs in the body of the bone. The gubernaculum dentis is also seen.

PERMANENT TEETH.

The eruption of the permanent teeth constitutes what is called the *second dentition;* and their development is in most respects analogous to that of the deciduous set. Their germs may all be traced in the fœtal jaw at birth, lodged deeply in the bone at the inner side of the deciduous teeth; and their follicles or sacs are in the first instance contained in the same socket, and both are nourished by branches of the deciduous vessels. By degrees, however, the permanent tooth is surrounded by a socket of its own; and when the deciduous tooth is protruded above the gum, the two sockets cease to have any communication.

A curious connection exists between the two sets of teeth called the *gubernaculum dentis;*—a cord that passes from the sac of the permanent to that of the deciduous tooth, and is cotemporaneous with the first development of the sacs: it is therefore at first seen deep in the jaw, where it forms an isthmus-like process between them, Figs. 88, 89, 90. As the infantile sac rises towards the gum, the gubernaculum becomes proportionably elongated; until finally, when

the deciduous tooth is protruded, the connecting cord is attached to the gum itself. Blake, the discoverer of this structure, and Hunter, both supposed its use to be to give the tooth a proper direction in its progress towards the margin of the jaw, and thereby prevent lateral and other aberrations. There are several objections to this view, of which two may be briefly stated; one is, that the cord becomes more and more atrophied and delicate as the first dentition advances; and in the second place, the cord is least developed in the molar teeth. Mr. Thomas Bell has explained these appearances in a very satisfactory manner. He remarks that at an early period in the formation of the temporary tooth, its investing sac "gives off a small process or bud, containing a portion of the essential rudiments, namely, the pulp covered by its proper membrane, fig. 89. This constitutes the rudiment of the permanent tooth. It commences in a small thickening on one side of the parent sac, which gradually becomes more and more circumscribed, and at length assumes a distinct form, though still connected with it by a peduncle." Fig. 90. It follows, therefore, that when the germ of the permanent tooth is completely formed from the parent source, the connecting link or cord becomes less and less essential to the progress of development, and is finally atrophied to a mere thread.

Fig. 89.

Fig. 90.

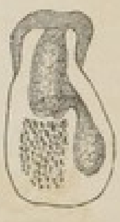


Fig. 89 represents a deciduous tooth embraced in its sac, with the gubernaculum connecting it to the sac of the permanent tooth. After T. Bell.

Fig. 90. Transverse section of the jaw, with the two dental sacs, the gubernaculum dentis between and dental cartilage at the summit. After T. Bell.

The deciduous teeth remain unimpaired so long as the permanent set are developed in the direction of the base of the socket; but the rise of the permanent tooth compresses and causes the partial absorption of the temporary alveolus above, so that a common cavity is formed by the contiguous sockets. As this process goes on, the effect is increased, until at length the fangs of the milk-teeth are entirely removed and their crowns alone remain, retaining their position by means of that portion of the gum that surrounds the neck of the tooth.

The order of succession of the permanent teeth is wholly different from that of the deciduous series; for the first tooth of these that appears above the gum is not an incisor, but a molar, which comes up behind the infant molar tooth, and while the entire deciduous set is yet perfect in the jaw. The following is the order of development, and the periods of time in which it is completed:

The first molars between six and seven years of age.

The incisors between seven and eight years.

The bicuspids between nine and ten years.

The cuspid or canine teeth at twelve years.

The second molars from twelve to fifteen years.

The third molars, or wisdom teeth, from eighteen to twenty-five years.

The central incisors appear before the lateral; and again the anterior bicuspid precedes the posterior. So also, as in deciduous dentition, the permanent teeth are first developed from the lower jaw; the corresponding teeth of

the upper jaw generally follow soon after; sometimes, however, cotemporaneously, and even by priority.

The periods of time at which the permanent teeth protrude above the gum, are liable to many variations; so that the rule above indicated is in this respect but an approximation to accuracy, and can serve only as a very general rule to which there are numberless exceptions.

Irregularities of dentition.—These are numerous. Children are occasionally born with the incisor teeth already above the gum. Sometimes all the lower teeth appear before any of the upper ones are cut. Meckel mentions an instance of but four permanent teeth in each jaw; another in which there was but a single incisor in the upper jaw; and he asserts that examples have occurred of the absence of every tooth. It is more common to find an excess than a deficiency of the teeth. I have in my possession several skulls containing supernumerary teeth; that of a New Hollander, for example, in which there are thirty-five.

Another irregularity consists of a *third dentition*, which usually occurs in old age; the new teeth are small, and soon decay. The structure of the teeth is also liable to many variations of size and form of the body, and the number and adjustment of the fangs.

ARTHROLOGY.

Arthrology, or *syndesmology*, is a description of the apparatus of the joints, the ligaments and other fibrous appendages, the articular cartilages, fibro-cartilages and synovial membranes.

GENERAL REMARKS ON FIBROUS TISSUE.

Fibrous tissue is one of the most abundant constituents of the body, pervading and binding together many of its organs. It embraces the ligaments, tendons, aponeuroses or fasciæ and all the fibrous membranes, such as the dura mater, tunica albuginea, sclerotica and many other analogous structures. It also enters largely into the composition of tissues of a mixed character—the skin, the mucous, serous, and synovial membranes, and areolar tissue. Its office is to bind together the various organs with which it is connected; permitting of motion without being in itself extensible, excepting in a very few instances.

From its diverse localities and uses it assumes many different forms and appearances; sometimes existing in firm, round, flat cords, as in the tendons and ligaments; and again spread out into strong, connecting and investing membranes, as seen in the aponeuroses; at one time limiting or preventing motion; in other instances being the medium through which it is produced.

All these modifications of this tissue are reducible to simple, solid fibres, elastic or non-elastic in their character, and existing separately, or blended in the same structure. Fibrous tissue is, therefore, divided into two varieties, differing in their physical character and function, viz: the white fibrous, and yellow-elastic fibrous tissues.

YELLOW FIBROUS TISSUE.

The fibres of this tissue are of a yellowish color and highly elastic, which latter property is their distinctive characteristic. The fibres branch in every direction and anastomose freely, so as to form an open network of very variable meshes. These appearances are readily brought into view with the microscope, as seen in the annexed drawing, fig. 91.

Fig. 91.

Yellow fibrous tissue. From Mandl.

To this variety of fibrous tissue belong the yellow ligaments of the spine, the middle coat of the arteries, the longitudinal bands of the trachea, the vocal cords, the cricoid, thyroid and thyreo-hyoid membranes, the stylo-hyoid ligament and the internal lateral ligament of the lower jaw.

Yellow fibrous tissue yields no gelatin by boiling, and is not acted on by the weaker acids.

WHITE FIBROUS TISSUE.

This tissue is composed of homogeneous white fibres, of a pearly, glistening appearance, and collected into fasciculi which are either parallel or slightly waved in their course, and sometimes interlaced. They have no definite size, and may be subdivided to almost any degree, the fibres being connected by areolar tissue. It is wholly inelastic, but capable of being stretched to a very limited extent, and is devoid of sensibility.

Fig. 92.

Fig. 92. Elementary fibres of tendon, as seen under the microscope.

Of this tissue are formed the ligaments, the tendons, the aponeuroses, periosteum, and perichondrium. To this variety of fibrous tissue belong also the investing membranes of the testicles and ovaries, of the corpora cavernosa penis, the clitoris and urethra; also the dura mater, the sclerotic coat of the eye and the fibrous pericardium. It is composed almost wholly of gelatin, which it yields by boiling, and it is readily acted on by acetic acid. When destroyed by disease or accident it is readily reproduced; the newly-formed tissue differing in no respect from the original one.

THE LIGAMENTS.

These belong, with a few exceptions, to the white fibrous tissue. They present themselves under various forms, but chiefly of the funicular, the capsular and the membranous varieties. The *funicular ligaments* are cords, flat, round, or oval, which extend from one bone to another, sometimes within the joint and in other instances exterior to it. The *capsular ligaments* are sacs, which, when separated from their adhesions, are open at both ends; but the latter, in the natural juxtaposition of parts, embrace the heads and necks of the bones of their respective articulations, and at these points of attachment are blended with the periosteum. The hip and shoulder joints are examples of perfect ligamentous capsules; but in other situations, as in the knee, the sac is imperfect, and in many instances it is partially represented by scattered fibres only. The *membranous ligaments* are simple expansions of the same tissue, placed between opposite bony margins to bind them together and afford attachment to muscles; such are the interosseous ligaments of the forearm and leg.

The blood-vessels of ligaments are few and extremely minute: no nerves have been traced in them; whence, as in the other varieties of this tissue, the absence of sensibility.

ARTICULAR CARTILAGE.

We have already spoken of the origin, development, and physical character of cartilage in general, and of those temporary cartilages which constitute the primary and deciduous state of bone; but on the present occasion it is necessary

to consider those permanent forms of cartilage that are necessary to the integrity of every articular surface. These are called *articular cartilages.* They are white, solid, pliable and elastic, thickest on convex surfaces where they are most subjected to pressure, and consequently thinner at the periphery of joints. Their greatest thickness seldom exceeds the tenth part of an inch. They are composed of very delicate fibres that radiate from the articular surface, one end being firmly attached to the bone, the other free and smooth, and covered by the synovial membrane.

No blood-vessels enter the articular cartilages; they stop at the adherent surface and go no further. They belong, therefore, to the series of non-vascular tissues, and are nourished on the principle of absorption or imbibition.

In the early periods of fœtal life, there is no distinction between the cartilage that is to become the osseous epiphysis and that which is to remain as articular cartilage; both alike originate from cells, and the vessels that supply them with nutrient materials penetrate no farther than their surfaces. At a later period, however, a line of demarkation is manifest between the vascular portion which is to be converted into bone, and the non-vascular part which is to remain in the form of cartilage. At this stage of development, the articular cartilage is nourished by a plexus of vessels spread over its free surface and beneath the synovial membrane, as well as by the vessels that come in contact with it where it itself is contiguous to the bone. Towards the period of birth, however, the sub-synovial vessels gradually recede from the surface of the articular cartilage, so that in adult life they merely form a band around its margin.*

INTER-ARTICULAR CARTILAGES.

These bodies exist in some joints in the form of very thin discs, having both surfaces free. They are always interposed between articulating bones, and for the most part are confined to those joints that are liable to sudden shocks and frequent movements. They both increase the depth of the articulating cavities, and break the violence of concussion. Hence it is that they impart solidity and mobility to the parts with which they are connected; as in the temporo-maxillary, sterno-clavicular and knee joints, and in the articulations between the scaphoid and lunar, and lunar and cuneiform bones of the wrist.

The inter-articular cartilages have a preponderance of white fibrous tissue in their circumference, and of cartilage in the centre. Microscopically examined, these, like other fibro-cartilages, are seen to consist of bundles of wavy fibres, with the cells or corpuscles of cartilage occupying the spaces formed by the interlacement of the fibrous tissue. It is very flexible, but has no contractility. Its blood-vessels are few and obscure, and no nerves can be detected in it, whence the absence of sensibility. It is composed chiefly of gelatin.†

* Carpenter's Principles of Human Physiology, § 188.

† Todd and Bowman's Physiolog. Anatomy, p. 94.

THE SYNOVIAL MEMBRANES.

These belong to the serous class of organs, which they not only resemble in their healthy state, but in their morbid conditions. The synovial membrane is a thin, soft, transparent tissue, and destitute of red blood. Its principal character is the secretion of an albuminous fluid for the lubrication of the joint.

These membranes are of three kinds; 1st, the articular class; 2d, the bursæ mucosæ; and 3d, the subcutaneous variety.

The *articular capsules* form a complete sac, which covers the articular surface of one bone, and is thence reflected to the proximate parts of the other; they adhere firmly to each of the cartilaginous surfaces, as proved by the recent observations of Henlé, but are more freely and distinctly attached to the internal surface of the proper capsular ligament.

THE BURSÆ MUCOSÆ.

The *bursæ mucosæ* are sheaths of synovial membrane interposed between bones and the tendons that play upon them, like cords upon pulleys. These tendons are inclosed in a synovial tube which is reflected on itself so as to line the groove within which the motion takes place, in the same manner as the pleura and peritoneum are reflected round the several viscera of the abdomen. The sheaths are so loose at their extremities as to allow the greatest freedom of motion; and they are lubricated by the same synovial fluid that is found in the proper joints,* with which, in various instances, they have an intimate relation.

The *subcutaneous synovial capsules* exist around some of the larger joints, as the knee, wrist and ankle, and wherever the skin is frequently moved over a resisting part, as between the skin and patella, and between the olecranon and the skin; over the trochanter major, the acromion process, the metacarpal and metatarsal articulations, &c.; and they are sometimes accidentally developed from local irritation or preternatural motion in different parts of the body.

When examined with a microscope, the free surface of synovial membranes is found to be covered with a single layer of tessellated epithelium, exterior to which is the common primary membrane.† On the outside again of the latter is a stratum of condensed areolar tissue, which constitutes the chief thickness of the membrane, gives it strength and elasticity, and attaches it to the parts it lines. The yellow fibrous tissue enters largely into the composition of the membrane itself, its filaments interlacing in a beautiful manner, and conveying blood-vessels, nerves and lymphatics in varying proportions.‡

Synovia.—This fluid is found freely secreted in all synovial membranes. It has an unctuous, viscid, ropy consistence, with a yellowish tinge strongly resembling the white of an egg. It is now regarded as a simple transudation, consisting of serum, with from six to ten per cent. of additional albumen.

* Gerber, General Anatomy, p. 220. † Basement membrane.

‡ Carpenter, Principles of Physiology, § 175.

According to M. Donné, it is always alkaline in health, owing to the presence of a small quantity of sodium.

Synovial membranes are interposed between parts that are exposed to friction from mutual action, and are therefore always seen where tendons play upon bones, as in the instance of the biceps flexor cubiti muscle. They are found also where tendon comes in contact with cartilage, of which the tendon of the peroneus longus affords an example in its course across the sole of the foot. Sometimes they completely envelop tendons, and give a lining to their sheaths, as in the flexors of the hands and feet; and a similar arrangement is made for tendons that come in contact with each other, as those of the extensor carpi radialis and the extensors of the thumb. They are moreover placed between tendons and external parts, and between tendons and ligaments, as in the flexors of the fingers and the capsular ligaments of the wrist; and they are always interposed where bones play on each other. Some communicate with other synovial sacs, and some again with the cavities of proximate joints.

THE JOINTS.

Notwithstanding the number and variety of the joints, anatomists have endeavored to arrange them according to their structure and function; and the classification now most generally adopted is, with slight modifications, the one proposed by Galen nearly two thousand years ago. Thus, all the articulations are distributed into three groups, called Diarthrosis, Synarthrosis and Amphiarthrosis.

1. Diarthrosis.—The joints of this group are *freely movable;* for which purpose they are covered with cartilage where the surfaces come in contact, and provided with synovial membranes and connecting ligaments. They are separated into four subordinate divisions called *arthrodia*, *enarthrosis*, *ginglymus*, and *rotary diarthrosis*.

In *arthrodia* the motion produced is that of two or more surfaces gliding on each other, one being partially convex, the other correspondingly concave; in other words, they are often nearly plane. Articulations of this kind are seen in the oblique processes of the vertebræ; in the junction of the radius with the first row of carpal bones; between the carpal and carpo-metacarpal surfaces; at the inferior radio-ulnar articulation, and in that between the head of the fibula and the tibia: so also in the tarso-metatarsal, temporo-maxillary, acromio-clavicular and sterno-clavicular joints. The articulation of the metacarpal bone of the thumb with the trapezium, is also of the same class.

Enarthrosis.—The characters of this joint are, a head or portion of a sphere, more or less completely received into a cavity, constituting what is called a ball and socket articulation. A capsular ligament is an essential part of this mechanism. Enarthrosis admits of motion in every direction—flexion, extension, adduction, abduction, circumduction and rotation, but the latter in a more limited degree than the others. Examples, the hip and shoulder joints.

Ginglymus.—This, which is a trochlear or hinge-like joint, is formed by a

mutual reception of the articular surfaces, so as to restrict the motion to a single direction. The elbow and ankle afford perfect examples of this kind; the knee is a less complete illustration, because it admits of some rotary motion. The phalangeal joints of the fingers and toes belong also to the class of ginglymus articulations, which are complete in proportion to the absence of lateral motion.

Rotary diarthrosis.—This form is also called *trochoid articulation*, and embraces the pivot and ring, which last is partly osseous, partly ligamentous. The motion is exclusively rotary, and its centre is the axis of the pivot. Examples are seen in the articulation of the tooth of the vertebra dentata with the atlas, and in the play of the head of the radius in the lesser sigmoid cavity of the ulna.

2. SYNARTHROSIS.—In this class of articulations the proximate surfaces are marked with teeth or other inequalities, which are mutually inserted in such manner as more or less completely to preclude motion. They are destitute of synovial apparatus, and for the most part of ligamentous fibres. There are three varieties of synarthrosis, viz.

Suture.—In this instance opposite serrated surfaces are freely received into each other, with or without the intervention of a thin layer of cartilage. Examples are abundant in the sutures of the cranium and face. In some instances the margin of one bone overlaps that of another, in simple apposition, as in the squamous suture on the side of the cranium. Sutures being mere appendages of the growing state, are only temporary, and hence are often obliterated before middle life.

Schindylesis is the reception of a lamina of bone into a groove in another, as seen in the junction of the azygos process of the os sphenoides and the vomer.

Gomphosis.—Parts joined by gomphosis resemble nails driven into a board, and are devoid of motion on each other. The only examples in man are the teeth in their sockets.

3. AMPHIARTHROSIS.—In this series are arranged those articulations with flat or nearly flat surfaces, partly in contact and partly continuous, and which are united by fibrous or fibro-cartilaginous tissue. Parts thus connected possess a perceptible, though very limited degree of motion; and hence amphiarthrosis, in its motory character, is intermediate between the diarthrodial and synarthrodial joints. Examples of this articulation are seen in the symphysis pubis; between the os innominatum and sacrum; and between the bodies of the vertebræ. These joints are liable to become obliterated by anchylosis in the later periods of life,—especially the symphysis pubis, less frequently the sacro-iliac junction, and still more rarely the intervertebral disks.

The articulations may be divided into four series, those of the head, the trunk, the superior and inferior extremities.

ARTICULATIONS OF THE LOWER JAW.

The only ligaments peculiar to the head, are those that connect the lower jaw with the temporal bone. The contiguous surfaces of the glenoid cavity and condyle are covered with cartilage in the usual way; but this joint embraces an *inter-articular cartilage*, oval in form, thickened at the margin, and

connected at its outer periphery with the lateral ligament. It divides the joint into two cavities, separate from each other and with distinct synovial capsules. In some rare cases this cartilage is perforate, and the synovial cavities communicate freely.

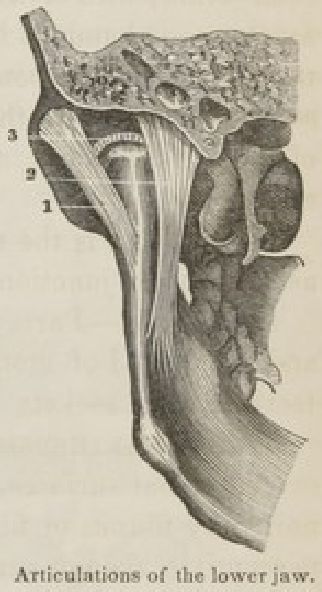
The *external ligament* is short and strong, and extends from the tubercle on the under margin of the zygoma to the outer side of the neck of the lower jaw. It is triangular, with its apex behind, and is firmly blended with the capsular ligament.

The *internal ligament* is extended between the spinous process of the sphenoid bone and the spine that borders the posterior mental foramen of the lower jaw. It has no direct connection with the joint. Between it and the neck of the jaw is a triangular opening for the passage of the internal maxillary artery, auricular nerve, the inferior dental artery and nerve and part of the external pterygoid muscle.

The *capsular ligament* hardly deserves the name. It consists of a few scattered fibres placed between the margin of the glenoid cavity and the inner side of the neck of the lower jaw.

The *stylo-maxillary ligament* passes between the styloid process of the temporal bone and the lower jaw near its angle internally. It has, of course, no connection with the joint.

Fig. 93.



Articulations of the lower jaw.

Fig. 93. Articulations of the lower jaw. 1, external lateral ligament; 2, internal lateral ligament; 3, inter-articular cartilage.

Motion.—The actions of this articulation are various; as depression and elevation, protrusion and retraction, and lateral motion. In *depression*, each condyle with its inter-articular cartilage rolls forward in the glenoid cavity, and mounts upon the glenoid ridge. In the act of elevation, the same parts are returned to their original position. These two actions are like the working of a hinge. Protrusion and retraction are simply gliding motions of the condyle within the glenoid cavity; in other words, the condyle is brought forwards to the base of the glenoid ridge, which in retraction it moves horizontally backwards to regain its original place in the articular cavity. The lateral movement is effected by the action of the muscles of one side; and their alternate motion produces a degree of rotation, in which one condyle rises upon the glenoid ridge, while the other occupies the back part of the articular fossa; and *vice versâ*.

CRANIO-VERTEBRAL ARTICULATIONS.

These consist of two sets of ligaments; one passing between the occipital bone and the atlas, the other between the occiput and vertebra dentata. The former has seven ligaments, the latter four.

Occipito-atlantal articulation.—The first of these connections is the anterior ligament, or *ligamentum teres;* which passes like a cord from the basilar process of the occiput to the anterior tubercle of the atlas. 2. The *ligamentum latum,* which is spread between the margin of the occipital bone above, and the entire length of the anterior arch of the atlas below. 3. The *posterior ligament* is attached above to the margin of the foramen magnum, and below to the posterior arch of the atlas. 4, 5. The *transverse ligaments,* running from the bases of the transverse processes of the atlas to the occipital bone above. 7. The *capsular ligaments* are membranous sacs that embrace the condyles of the occipital bone and the corresponding oblique processes of the atlas.

Motion.—The motion of this joint is distinct but very limited: and much care is requisite in order not to confound it with that of the whole cervical column. It consists of flexion and extension; during the former the condyles glide backward, but the position of the condyles precludes rotation. I have already observed that in rare instances the atlas is completely anchylosed to the occipital bone.

The *occipito-axoid articulation* exists between the occiput and the atlas or dentata. It presents the following ligaments: 1. The *occipito-axoid ligament,* arising from the basilar groove of the occipital bone, and inserted below into the posterior side of the body of the axis, so as to cover and conceal the processus dentatus. 2, 3. The *moderator ligaments.* These arise, one on each side, from the lateral summit of the tooth-like process, whence they pass upwards and outwards to be attached to the occipital condyles. 4. The *vertical ligament* runs from the apex of the odontoid process to the anterior margin of the foramen magnum.

Fig. 94.

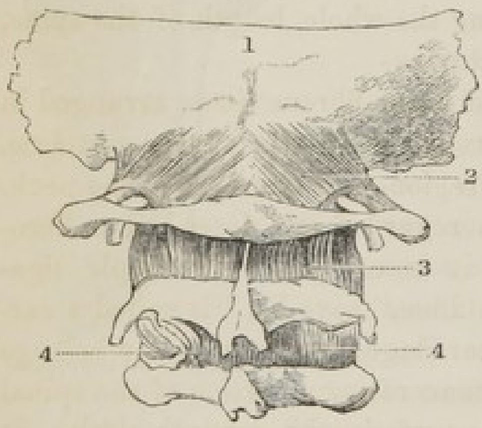


Fig. 95.

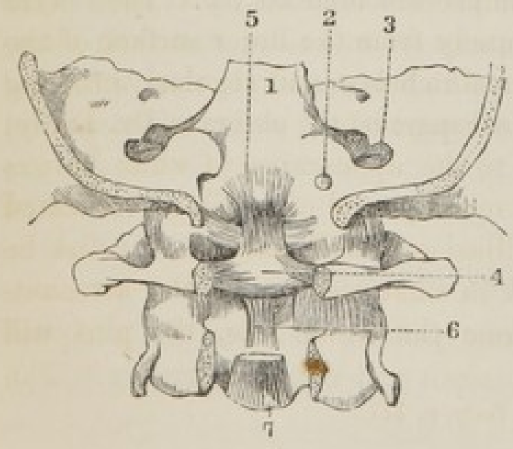


Fig. 94. 1, occiput; 2, posterior occipito-atlantal ligament; 3, posterior atlanto-axoid ligament; 4, 4, second pair of yellow ligaments.

Fig. 95. In this drawing the posterior arch of the occiput and two upper vertebræ are removed. 1, Basilar process; 2, anterior condyloid foramen; 3, posterior foramen lacerum; 4, transverse ligament of the atlas; 5, its superior fasciculus; 6, its inferior fasciculus; 7, anterior vertebral ligament.

The *atlanto-axoid articulation.*—This exists between the atlas and dentata, and embraces five ligaments. The *anterior ligament* is attached, above, to the tubercle of the atlas and the arch on each side; and below, to the body of the axis. The *posterior ligament* is thin and membranous, and is interposed between the arch of the

atlas and the corresponding margin of the axis. The *capsular ligaments* embrace the oblique processes, and being loose, permit great freedom of motion. The *transverse ligament* passes, like a cord, between the tubercles at the base of the oblique processes within the ring of the atlas, so as to confine the odontoid process. It sends down a slip for insertion into the body of the axis, and another upwards to be attached to the basilar process of the occiput. Fig. 95.

Motion.—The atlas and cranium are to be regarded as a single piece in this articulation; and their motion on the axis is a free rotation, limited only by the oblique odontoid ligaments. Not the least flexion or extension is permitted.

VERTEBRAL ARTICULATIONS.

These consist of a series of ordinary ligaments, the yellow ligaments, intervertebral substance and synovial capsules.

1. The *anterior vertebral ligament* is a broad range of fibres covering the bodies of the vertebræ in front from the axis to the sacrum. These fibres are of variable length and closely blended, with fissures for the passage of blood-vessels. This ligament adheres firmly to the intervertebral substance and bodies of the vertebræ.

2. The *posterior vertebral ligament* is spread on the posterior face of the bodies of the vertebræ within the spinal canal. It begins at the vertebra dentata and terminates at the os coccygis. It is remarkably smooth and glossy, its fibres, like those of the anterior ligament, not running the whole length of the spine, but extending between two, three or four vertebræ.

The *intervertebral ligaments* are composed of white fibrous tissue arranged in discoidal plates, one of which is interposed between every pair of true vertebræ. They are of greatest thickness in the lumbar region, and thinnest in the neck. The outer third of the disk has hitherto been regarded and described as fibro-cartilage; but Cruveilhier has shown that it is composed of simple ligamentous structure. "The intervertebral substance," says he, "is called a cartilaginous ligament by Vesalius; by others a cartilage; but it evidently belongs to the fibrous tissues. This may be shown by macerating a portion of the spinal column for some days, or even by rubbing the surface with a rough cloth. It will then appear that this pretended fibro-cartilage is nothing more than a series of concentric fibrous layers, strongly compressed together; that each layer is formed of parallel fibres, directed very obliquely from the lower surface of the vertebra above, to the upper surface of the vertebra below, and regularly crossing with the fibres of the next layer."* "This arrangement," observes Dr. Leidy, "when viewed from either side gives rise to the appearance of white fibrous tissue, indicated by its shining whiteness and opacity, and of cartilage, indicated by its semi-transparency and dulness. The illusion is well marked: if a disk be held sideways in the hand, and pins be stuck in what seem to be the attenuating layers of cartilage and then viewed from the other side, the pins will

* Anatomy of the Human Body, p. 117.

actually appear to have changed their position from the cartilaginous to the fibrous layers."*

The intervertebral ligaments are inelastic in structure, but eminently elastic by arrangement; for the decussation of the concentric laminæ enables them to yield to pressure, and to resume their original position when the pressure is removed; and this elasticity is greatly increased in the whole disk by the presence of a central pulp, that occupies the hollow circle within the ligamentous structure.

The *yellow ligaments*, or ligamenta subflava, are placed between the arches of the vertebræ behind, filling up their intervals and completing the spinal canal from the axis to the sacrum. They are two in number on each side, and consist of twenty-three pairs. They extend from the anterior face of the upper vertebra, to the upper margin of the vertebra below, and are separated by a vertical fissure. Their length is greater in the neck than in the other parts of the column, but their greatest thickness is in the lumbar series. They are composed of parallel fibres, and combine great strength with remarkable elasticity; thus differing in an essential particular from ordinary ligaments. They belong to the class of *yellow fibrous tissues*, already described.

Oblique processes.—These are articulated by irregular ligamentous fibres, which are stronger on the external side. The synovial capsule is complete.

The *spinous processes*, excepting those of the neck, are connected by the *interspinous ligaments*, which arise from the whole length of the spine above, to be inserted into the proximate margin of the one below, being thickest in the lumbar region.

The *supra-spinous ligament* extends from the point of the spinous process of the last cervical vertebra, and terminates at the spine of the sacrum. It increases in strength in its descent, being strongest in the lumbar vertebræ. This ligament is continuous with the *ligamentum nuchæ*, which extends from the seventh cervical spine to the occipital protuberance. It is a thin, membranous septum between the muscles of the neck, with which it is intimately connected.

MOTIONS OF THE VERTEBRAL COLUMN.

If we regard the vertebral column as a whole, it will be found susceptible of five classes of motion, as follow: 1, flexion, or bending forward: 2, extension, by which the spine becomes erect, and to a certain extent inclines backwards; 3, lateral inclination: 4, circumduction, in which the column describes a cone, with the apex below and the base above: 5, rotation on its axis.

1. In simple *flexion* the anterior ligament is relaxed, the anterior part of the intervertebral substance is compressed, and the posterior portion extended in proportion, and the yellow ligaments yield, from their elastic nature, according to circumstances; from which cause the arches or laminæ are separated, and hence the spinal canal is more exposed.

2. In *extension* the anterior vertebral ligament and the proximate intervertebral

* Proceedings of the Acad. of Natural Science of Philadelphia, August 1847.

disks are put on the stretch, and consequently the posterior part of the apparatus is relaxed. This motion is limited by the anterior vertebral ligament and the junction of the spinous processes.

3. The *lateral* movements of the spine are much restricted by the lateral fasciculi of the anterior vertebral ligament, and by the proximity of the transverse processes to each other.

4. *Circumduction* has its centre in the lumbar region and results from all the preceding movements. It is seemingly extensive, but in reality very limited; the deceptive appearance being caused by the consentaneous motions of the hip joint.

5. *Rotary motion* is effected by the twisting of the intervertebral disks; and, although the motion of each disk is very slight, the combined action of the whole series gives a lateral turn to the column, which, however, is but inconsiderable, even in the aggregate.

It is important in all these motions to separate them from others which are derived from the ileo-femoral articulation, which should be kept quiescent when the vertebral motions are alone examined. Again, although these motions are common to the vertebral column, the several classes of vertebræ are capable of them in very variable degrees. Thus *flexion* is most freely accomplished by the *cervical vertebræ*, for the chin can be brought into contact with the sternum: and in like manner *extension* can be effected so as to bend the neck very considerably backwards. So also *lateral inclination* and *rotation* are made with great freedom, even to the extent of luxation, which can nowhere else occur in the spine without fracture of the bones.

In the *dorsal region* flexion is precluded altogether on account of the position of the sternum; *extension* is prevented by the junction of the spinous processes; *lateral motion* is rendered impossible by the double articulation of the ribs; and circumduction and rotation are consequently wholly impracticable. Fixedness or immobility is, therefore, the essential characteristic of the dorsal vertebræ.

The *lumbar region* has a degree of mobility intermediate between the freedom of the cervical vertebræ and the stationary nature of the dorsal series, but it is chiefly limited to a hinge-like action,* resulting from flexion and extension, at the same time that there is a manifest degree of lateral inclination.

COSTO-VERTEBRAL, AND COSTO-TRANSVERSE ARTICULATIONS.

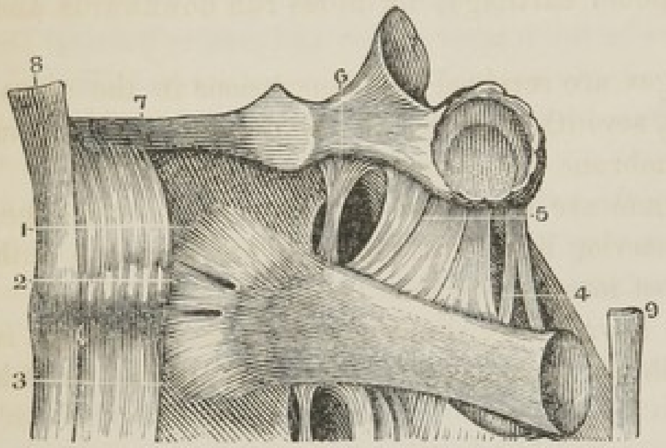
These articulations are two in number: one connects the head of the rib with the body of the vertebra; the other connects the tubercle of the rib with the transverse process.

The *anterior costo-vertebral ligament* has three fasciculi, which radiate from the head of the rib anteriorly. One of these bands passes upwards to be attached to the vertebra above; another downwards to the vertebra below; and the third runs horizontally between them, to be inserted into the intervertebral substance. The first, eleventh, and twelfth ribs, however, are only connected with

* Cruveilhier, Anatomy, p. 123.

the bodies of their respective vertebræ. The *inter-articular ligament* is a short, strong fasciculus that connects the ridge on the head of the rib with the corresponding intervertebral substance. It separates the articulation into two cavities, which have their own synovial membranes and do not communicate with each other. Those ribs that are connected with a single vertebra only, as the first, eleventh and twelfth, have no inter-articular ligament.

Fig. 96.

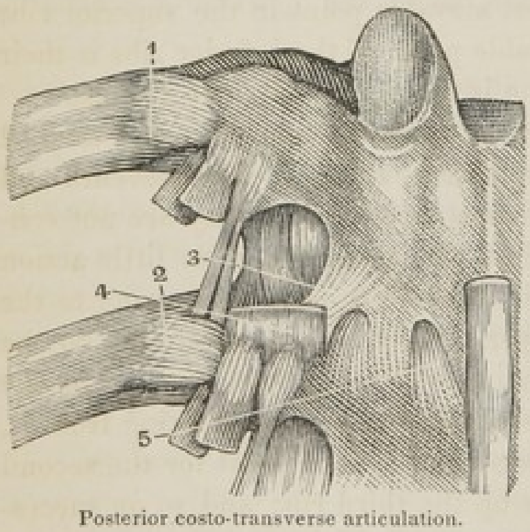


Costo-vertebral articulation.

Fig. 96. View of the costo-vertebral and some contiguous ligaments. 1, 2, 3, three fasciculi of the costo-vertebral ligament:—1, inserted into the vertebra above; 2, into the intervertebral disk; and 3, into the vertebra below; 4, 5, 6, fasciculi of the anterior costo-transverse ligaments; 7, body of the seventh dorsal vertebra; 8, anterior vertebral ligament.

The *anterior* or *internal costo-transverse ligament* is attached above to the inferior margin of the transverse process its whole length, and below to the crest on the neck of the rib between its head and tubercle. The *middle costo-transverse ligament* connects the neck of the rib posteriorly with the transverse process against which it rests. It is best seen by making a longitudinal section of the bones. The *posterior costo-transverse ligament* unites the tubercle of the rib with the end of the transverse process.

Fig. 97.



Posterior costo-transverse articulation.

Fig. 97. The posterior costo-transverse articulation. 1, 2, posterior costo-transverse ligaments; 3, lamello-transverse ligament, passing from the bony bridge to the transverse process; 4, tendon of the transverso-spinalis muscle; 5, yellow ligament of the spine.

The costo-vertebral articulations have very little motion, but this is in every direction—upwards, downwards, inwards, and outwards; and from these combined actions is also derived a slight revolving motion. The eleventh and twelfth ribs, from their comparatively feeble attachments, are most movable of all.

COSTO-STERNAL ARTICULATIONS.

These embrace the ligaments that connect the ribs with the sternum and with each other, and are three in number. The *anterior ligament* consists of a series

of smooth fibres that originate at the sternal end of the cartilage, and diverging, are attached to the sternum in front, and send fasciculi across to mingle with those of the opposite side. The *posterior ligament* is much more delicate than the other, but its fibres pursue a similar direction. The *costo-xiphoid ligament* is placed between the lower margin of the seventh cartilage near the sternum and the anterior face of the xiphoid cartilage; its fibres run downwards and inwards.

The costal ends of the cartilages are received into depressions in the corresponding ribs. Where the sixth, seventh, and eighth costal cartilages come in contact, they have a synovial membrane and connecting ligaments.

The several bones of the sternum are connected to each other by cartilage, and have both anterior and posterior ligaments, but they are so mixed with those just described as to be almost inseparable from them.

The costo-sternal articulations have a very slight degree of motion, which is of the gliding kind. The first rib has least mobility; the eleventh and twelfth the most of all.

MOTIONS OF THE THORAX.

These are two; one, that of *dilatation*, which takes place when the lungs are filled with air; and that of *contraction*, which follows the act of expiration. Dilatation is caused by the elevation of the ribs and sternum, whence an increase in all the diameters of the chest. The most movable point in the superior ribs is at the centre of curvature; the most movable point of the inferior ribs is their junction with the cartilages; while the spine is the centre of these actions.

The costo-vertebral motion is very limited at the same time that it is exerted in every direction so as to be, to a certain extent, rotary. The eleventh and twelfth ribs possess most motion, for the obvious reason that they are not connected to the transverse processes. The first rib is capable of so little action that it is regarded as a fixed point; and this immobility is in part owing to the insertion of the scaleni muscles into its upper surface, and in part, also, to the firmness with which its tubercle is attached to the transverse process of the proximate dorsal vertebra. "The first intercostal muscles, contracting from it, draw up the second rib, which, in its turn, becoming a fixed point for the second intercostal muscles, they contract and draw up the third rib; and so on successively to the last."* This series of motions increases the lateral diameter of the thorax.

The sternum, from its connection with the ribs, is necessarily elevated with them; whence an increase in the antero-posterior diameter of the thorax at every inspiration. The vertebral diameter of the thorax, is augmented by the contraction of the diaphragm occurring simultaneously with the elevation of the ribs and sternum.

The *contraction* of the thorax results from the depression of the ribs in the expiratory act. This is produced partly by their own weight; partly by the

* Horner, Anatomy and Histology, i. p. 149.

elasticity of their cartilages, which, in consequence of the relaxation of the muscles, react, and restore the ribs to their original position; and partly again by the action of the muscles of expiration.*

Some further observations will be made on this subject under the head of the respiratory function.

THE VERTEBRO-PELVIC ARTICULATIONS.

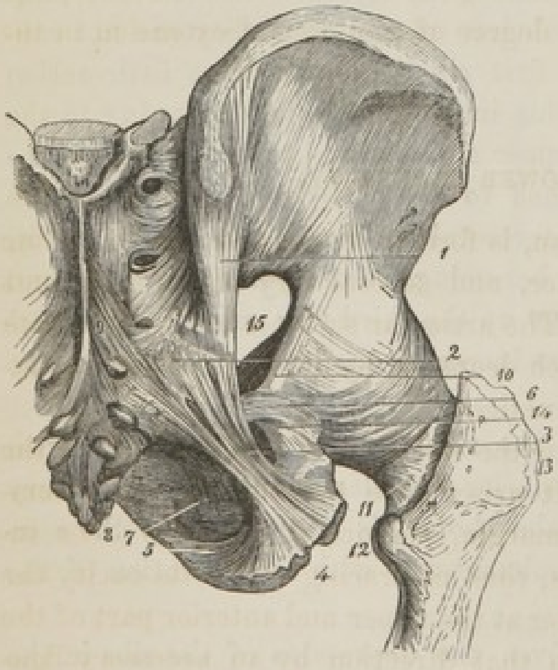
The junction of the sacrum with the last lumbar vertebra differs in nothing from the other spinal articulations; but there are two special ligaments between these bones that remain to be noticed. The first of these is the *sacro-lumbar ligament*, which is attached below to the upper, posterior margin of the sacrum, and above to the transverse process of the last lumbar vertebra. The second of these ligaments, the *ilio-lumbar*, arises from the crista of the ilium above the sacro-iliac junction, and is inserted into the transverse process of the last lumbar vertebra.

THE PELVIC ARTICULATIONS.

The *anterior sacro-iliac ligament* is placed in front of the bones that constitute this articulation; the fibres, which are short and strong, running from the venter of the ilium to the proximate surface of the sacrum.

The *posterior sacro-iliac ligament* is on the back of the articulation. It arises from the upper rudimentary spinous processes of the sacrum and the space between them, and is inserted into the rough surface of the ilium posteriorly. The *oblique sacro-iliac ligament* is attached by one end to the posterior superior spine of the ilium, and by the other to the third transverse tubercle of the sacrum.

Fig. 98.



Articulations of the pelvis and hip.

Fig. 98. 1, posterior sacro-sciatic ligament, (vertical ligament of Bichât,) arising from the sacro-iliac junction; 2, also from the sacrum and coccyx; 3, free portion of the ligament, terminating in the tuber ischii at 4 and 5; 6, lesser or anterior sacro sciatic ligament; 7, obturator ligament; 8, os coccygis; 9, sacral fasciculus of the posterior sacro-sciatic ligament; 10, 11, capsular ligament of the hip-joint; 12, trochanter minor; 13, trochanter major; 14, lesser sciatic notch; 15, greater sciatic notch; 16, posterior sacro-iliac ligament.

The *anterior sacro-sciatic ligament*, is an angular fasciculus of fibres that arises by its broad edge from the sacrum below the ilium, and from the whole side of the os coccygis; from these origins its fibres converge, and are inserted

* Cruveilhier, p. 178.

by a point into the spine of the ischium. Fig. 98, 6. The *posterior sacro-sciatic ligament*, which is much the larger of the two, arises from the posterior inferior spinous process of the ilium, and from the lateral margin of the sacrum and upper end of the coccyx; from this broad origin it passes downwards, becoming narrower in the middle, and then expands again to be inserted into the inner margin of the tuberosity of the ischium and the ramus of that bone. Fig. 98.

The *sacro-coccygeal ligaments* are thin fasciculi that pass between the bones both behind and before. A similar arrangement connects the several coccygeal bones with each other.

The *obturator ligament* completely covers and closes the foramen thyroideum, excepting an opening at its upper margin for the passage of the obturator blood-vessels and nerves. It is thin but strong, and affords a partial origin to the obturator muscles.

The *interpubic articulation* is formed by the symphysis and several ligaments. The *anterior pubic ligament* is formed by scattered, straight and oblique fibres that pass from bone to bone in front of the symphysis. The *posterior ligament* presents a similar arrangement of fibres behind the symphysis. The *superior pubic ligament* crosses from side to side on and over the upper end of the symphysis, and fills the space between the two bones. The *sub-pubic ligament* is about half an inch broad, of a triangular form; it is extended between the crus pubis on one side to the same margin on the other, connecting the two bones, and forming the upper boundary of the pubic arch.

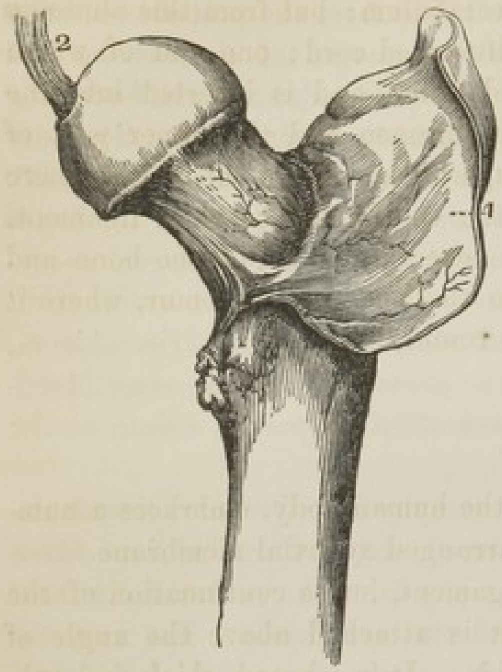
The *symphysis pubis* is an interosseous fibro-cartilage, interposed between the two surfaces of the pubes for something more than an inch in length. It resembles the intervertebral substance in being composed of concentric lamellæ, of which the fibres are oblique and more dense at the margin than in the centre; but there is nothing in this articulation analogous to the intervertebral pulp. The symphysis pubis admits of a slight degree of motion and extension in the parturient state.

LIGAMENTS OF THE LOWER EXTREMITY.

The *ileo-femoral* or hip-joint articulation, is formed by the acetabulum on one side, the head of the femur on the other, and several very strong ligaments serve to keep these parts in apposition. The articular surfaces are covered with cartilage, and the acetabular cavity is much deepened by fibro-cartilaginous matter disposed in a manner presently to be noticed.

The *capsular ligament* of the hip-joint is the strongest of its class, and at the same time one of the most complete. It arises from the outer basal circumference of the acetabulum, (not from its margin,) whence it descends to be inserted into the roots of both trochanters, thus embracing within its cavity the whole neck of the os femoris. It is thicker at the upper and anterior part of the joint; and it receives especial strength in that direction by an accessory ligament, called the *ileo-femoral*, that descends from the anterior inferior spine of the ilium to the ridge between the trochanters, on the front of the femur.

Fig. 99.



Hip-joint articulation. After Sir Astley Cooper.

The *cotyloid ligament* is an angular ring of fibro-cartilage, based on the margin of the acetabulum to deepen its cavity and thereby to strengthen the joint. It is formed into a free acute margin on top, and at its external side gives attachment, as we have seen, to the capsular ligament. It is much thicker on its upper and posterior margin than in front; and where it crosses the notch of the acetabulum, is strongly reinforced by the subjacent ligamentous fibres, which pass from the upper to the lower margin of the notch, and partially crossing each other, adhere at the same time to the cotyloid ligament.

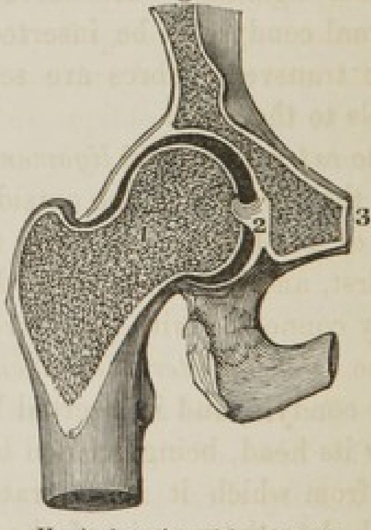
Fig. 99. View of the capsular ligament, 1, which is separated from the acetabulum, and thrown back to show the manner in which it invests and conceals the neck of the femur; 2, ligamentum teres.

Fig. 100.

Vertical section of the os femoris. After Sir Astley Cooper.

Fig. 100, another view of the upper end of the femur, divided by a vertical section. 1, 1, capsular ligament; 2, ligamentum teres.

Fig. 101.



Vertical section of the hip-joint.

Fig. 101. Vertical section of the hip-joint articulation, to show the manner in which the head of the femur is received into the acetabulum. 1, os femoris sawed through; 2, round ligament; 3, 3, os innominatum divided.

The *ligamentum teres*, or round ligament, is concealed within the capsular sac. It arises from the subcentral depression on the head of the femur, and is indi-

rectly and partially attached, by its investing synovial membrane, to the fatty mass that fills the excavated bottom of the acetabulum: but from this adhesion it is readily separated and dissected into a bifurcated cord; one end of which passes out at the lower margin of the cotyloid notch, and is inserted into the outer face of the ischium between the thyroid foramen and the upper part of the tuberosity; the other end passes to the superior margin of the notch, where it is attached, and becomes blended with the contiguous cotyloid ligament. The synovial membrane is a complete sac; it covers the head of the bone and lines the acetabulum, whence it is reflected to the neck of the femur, where it takes the place of periosteum, and invests the round ligament.

KNEE-JOINT.

This, the most complicated articulation of the human body, embraces a number of dissimilar ligaments and a peculiarly arranged synovial membrane.

The *ligamentum patella* is not a proper ligament, but a continuation of the tendon of the recti muscles of the thigh. It is attached above the angle of the patella; below, to the tubercle of the tibia. It is a broad, thick and subtriangular band of fibres at its attachment, but diminishes in width in its course downwards.

The *posterior ligament*, or ligamentum Winslowi, is a broad, membranous expansion on the posterior face of the joint, where it performs the office of a capsular ligament. Its fibres run obliquely downwards and inwards from the external condyle to be inserted into the inner side of the head of the tibia. Some transverse fibres are seen in it, and foramina for the passage of blood-vessels to the joint.

The *external lateral ligament* is double; one part, which is cord-like, passes from the tubercle on the outside of the femoral condyle to the outer part of the head of the fibula; the other and shorter part, arises from the condyle behind the first, and is inserted into the posterior part of the head of the fibula. It is firmly connected with the corresponding semilunar cartilage.

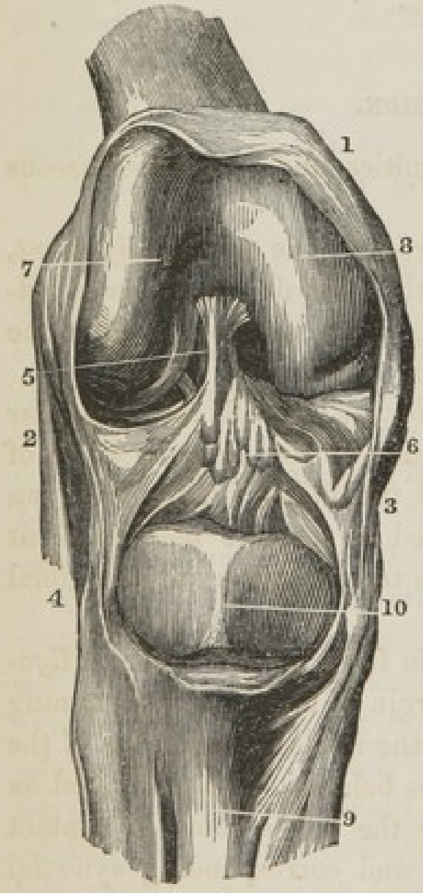
The *internal lateral ligament* arises from the tubercle on the surface of the inner condyle, and is inserted by a broad margin into the inner side of the tibia below its head, being crossed below by the tendons of the inner hamstring muscles, from which it is separated by a bursa. In its course to the tibia it is attached to the margin of the internal semilunar cartilage.

The *anterior crucial ligament* arises from the depression on the head of the tibia in front of the spine, and going backwards and upwards is inserted into a fossa on the inner side of the external condyle of the os femoris. The *posterior crucial ligament* arises from the posterior tibial depression, and runs upwards and forwards to be inserted into the external face of the inner condyle. The crucial ligaments are cord-like, very strong, and covered by the synovial membrane of the joint. When the leg is bended they are relaxed; but when the leg is extended they become tense, checking its further motion forwards and preventing rotation.

The *semilunar cartilages*, two in number, are placed on the top of the tibia for the purpose of deepening the articulation, as well as to lessen the force of concussion when applied to the joint. They are thick at the periphery, which is firmly attached to the ligamentous apparatus of the joint and especially to the lateral ligaments and to the margin of the fossæ before and behind the spine of the tibia. Towards the interior of the joint they become thinner and thinner until they terminate in a sharp, free, curved margin facing the spine. The external cartilage is nearly circular; the internal is smaller and lunated. Their anterior margins are united by a fibrous cord called the *transverse ligament*, which runs in front of the crucial ligament between the articular faces of the bone.

The *synovial membrane* is remarkable both for its extent and complexity. It covers the condyles of the femur, the head of the tibia, the internal face of the patella, both surfaces of the semilunar cartilages, and the crucial ligaments. It also rises above the superior margin of the patella, covers the posterior face of the tendons of the recti muscles, and extends up between them and the bone for two or three inches, thus forming a complete cul-de-sac which communicates freely with the cavity of the joint.

Fig. 102.



Knee-joint articulation.

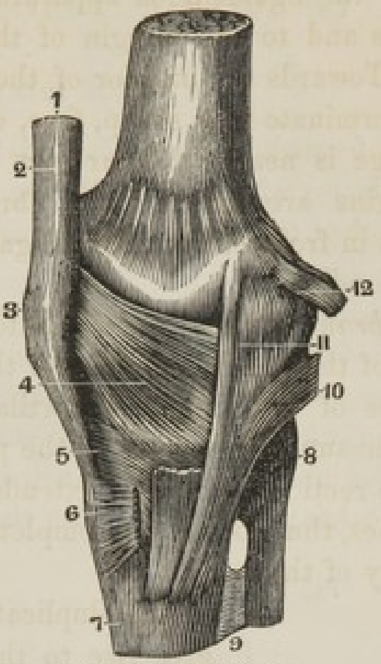
The duplications of the synovial membrane give rise to three delicate attachments which are ligamentous in function, and intimately connected with a mass of fat that is interposed between the cavity of the joint and the ligamentum patellæ. Below this ligament the adipose cushion protrudes into the joint, and forms a ridge on each side. The synovial capsule which is continuous with the external ridge is the *external alar ligament;* the other is the *internal alar ligament* and the largest of the two. The *ligamentum mucosum* is another duplication of the synovial membrane: it is of a triangular form, its base being downwards and attached to the adipose cushion and to the transverse ligament, and its apex inserted into the anterior part of the condyloid notch of the os femoris.

Fig. 102 is a front view of the knee-joint. 1, 2, 3, 4, synovial capsule, laid open; 5, ligamentum mucosum; 7, 8, condyles of the femur; 9, tendon of the recti muscles of the thigh, cut off and thrown down over the tibia in order to show the posterior face of the patella; 10, and its several connections.

In addition to the proper ligaments of this articulation, the knee-joint is more or less invested by a membranous expansion of the fascia femoris called the *involucrum generale*. The fascial portion is strengthened by accessory slips from the ex-

tensor muscles of the thigh, and especially from the vastus internus. The involucrum is well developed in front, and is thicker on the outer than on the inner side; but behind it is very imperfect, and becomes insensibly blended with the adipose and cellular tissue.

Fig. 103.



Knee-joint articulation.

Fig. 104.

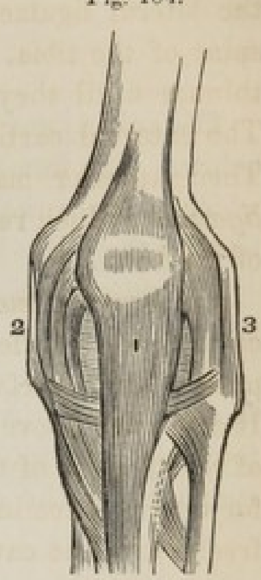


Fig. 103, lateral view of the knee-joint. 1, 2, common tendon of the quadriceps femoris; 3, patella; 4, internal lateral ligament of the patella; 5, ligament of the patella; 6, attachments of the sartorius and gracilis; 7, upper end of the tibia; 8, head of the fibula; 9, interosseous ligament, with the opening of the blood-vessels above it; 10, insertion of semi membranosus muscle; 11, internal lateral ligament of the knee-joint; 12, tendinous heads of the gastrocnemius.

Fig. 104. Front view of the knee-joint, to show, 1, the ligamentum patellæ; 2, internal lateral ligament; 3, external lateral ligament.

PERONEO-TIBIAL ARTICULATION.

The tibia and fibula are connected at their extremities, and by an interosseous ligament that unites their shafts.

The upper articulation is small; it is bounded in front by the *anterior ligament*, which extends from the outer side of the head of the tibia downwards and outwards to the head of the fibula. The *posterior ligament* is arranged like the former between the contiguous bones, but is smaller.

The *interosseous ligament* is a strong fibrous membrane that fills the triangular space between the bones; being attached on one side of the external angle of the tibia; on the other to the proximate edge of the fibula. The fibres run obliquely downwards and outwards, and are covered by muscles both in front and behind. At its upper end is an opening for the transit of the anterior tibial vessels.

The *lower peroneo-tibial* articulation is formed in front by the *anterior ligament*, the fibres of which originate on the outer margin of the tibia, and running downwards and outwards are broadly inserted into the malleolus externus of the fibula. The *posterior ligament* connects the bones behind, and is arranged on the same plan as the anterior ligament. Where the bones come in contact below there is a very small cartilaginous surface and corresponding synovial membrane, which last communicates with that of the ankle-joint.

THE TIBIO-TARSAL ARTICULATION.

THE ANKLE JOINT.

The ankle joint is formed by the tibia and fibula above, and the astragalus below. The former bones with their malleolar processes form a deep concavity which receives the arched top of the astragalus; and they are retained in position by the following ligaments.

The *anterior ligament* is a membranous expansion attached above to the front margin of the tibia; below, to the astragalus just in front of its articular surface.

The *deltoid* or *internal lateral ligament*, arises from the inferior margin of the malleolus internus, whence its fibres radiate to be inserted by three blended fasciculi; one into the inner side of the astragalus; a second into the lesser apophysis of the os calcis; and a third into the scaphoides, where it is mingled with the fibres of the calcaneo-scaphoid ligament.

Fig. 105.

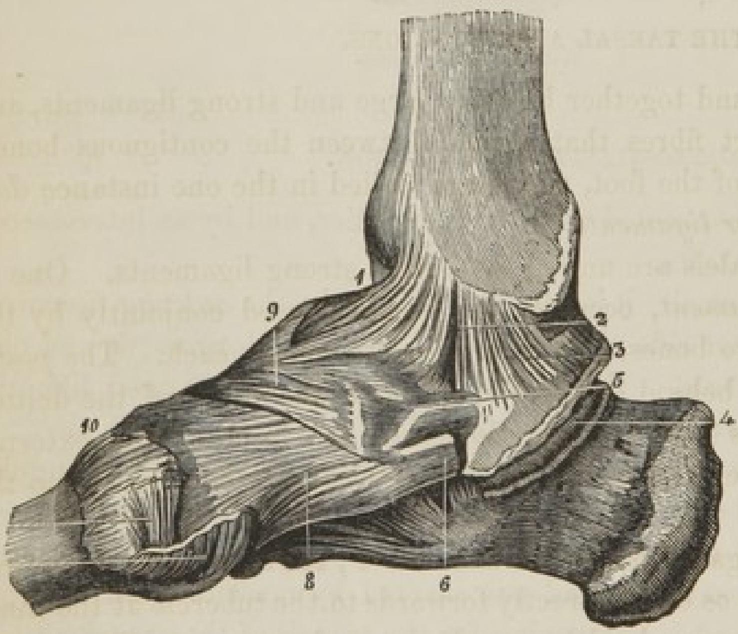


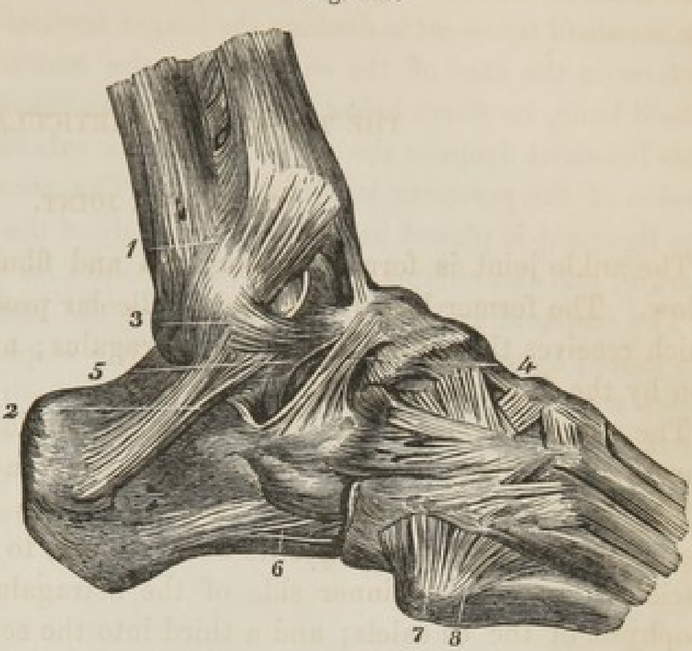
Fig. 105. Internal ligaments of the ankle and foot. 1, anterior fasciculus of *deltoid ligament;* 2, middle fasciculus; 3, posterior fasciculus; 4, groove for the flexor digitorum communis; 5, internal calcaneo-scaphoid ligament; 6, tendon of the tibialis posticus; 7, tendon of the tibialis anticus; 8, ligament connecting the os scaphoides with the first cuneiform bone; 9, ligament connecting the scaphoides with the cuneiforme medium; 10, ligaments connecting the first metatarsal with the first cuneiform bone.

The *external lateral ligament* is also composed of three fasciculi, which are distinct from each other. They all arise from the inner margin of the external malleolus, and are severally inserted into the astragalus in front, the os calcis below, and the astragalus behind.

The tibia and astragalus are also attached behind by some loose ligamentous fibres that pass between the bones, and imperfectly represent a capsular ligament.

Fig. 106. The external lateral ligaments of the ankle and foot. 1, anterior ligament of the lower tibio-fibular articulation; 2, external lateral ligament, sometimes called peroneo calcaneum; 3, anterior fasciculus of the same, or peroneo-astragalar ligament; 4, external calcaneo-astragalar ligament; 5, interosseous ligament; 6, lower calcaneo-cuboid ligament; 7, ligament (ligamentum dorsale obliquum), uniting the fifth metatarsal bone with the os cuboides; 8, dorsal ligament of the fourth metatarsal bone. The dorsal surface of the foot is covered by smaller ligaments that connect the tarsal and metatarsal bones, and these again with each other.

Fig. 106.



THE TARSAL ARTICULATIONS.

The tarsal bones are bound together by a few large and strong ligaments, and by a great number of short fibres that extend between the contiguous bones, both on the back and sole of the foot, which are called in the one instance *dorsal* and in the other *plantar ligaments.*

The astragalus and os calcis are united by several strong ligaments. One of these, the *interosseous ligament*, occupies the canal formed conjointly by the articular surfaces of the two bones, and is firmly attached to each. The *posterior ligament* unites them behind, being blended with the fibres of the deltoid ligament; and the joint is greatly strengthened by the internal and external lateral ligaments, that descend from the malleolar processes to be attached to the tarsal bones.

The *calcaneo-scaphoid* ligaments are two in number; the *internal* extends from the lesser apophysis of the os calcis directly forwards to the tubercle at the inner and inferior margin of the scaphoid bone. It is as dense as cartilage; and being moulded on the internal part of the astragalus, presents a groove or pulley externally for the play of the tendon of the tibialis posticus muscle. Besides connecting these bones, it receives and supports the intermediate smooth surface of the astragalus. At its under margin is the bony groove, completed into a canal by the fibres of this ligament, for the play of the tendons of the flexor longus pollicis, and flexor digitorum longus muscles. The *external calcaneo-scaphoid ligament* is placed between the tubercle of the scaphoides and the greater apophysis of the os calcis, and thus crosses the foot obliquely.

The *calcaneo-cuboid ligaments* are also two in number; the *dorsal* one is a broad layer of fibres that extends from the outer surface of the os calcis, and is

inserted into the corresponding margin of the os cuboides. The *plantar calcaneo-cuboid ligament* is double; the longer fasciculus is extended from the rough surface on the base of the os calcis, to the summit of the oblique ridge of the cuboid bone, its fibres being continued to the third and fourth metatarsal bones. This ligament deepens the canal in the os cuboides through which passes the tendon of the peroneus longus muscles. The second and shorter fasciculus of this ligament is placed between the tubercle of the os calcis at its anterior basal margin, and the oblique ridge of the cuboides its whole length.

The scaphoid and cuboid bones, besides the usual dorsal and plantar fibres, are united by an interosseous ligament. The scaphoides and the three cuneiform bones are connected by a triple ligament on both the plantar and dorsal surfaces. This ligament arises from the scaphoides, and branching forwards, sends a fasciculus to each cuneiform bone. A single synovial capsule covers all these articular surfaces, from which it is extended between the first and second, and second and third cuneiforms.

TARSO-METATARSAL AND METATARSAL ARTICULATIONS.

These are chiefly maintained by *dorsal*, *plantar*, and *interosseous ligaments;* the former passing from the tarsal to the metatarsal bones on the top of the foot; and the plantar fibres, though more delicate, performing the same part on the sole. The *interosseous ligaments* are placed between the sides of the metatarsal bones of the four lesser toes at their tarsal ends. There is also one of these ligaments between the internal cuneiform bone and the proximate base of the second metatarsal, and another when the latter bone comes in contact with the cuneiforme externum. The metatarsal bones are further attached at their bases, above and below, by transverse ligamentous fibres that pass from bone to bone, and constitute a series of dorsal and plantar ligaments. These bones are attached at their anterior extremities by transverse ligaments, which run from bone to bone on the under surface of the foot.

METATARSO-PHALANGEAL ARTICULATIONS.

These exist between the anterior extremities of the metatarsal bones and the first phalanges. The head of each metatarsal is flattened laterally into a small condyle, which is received into a corresponding concavity of the proximate phalangeal bone. The *plantar ligament*, consisting of thick, interlaced fibres, which extends between the points just mentioned, and is grooved below by the tendons of the flexor tendons of the toes. There is also a *lateral ligament* on each side, which is blended with the plantar one, and goes longitudinally from bone to bone. There are no dorsal ligaments, their place being supplied by the tendons of the extensor muscles.

The phalanges of the toes are articulated in the same manner as those of the feet; viz. by the plantar and lateral ligaments; the dorsal surface being covered by the extensor tendons.

THE UPPER EXTREMITIES.

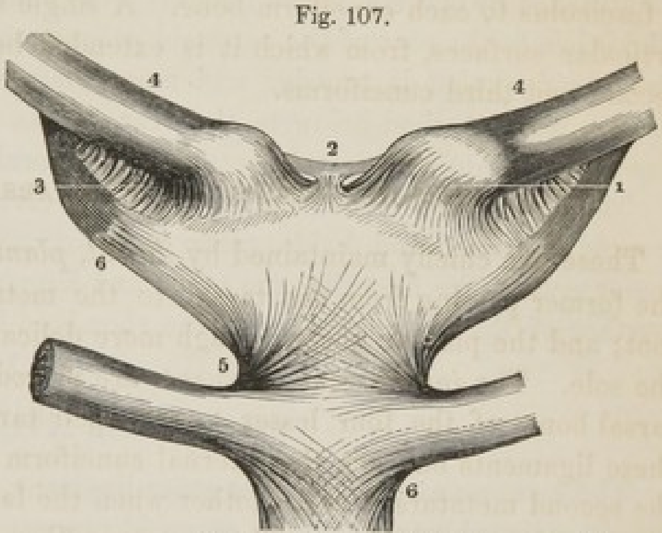
THE STERNO-CLAVICULAR ARTICULATION.

The *capsular ligament* of this joint is composed of two parts, one anterior, the other posterior. The first extends obliquely downwards and forwards from the clavicle to the sternum in a radiated manner. The posterior fasciculus is also broad, and envelops the joint on that side; and as the fibres are continuous above and below, they constitute a true capsule. Fig. 107.

The *inter-clavicular ligament* is extended like a cord between the two clavicles over the top of the sternum, to which it is firmly attached. Fig. 107.

Fig. 107 is a view of the parts composing this articulation. 1, capsular ligament; 2, interclavicular ligament; 3, costo-clavicular or rhomboid ligament; 4, 4, clavicles; 5, 6, costo-sternal or chondro-sternal ligaments.

Fig. 107.



Sterno-clavicular articulation.

The *inter-articular cartilage* is connected above to the clavicle, below to the junction of the sternum with cartilage of the first rib, and by the rest of its periphery to the capsular ligament; thus separating the bones from each other, and dividing the joint into two compartments. Each of these has a distinct synovial capsule, which has no communication with the other, excepting in those rare instances in which the inter-articular cartilage is perforated in the centre.

Motion.—The sterno-clavicular articulation is the centre of the movements of the shoulder. It admits of *elevation and depression*, and a motion forwards and backwards, together with circumduction resulting from the other movements in combination. The action of this joint is very limited in itself; but when transmitted, as Cruveilhier remarks, by the lever of the clavicle, it becomes greatly increased at the apex of the shoulder.

THE COSTO-CLAVICULAR ARTICULATION.

This is made by a single ligament, the *rhomboid;* a strong fasciculus of fibres that arises from the cartilage of the first rib, and running obliquely upwards, is inserted into the rough depression at the under and sternal end of the clavicle. Fig. 107.

THE SCAPULO-CLAVICULAR LIGAMENTS.

The acromio-clavicular ligament.—The scapular end of the clavicle meets the acromion process by a narrow elliptical facet provided with a synovial membrane and a *capsular ligament*, which last is strongly developed on the upper and lower surfaces of the articulation.

The acromio-clavicular articulation admits of motion in two directions; the first is a simple gliding of the proximate surfaces upon each other; the second is the rotation of the scapula, forwards and backwards, upon the end of the clavicle.

The *coraco-clavicular ligament* is double; the conoidal portion, *conoid ligament*, is attached by one end to the tubercle on the under surface of the clavicle, and by the other to the root of the coronoid process, the base presenting upwards. The *trapezoid* portion is broader and more membranous than the other; like the latter, it is attached below to the root of the coronoid process, but above its insertion is into the clavicle between its tubercle and external end.

The *ligamentum bicorne* arises from the clavicle at the inner margin of the conoid ligament, and dividing into two portions, of which one is attached to the inner end of the first rib; the other and longer head, is inserted into the under surface of the clavicle as far as the rhomboid ligament.

THE SCAPULAR LIGAMENTS.

The *coraco-acromial*, or triangular ligament, arises by a broad base from the whole external margin of the coracoid process, whence its fibres converge to be united by its apex into the end of the acromion process. It forms an arch over the shoulder-joint, and underlies the deltoid muscle.

The *coracoid ligament* is a small cord that crosses the notch on the superior margin of the scapula. A foramen is thus formed for the superior scapular blood-vessels and nerve.

SCAPULO-HUMERAL ARTICULATION.

The shoulder-joint is formed by the glenoid cavity, the head of the humerus, and three ligaments with their synovial and other appendages.

The *capsular ligament* arises from the margin of the glenoid cavity and is inserted into the neck of the humerus. It is thick and strong above, where it is greatly strengthened by the tendons of the four muscles that go to be inserted into the tubercles on the head of the os humeri. Below it is comparatively membranous.

The *coraco-humeral ligament* arises by a broad base from the external margin of the coracoid process, and going under the triangular ligament, is inseparably blended with the articular capsule to which it imparts great strength above and in front. It is sometimes called *ligamentum adscititium*.

The *glenoid ligament* is a fibro-cartilaginous ring placed on the margin of the articular cavity, to deepen it for the better reception of the head of the humerus. At its superior border, at the origin of the biceps muscle, its fibres divide, and then immediately coalescing form the tendon of that muscle, which runs in the bicipital groove through the whole length of the capsular ligament. That the tendon is thus derived from the glenoid ligament, and really continuous with it, a little dissection will prove; and from this cause, and from its function of keeping the head of the os humeri applied to the glenoid cavity, it has been called by Cruveilhier the inter-articular ligament.

The synovial membrane, besides lining the capsular ligament, forms a sheath round the tendon of the biceps which terminates below in a cul-de-sac; and it has two openings, by one of which it communicates with the bursa of the subscapularis muscle; by the other, with a bursal sac of the infra-spinatus.

Fig. 108.

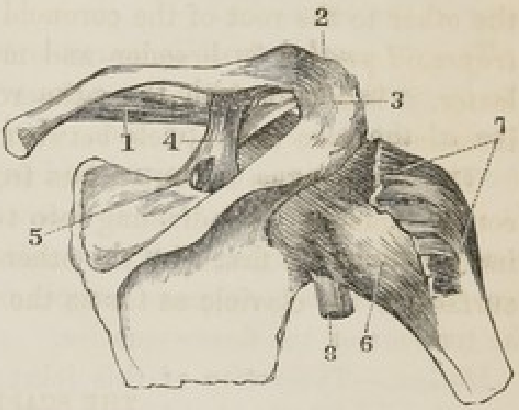


Fig. 108. Scapulo-humeral articulation. 1, ligamentum bicorne; 2, acromio-clavicular ligament; 3, coraco-acromial ligament; 4, coraco clavicular ligament; 5, coracoid or supra-scapular ligament; 6, capsular ligament; 7, tendons of the supra-spinatus, infra-spinatus and teres minor muscles; 8, tendon of the long head of the biceps.

Motion. — The movements of the scapulo-humeral articulations are more numerous and varied than those of any other joint. The most extensive of these motions is that by which the humerus is thrown forward and backward; it may thus be made to assume even an upward vertical position, and thence forwards, downwards and backwards, until it forms an angle of 45° with the axis of the body. Its motion between these extremes is perfectly free, and results from a simple gliding of the head of the bone upon the glenoid cavity. The upward and backward and downward and backward movements are restricted to the points above indicated by the coracoid process, which receives the pressure of the head of the humerus, and so restrains it as to prevent dislocation.

In *abduction* the scapula is fixed, and the head of the humerus passes to the lower margin of the glenoid cavity, where its further descent is checked by the capsular ligament. It is a familiar fact, and readily verified by experiment, that the movement of abduction may be extended to a degree that will permit the arm to touch the head without dislocation; for the head of the bone, though it glides from the glenoid cavity, is almost entirely received into the loose capsular ligament below.

Adduction is the simplest of this series of motions; *circumduction*, of course, results from a combination of the preceding movements, for which the whole articular apparatus is admirably adapted; and the rotary motion consists in the rolling of the head of the bone in the glenoid cavity, by the action of the muscles inserted into the tuberosities of the humerus.

HUMERO-CUBITAL ARTICULATION.

THE ELBOW-JOINT.

The elbow-joint presents an articulation of three bones, the humerus, the ulna and the radius, which are bound together by three ligaments.

The *capsular ligament* is broad, radiated and membranous in front, where it arises from the humerus above the joint, and is inserted below into the coronoid process of the ulna and the coronary ligament of the radius. At the sides it is strengthened by the lateral ligaments; and behind it descends broadly from the supra-articular surface of the os humeri, to be attached to the ridge at the base of the olecranon.

The *external lateral ligament* is connected above with the outer condyle of the humerus, below with the coronary ligament of the radius and the external face of the olecranon process. It is much blended above with the tendons of the extensor longus digitorum and supinator radii brevis muscles. It is a cord-like fasciculus. The *internal lateral ligament* arises from the inner humeral condyle, and diverging as it descends, is inserted into the margin of the coronoid process, and the contiguous margin of the olecranon. It is much blended with the tendons of the flexor muscles.

Motion.—The action of this joint is of the simplest kind, being confined to extension and flexion, without any lateral action. The flexion, however, is very extensive, being checked only by the reception of the coronoid process of the ulna into the lesser sigmoid cavity of the humerus. Extension is also so great, that the arm and forearm meet end to end in the same axis; and this action is in turn limited by the point of the olecranon process coming in contact with the bottom of the greater sigmoid cavity of the ulna.

THE RADIO-ULNAR ARTICULATION.

These are two; one above, the other below. The superior radio-ulnar articulation is formed by the play of the head of the radius in the lesser sigmoid cavity of the ulna; the parts being kept in apposition by the coronary or annular ligament.

The *coronary ligament* arises from the anterior edge of the lesser sigmoid cavity of the ulna, and embracing the neck of the radius, is inserted into the opposite margin of the same cavity. It is a strong fasciculus, nearly half an inch in breadth, and strengthened behind by the external lateral ligament.

The synovial sac of the elbow-joint covers the articular face of the three bones, including the several sigmoid cavities, and is also reflected outwards so as to embrace the neck of the radius.

Motion.—The only action of which this joint is capable is rotation; and to accomplish it the head of the radius rolls backwards in the lesser sigmoid cavity

of the ulna. The consequence is that the radius crosses over the ulna, so as to get on the inner side of the last-named bone. The palm of the hand is thus turned downwards, and this motion is called *pronation*. Reverse this action and the bones again assume a parallel position; the palm of the hand is turned upwards and *supination* is induced.

Fig. 109.

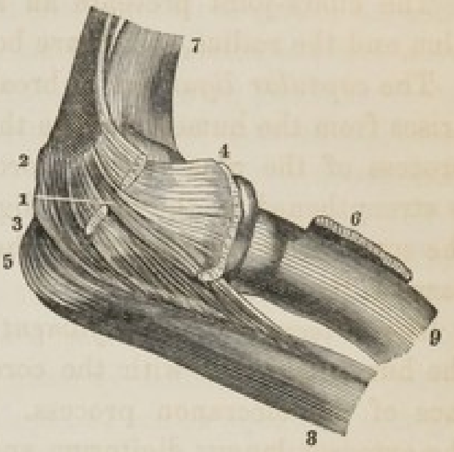


Fig. 109. The humero cubital articulation. 1, external lateral ligament, blended with the extensor tendons; 2, 3, 4, 5, capsular ligament; 6, tendon of the biceps; 7, humerus; 8, ulna; 9, radius.

The *interosseous ligament* is an aponeurotic membrane that fills the space between the two bones except at the extreme ends, each of which is perforated by a foramen; through the upper of these openings the posterior interosseous artery is transmitted; through the lower one, the anterior interosseous artery. This ligament, by being attached by one margin to the angle of the radius, and to the angle of the ulna by the other margin, contributes strongly to keep these bones in their relative apposition; at the same time that it affords support and partial origin to the flexor muscles on its anterior surface, and to the extensors on its posterior side.

The *ligamentum teres*, or round ligament, is inserted by one end into the ulna anteriorly at the base of the coronoid process; and by the other end into the radius below its tubercle. It assists the interosseous ligament in binding the bones of the forearm together.

At their lower ends, the radius and ulna are further bound together by thin fasciculi of fibres that pass from bone to bone, transversely, both back and front. The articular surfaces of these parts are formed by the head of the ulna and the sigmoid cavity of the radius. The *triangular ligament* is a fibro-cartilaginous lamina that arises by its apex from the fossa at the base of the ulnar styloid process, and is inserted by its base into the carpal margin of the sigmoid cavity of the radius. Its upper surface is covered by a synovial membrane, of which a process is extended upwards between the radius and ulna, forming the *membrana sacciformis*.

Motion.—This is limited to circumduction, in which the radius revolves partially round the head of the ulna. This action is necessary to effect pronation and supination, and for that purpose is simultaneously performed with the rotation of the upper radio-ulnar joint.

RADIO-CARPAL ARTICULATION.

The wrist joint is formed above the radius and triangular ligament and by the three first bones of the carpus below: these bones are, the scaphoides, lunare and cuneiforme, forming together a condyle of which two-thirds is

received into the articular face of the radius. The cuneiform bone is placed opposite to the ulna, but contact is prevented by the triangular fibro-cartilage already described, which performs the office both of a cartilage and a ligament. This joint is bounded at its sides by the styloid processes of the radius and ulna.

The *capsular ligament* arises above from the entire margin of the two bones, adhering closely at its inner side to the inter-articular cartilage; and it is inserted below into the corresponding margins of the scaphoides, lunare and cuneiforme, and from these, in a partial degree, into the bones of the second row. It is membranous and loose, but strengthened laterally by two ligaments next to be noticed.

The *external lateral ligament* extends from the styloid process of the radius to the proximate surface of the scaphoid bone and the annular ligament.

The *internal lateral ligament* connects the styloid process of the ulna with the pisiform and cuneiform bones. Two other ligaments, an anterior and posterior, are described by some anatomists, but they are so blended with the capsular envelope as not to require a separate notice.

Motion.—This is fourfold—flexion, extension, abduction and adduction; and the combination of these actions produces a very free circumduction. This function is so simple as to require no comment: it obviously results from the gliding of the head of the carpus in the concavity of the cubital articulation, at the will of the flexor and extensor muscles.

THE CARPAL ARTICULATION.

This joint is formed between the two rows of carpal bones, excluding only the os pisiforme. They are covered by a capsular ligament, formed of palmar and dorsal ligaments that pass from bone to bone of the two rows, and are strengthened laterally by fibres that pass between the cuneiform and unciform, and between the scaphoides and trapezium. All these fibres are much blended with those of the surrounding ligaments already described. The carpal bones are further connected by delicate interosseous ligaments, which have intervals between them in order that the synovial membrane may be continued to the metacarpal bones.

The pisiform bone, besides the attachments already mentioned, is articulated with the cuneiforme by a separate cartilage and synovial membrane, and by a proper capsular ligament.

The synovial membrane between the two carpal series, is prolonged between the bones of the second row to join the basal ends of the metacarpal bones of the four fingers, thus forming a sac with several partitions that communicate freely with each other; but there is a distinct synovial capsule between the trapezium and the metacarpal bone of the thumb.

Motion.—The arched form and numerous ligaments of this articulation give it great strength; but its motions are very limited, more especially that between the component bones of each row with each other. The action of the two rows

is confined to a very moderate degree of flexion; but the flexion is almost inappreciable, and lateral movement is altogether precluded by the enarthrodial arrangement of the bones.

CARPO-METACARPAL ARTICULATIONS.

These are ligamentous fibres that connect the second row of bones with the proximate metacarpals. They consist chiefly of two series, dorsal and palmar ligaments. The *dorsal ligaments* run directly between the carpal and metacarpal surfaces on the top of the hand; and the bases of the metacarpal bones are further connected by transverse fibres. The *palmar ligaments* correspond with the dorsal; they are not so strong, but like them are reinforced by scattered fibrillæ that run across the bones. The articulation of the thumb with the trapezium, on account of its isolated position, has a true capsular ligament and a separate synovial capsule. The synovial sac of the other parts of this articulation, is a prolongation of that of the two rows of carpal bones already noticed.

The metacarpal bones, independently of their connection with the carpus, have strong lateral articulations where the surfaces come in contact, being bound together by transverse ligaments both on their dorsal and palmar faces; and their contiguous surfaces are furnished with a synovial membrane by digitations from that of the carpus. The metacarpal bones are further connected near their phalangeal ends by means of transverse ligamentous fibres that pass from bone to bone on the palmar surface.

Fig. 110.

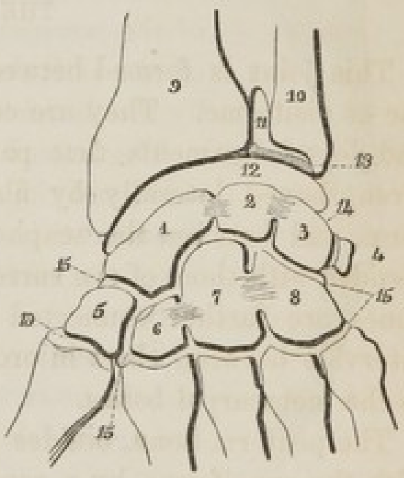


Fig. 110. Articulations of the bones of the carpus with each other, and with those of the forearm and metacarpus. 1, scaphoides; 2, lunare; 3, cuneiforme; 4, pisiforme; 5, trapezium; 6, trapezoides; 7, magnum; 8, unciforme; 9, radius; 10, ulna; 11, synovial membrane of the inferior radio-ulnar articulation; 12, synovial membrane of the radio-carpal articulation; 13, inter-articular ligament between the ulna and radius, and separating the two preceding synovial membranes; 14, synovial membrane of the os pisiforme; 15, 15, synovial apparatus between the first and second rows of carpal bones, and between the second row and the metacarpus; 16, synovial membrane of the articulation of the os trapezium with the first metacarpal bone.

Motion.—As a whole, the action of this joint is extremely limited, but varies in different parts of the structure. Thus, the second and third metacarpal bones are immovable; the others possess some motion in all directions, amounting, in the first and fifth, to partial circumduction.*

* Cruveilhier, Anatomy, p. 197.

THE METACARPO-PHALANGEAL ARTICULATIONS.

These joints, as their names express, are formed between the terminal ends of the metacarpal bones and the proximate phalanges. The *anterior ligaments* are fibro-cartilaginous, and run transversely to be inserted into the proximate ridges on the sides of the metacarpals near their heads. They are very thick and strong, and grooved for the passage of the flexor tendons of the fingers.

The *lateral ligaments* are short, strong cords, that extend obliquely from the pits on the sides of the metacarpal heads, to the contiguous sides of the first phalanges. There are no dorsal ligaments; for their place is supplied by the tendons of the extensor muscles, in their passage over the back of the joints; these tendons being thus in contact with the synovial capsules.

These joints permit of flexion and extension, abduction and adduction, and consequently of the combined movement of circumduction. The flexion is complete; but extension is limited to the restoration of the fingers from the flexed to the straightened position; or it may go on a little further by placing the fingers at a slight backward angle. This power is remarkably developed in some persons, and like most other articular functions, may be much increased by habit.

Fig. 111.

PHALANGEAL ARTICULATIONS.

Each finger joint has an *anterior ligament* precisely like that of the metacarpo-phalangeal articulation, and like it, forms part of the articular surface for the head of the bone. It is grooved by the flexor tendons.

The *lateral ligaments* pass from phalanx to phalanx on the side; and the extensor tendons supersede the necessity for dorsal ligaments.

Fig. 111. Phalangeal articulation of the fingers. 1, 2, 3, external lateral ligaments.

The motion of these joints is limited to flexion and extension; and the remarks made on the metacarpo-phalangeal articulations, are applicable equally to these.

DERMOLOGY.

THE SKIN AND ITS APPENDAGES.

Although the skin and mucous membrane are formed of similar elements, and regarded in general anatomy as continuations of a single tissue, we have thought best to separate them on this occasion, and from motives of convenience, to describe together the skin, the hair and the nails, with some subordinate structures.

The skin embraces a series of laminated tissues which serve several important purposes in the animal economy. Thus it affords a universal and comparatively insensitive covering to the whole body, being thicker in some places than in others, and possessed of a degree of flexibility that adapts it to all the varied conditions of the organs of locomotion. It also contains those elements which give to the human races their varied complexions; it contains within itself the apparatus that affords the sense of touch; it, moreover, forms a vast exhalent surface for the elimination of effete fluids from the interior organs; and at the same time it possesses an inhalent property or function, by means of which fluids are absorbed in order to be conveyed to the parts within.

The laminæ constituting the skin, have long been familiar to anatomists by the names of cutis vera, rete mucosum and epidermis; but recent investigations, and especially with the aid of the microscope, have considerably extended our knowledge of these tissues, of which we proceed to speak in detail.

CUTIS VERA, OR DERMIS.

Although this structure invests the whole exterior of the body, it is thicker in some parts than in others; thus, for example, it is much more attenuated on the front of the body than on the back, being on the latter surface, and on the scalp, of double thickness in comparison. Contiguous surfaces are also thin, as the inside of the arm and leg; it is remarkably delicate also on the eyelids, the scrotum and the mammary gland. The reverse again is seen on the outside of the limbs, the palm of the hand and the sole of the foot. It is of a pink color in life, and of an opaque white in death, when examined independently of its connections; and this holds good with all nations, whatever may be their different

complexion from a variable distribution of the pigmentum nigrum. It is highly extensible and elastic, as is manifest in its alternate states of distension and contraction, attendant on locomotion, but more obviously in pregnancy and parturition, and in abdominal and other forms of dropsy; and this property continues in a remarkable degree long after life is extinct, and until dryness or decomposition destroys it.

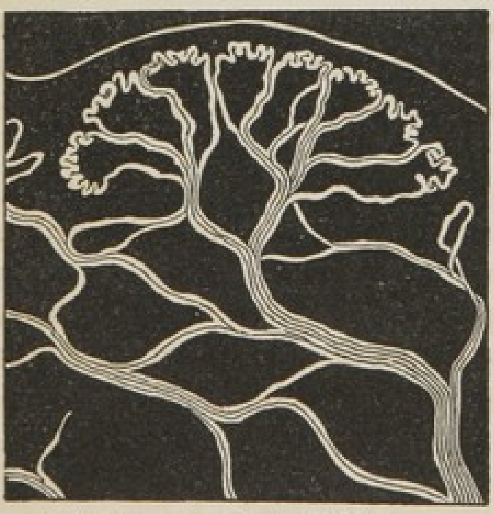
The true skin is thrown into folds in those parts where it is subject to frequent and prolonged extension, as in the palm of the hand and on the dorsum of the fingers; and so also the constant action of muscles gives rise to a corrugated or wrinkled condition, as in the forehead in the later periods of life. Wrinkles also arise in old age from the absorption of fat; and they are moreover common in the abdomen after parturition and the removal of chronic hydropic effusions.

The cutis is composed of several elements, among which the white and yellow fibrous tissues are conspicuous; the former giving strength, the latter strength and elasticity combined. These two forms of tissue are distributed in nearly equal proportions in different parts of the body; but they everywhere present a retiform arrangement, in which the meshes are closely interwoven with each other, and with the cellular or areolar tissue which also forms a large and important element of the dermal structure.

It is also from these elements, but especially from the white fibrous tissue, that the skin yields so large a proportion of gelatin.

The cutis presents two very different surfaces, of which the external is called the *papillary body*, the internal, the *corium*. The papillary surface possesses a varied function, being at the same time an organ of touch and secretion; the first is due to the tactile papillæ; the second to a glandular apparatus of extreme delicacy. The *papillæ* are for the most part irregularly distributed over the surface of the body, and are distinctly seen as small eminences when the body is exposed to cold, giving rise to the rough or villous appearance called *cutis anserina*, or goose-flesh. In the palm of the hand and sole of the foot the papillæ are always conspicuous, arranged in elevated lines which are more or less concentric, and separated from each other by corresponding furrows. They consist of erectile tissue, in which the microscope reveals an admirable arrangement of nerves, arteries, veins and lymphatics; and these *sensory papillæ*, especially in the fingers, are the seat of those impressions which constitute the sense of touch. Each papilla encloses loops of tactile nerves, which are accompanied by an analogous anastomosis of blood-vessels: these loops are graphically exhibited in the annexed drawing from Gerber, which

Fig. 112.



Ultimate anastomosis of a digital nerve. After Gerber.

represents a terminal cord of the median nerve on the volar surface of the human thumb. The meshes and loops belong to a single papilla only.* Fig. 112.

This surface is also marked by multitudinous orifices which are the openings of the sudoriferous glands. These are found in every part of the papillary body, and, as their name imports, are the sources of the perspiratory fluid. In other parts the skin is traversed by the ducts of the sebaceous glands, which convey an oily secretion; which last, however, in comparison with the perspiration, is but partially distributed. These structures will be more fully described in the further progress of this inquiry.

The internal surface of the skin, or *corium*, is intimately blended with cellular and adipose tissue: but when these have been carefully removed, we perceive a multitude of depressions or pits that bear a strong resemblance to the cicatrices of small-pox. Each one of these depressions lodges a conical peleton of fat.

The lymphatics of the skin are very abundant, being arranged in the form of a network which is situated superficially to the blood-vessels as Mascagni had observed, and is composed of two different layers placed between the papillary surface and epidermis: one being superficial and extremely delicate; the other lying directly upon the dermis and belonging to deeper vessels.†

Sense of Touch.—This sense is defined a general feeling or sensibility, possessed by the skin especially, which takes cognizance of the form, temperature and other properties of bodies. It is dependent upon contact between the skin and other surfaces, or upon certain temperatures which are greater or less than that of the cutaneous surface. It is greatest where the papillæ are most numerous, which is the point of the middle finger; and least in the middle of the back, and the same region of the arm and thigh. As a general rule it will be found acute in proportion to the delicacy of the cuticle, or where the latter assumes the epithelial form, as on the lips, glans penis, &c., and *vice versâ*. Where the skin merges into mucous membrane, the tactile sense is most complete, at the extremities of canals than on their internal surface. The food produces in the mouth the sense of touch, but excites hardly any impression after it enters the esophagus and stomach; and it is not until it reaches the terminal end of the alimentary canal in the excrementitious form, that its presence is again indicated by this sense.‡

The sense of touch is resident in the nervous loops of the papillary surface; and Gerber supposes that each loop is embraced by a portion of vesicular matter on which the sensory impression is first made.

Some physiologists refer the sense of temperature to a set of fibres wholly distinct from those of touch; for many examples have occurred in which the former sensation was lost while the sense of touch remained.

* Gerber. General Anatomy, p. 263.

† Mascagni. Prodromo.

‡ Dunglison's Physiology, i. p. 101.

THE BASEMENT MEMBRANE.

This structure, which is also called the primary membrane, "is a pellicle of such extreme delicacy that its thickness scarcely admits of being measured. It is to all appearance perfectly homogeneous, and presents not the slightest trace of structure under the highest powers of the microscope, appearing like a thin film of coagulated gelatin. It would seem as if the first and simplest form was produced by the simple consolidation of a thin layer of homogeneous fluid; the second, by a layer of such fluid including granules; and the third, by the coalescence of flattened cells whose further development had been checked."* It is regarded as the outer layer of the cutis vera, and independently of the mucous tissue hereafter to be mentioned, underlies the epidermis on all the free surfaces of the body.

The offices of this basement are various. It appears, for example, to form a boundary between the papillary body and the cuticle, and to restrain the profuse escape of fluids from the one to the other; at the same time that it permits of a sufficient exudation for the nourishment of the cells which are placed upon it. It is further suggested by Dr. Carpenter, that this membrane with its granular structure furnishes the germs of those cells that become finally consolidated in the epidermis; and he supposes the distinct spots that are visible in it to be collections of granules, each of which may give rise to a large number of such cells, which spring from it as from a centre. The basement membrane is further regarded as a transitional rather than a permanent structure, and as the medium of nutrition of the cells upon its surface.†

THE EPIDERMIS.

The *epidermis* or *cuticle* is that familiar membrane which invests the entire surface of the body, or, in other words, forms its exterior envelope. Anatomists of the present day consider it to be composed of two laminæ: the exterior one, or proper epidermis, and the internal layer, which is chiefly made up of pigment cells.

The proper epidermis, divested of the subjacent coloring matter, is of a dull white color, elastic and semi-transparent. Its structure is allied to that of horny substances; it is entirely insensible, and wholly destitute of nerves or blood-vessels. Its thickness on the unexposed parts of the body does not exceed the twentieth part of a line; but in situations in which it has been augmented by laborious employment, as in the palm of the hand or sole of the foot, it varies from half a line to more than two lines in thickness. It does not readily decompose, and is consequently very durable.

The epidermis has of late years been generally regarded as an inorganic structure; but Della Torre, Fontana and Mascagni long ago announced their con-

* Carpenter. Elements of Physiology, § 206. † Ibid. § 209.

viction of its organic structure, which they thought to consist in a network of lymphatic vessels. These distinguished men were correct as to the fact, but mistaken as to the mode; which has only been revealed by the more elaborate employment of the microscope in our own day. These researches prove the epidermis to consist of peculiar cells arranged in a laminated order. The innermost layer is soft and granular: "It consists of nuclei, in various stages of development into cells, held together by a tenacious, semi-fluid substance. This was formerly considered as a distinct tissue, and was supposed to be the peculiar seat of the color of the skin: it received the designation of *rete mucosum*. Passing outwards, we find the cells more completely formed; at first nearly spherical in shape, but becoming polygonal where they are flattened against one another. As we proceed further towards the surface, we perceive that the cells are gradually more and more flattened, until they become mere horny scales, their cavity being obliterated. Their origin is indicated, however, by the nucleus in the centre of each. Thus each cell is developed from the surface of the basement membrane, and is gradually brought to the surface by the development of new cells beneath, and the removal of the superficial layers; while at the same time it is progressively changed in form until it is converted into a flattened scale."*

These several stages of derangement and development are exhibited in the annexed drawing, Fig. 113, which gives an oblique section of epidermis. At 1 is seen a primitive corpuscle; 2, 3, 6, are secondary corpuscles in different phases; at 4, these secondary corpuscles are transformed into laminated structure; and 5 represents the true skin.

Fig. 113.

Oblique view of the epidermis, showing its component cells; magnified 350 times. From Mandl.

Another remarkable feature of the epidermis is that it sends down processes into the sebaceous and sudoriferous glands, each one of which forms a perfect tube for the transmission of the secretion of these glands to the surface, where they open by raised and rounded papillæ, each with a central depression and aperture. Several of these funnel-shaped canals are seen in Fig. 120. Mr. Hassell observes that the orifices of these tubular processes are immense, not less, indeed, than 3000 to the square inch; a fact that will convey some idea of the perspiratory function on the entire surface of the human body. Besides the prolongations of epidermis thus sent to the subcutaneous glands, others are furnished to the hairs, of which each one has an epidermic sheath encircling its base.†

There has been some difference of opinion among anatomists respecting the epidermis of the white and colored races; but the most recent observers assert that no structural difference exists between them; and that the seeming diversity consists only in a greater or less accumulation of pigment cells; "and is, therefore," as Mr. Hassell expresses it, "rather in degree than in kind." But I can-

* Carpenter's Elements of Physiology, § 225. † Hassell. Microscopic Anatomy, Plate XXIII.

not agree with him in supposing it possible that climate alone, acting through many ages, would be sufficient to cause the various modifications of color observed in the different races, and in respect to which I shall presently offer some remarks.

The epidermis is constantly destroyed and replaced, as is proved by the disappearance from the skin of such stains as those produced by nitrate of silver; by the desquamation that takes place in bathing; or by frictions to the skin with a brush or towel; and above all, by the white scales thrown off after some diseases, and especially scarlatina. The white and soap-like crust that sometimes covers the skin of new-born children, when examined by the microscope, is found to consist of epithelial scales mingled with mucus and oil globules,* and has received the name of *vernix caseosa.* Fig. 114.

Fig. 114.

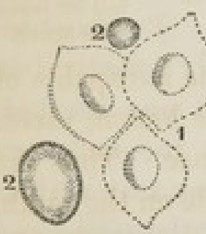


Fig. 114. Vernix caseosa. 1, epithelial cells; 2, oil globules. After Wagner.

The restoration of the epidermis is also observed after the process of vesication by blisters, and in consequence of burns and scalds. By these means very large patches of cuticle are taken away; but a very few days, under favorable circumstances, are sufficient for its perfect renewal.

The uses of the epidermis are various. It serves, in the first place, to cover and protect the delicate and sensitive parts beneath it; to prevent, by its peculiar constitution, the too rapid dissipation of caloric;† and to restrain the evaporation of the fluids of the skin and its appendages, at the same time that it furnishes a medium through which those secretions can reach the surface of the body.

THE PIGMENT-CELLS.

These cells are the seat of all the diversities of color of the skin and eye among the different races of men. They are contained in a soft granular matrix of a tenacious consistence which until recently has been designated as the *rete mucosum*, but which is now regarded, not as a separate membrane, but as the inner layer of the epidermis itself. Each of these cells, like that of the cuticle, has a cell-wall, nucleus and granules, as seen in Fig. 115.

Fig. 115.

Pigment cells, magnified 300 diameters. After Mandl.

The coloring matter is seated in the granules, about the $\frac{1}{20,000}$th of an inch in diameter, of a black color and flattened into discs or points. Fig. 116. The cells of the skin form layers of unequal thickness, and accumulate in the depressions between the papillæ. Their form is hexagonal, polygonal or irregularly rounded; abundant everywhere in the skin of the negro, but absent in the races of fair complexion excepting on certain parts of the body, as the areola of the nipple, the genital organs and the perineal region. But even here the pigment-cells are fewer in number, smaller, and more rounded than in the negro, yet they sometimes present the nucleus and cell-wall. That appearance

* Hassell. Microscopic Anatomy, p. 251.

† Idem.

of the skin called freckles is due to a modified character of the pigment-cells; and I have often observed that in mulattoes who are marked in this way, the freckles are themselves the lightest parts of the face.

Fig. 116.

Pigment molecules, magnified 500 times. After Mandl.

Pigment cells are developed in the fœtus at a very early period; yet those of the negro do not acquire their deep black color until some days after birth. In the Albino the cells are altogether deficient. The pigmentary substance is capable of rapid reproduction, as every one must have noticed who has seen blisters applied to the skin of the negro.*

It is a common opinion, as already observed, that climate alone is capable of producing all those diversities of complexion so remarkable in the human races. A very few facts may suffice to show that such cannot be the case. Thus the negroes of Van Diemen's Land, who are among the blackest people on the earth, live in a climate as cold as that of Ireland, while the Indo-Chinese nations, who live in tropical Asia, are of a brown and olive complexion. It is remarked by Humboldt, that the American tribes of the equinoctial region have no darker skin than the mountaineers of the temperate zone. So also the Puelchés of the Magellanic plains, beyond the fifty-fifth degree of south latitude, are absolutely darker than Abipones, Tobas and other tribes, who are many degrees nearer the equator. Again, the Charruas, who inhabit south of the Rio de la Plata, are almost black, whilst the Guaycas, under the line, are among the fairest of the American tribes. Finally, not to multiply examples, those nations of the Caucasian race which have become inhabitants of the torrid zone in both hemispheres, although their descendants have been for centuries, and in Africa for many centuries, exposed to the most active influences of climate, have never, in a solitary instance, exhibited the transformation from the Caucasian to a negro complexion. They become darker, it is true; but there is a point at which the change is arrested. Climate modifies the human complexion, but it is far from being the cause of it.

APPENDAGES OF THE SKIN.

THE HAIR.

The hairs are filaments of extreme tenuity in proportion to their length, always flexible, and variable in size and color. The whole body, excepting the palms of the hands and soles of the feet, is covered by a delicate pilous struc-

* The researches of M. Gaultier on the rete mucosum, have attracted much attention of late years, and deserve a brief notice. He thought he could trace four distinct laminæ in this structure. The lowest of these, called by him *bourgeons sanguins*, are evidently the apices of the papillæ, as seen in Fig. 113. Above this is the *tunica alba profunda* which seems to answer to the basement membrane of the existing physiology. The *gemmula*, or third layer of M. Gaultier, is charged more or less with coloring matter, and appears to be the proper pigment membrane; and over this again he describes a fourth tunic, which is without color, and which he calls *tunica albida superficialis*. This last layer is no doubt a part of the epidermis itself.

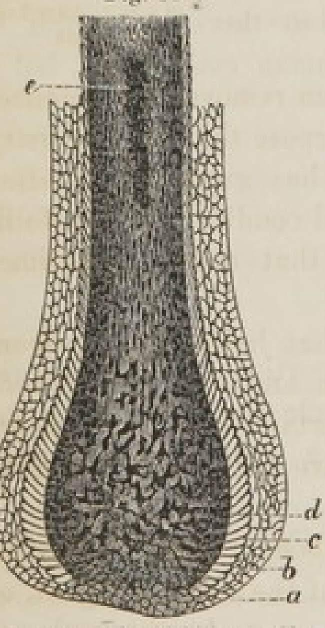
ture that is even downy in childhood, and limited to a certain definite growth. On the other hand the hair of the scalp is long and strong, and often continues to grow in the white races until it reaches a remarkable length, at the same time that it possesses a proverbial diversity of texture.

The whole visible hair above the skin is the *shaft*. It is covered by a delicate envelope called the *cortex*, within which is the fibrous body of the hair, filled within by the medullary substance, which last is formed in great measure by colorless cells through which the pigment-cells are distributed at irregular intervals. In some instances the whole shaft is made up of fibres; and Todd and Bowman reject the term medullary structure as applied to the interior of the hair. They describe it as composed only of longitudinal fibres and a delicate, film-like envelope.

This envelope or cortex, according to these accurate observers, is formed from a single layer of the cells immediately surrounding those about to form the fibrous tissue of the shaft, at the bottom of the follicle. The cells assume an imbricated arrangement, and, ascending on the shaft, become more and more pressed against it until they form upon its surface a thin, transparent film.

The follicle is swelled like the bulb that it accommodates. It is formed by an inversion of the skin and lined by the epidermis, which last is consequently in contact with the exterior surface of the hair. "The hair grows from the bottom of the follicle, and the cells of the deepest stratum there resting on the basement membrane, are very similar to those which, in other parts, are transformed into scales of cuticle. A gradual enlargement occurs in these cells as they mount in the soft bulb of the hair, which, indeed, owes its size to this circumstance. If the hair is to be colored, the pigment-grains are also here developed;—for the most part in scattered cells, which may send out radiating processes;—at other times, in a diffused manner around the nuclei of the cells generally."*

Fig. 117.



Scrotal hair, highly magnified. After Todd and Bowman.

Fig. 117 represents a scrotal hair highly magnified. The basement membrane of the follicle is seen at *a*; and at *b* is a layer of epidermic cells resting upon it, and becoming more scaly as they approach *c*, which is a layer of imbricated cells forming the *cortex* of the hair. These cells are seen more flattened and compressed the higher they are traced on the bulb. Within the cortex is the proper substance of the hair, consisting at the base of small angular cells, which at *d* become larger, and the bulb thicker in consequence; at the same time the black pigment is blended with them. Above *d* they assume a fibrous character, and become condensed; while at *e* the shaft of the hair is charged with a mass of coloring matter.

The follicle is extremely vascular; but no vessels have been detected in the bulb, notwithstanding that it may be reddened by a minute injection.† The hairs are no longer regarded as the mere product of secretion; but on the contrary, they "are beautifully

* Todd and Bowman. Physiology, i. p. 417.

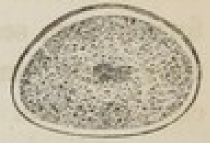
† Burdach. Physiologie, vii. p. 232.

organized, and retain a vital, though not a vascular connection with the body."

According to some chemists the color of the hair depends on a pigment analogous to hematosin: iron is also said to be present, and in larger proportion in dark than in light hair. Vauquelin, however, ascribes the color of the hair to a peculiar oil, which is of a sepia tint in dark hair, blood-red in red hair, and yellowish in fair hair.* There is every reason to believe that the hairs are moistened by such a fluid, which they derive from the follicle by imbibition and transmit to every part of the texture. Gaultier has traced the source of this secretion to some sebaceous glands in the follicle itself. The gray color of the hair in old age, and in some persons in the early periods of life, is attributed by Olivier to the absence of coloring matter in the oily fluid and a simultaneous development of phosphate of magnesia. The rapid manner in which hair sometimes becomes gray, is proverbial. A few hours have in some instances produced this change. Bichat records an example that came under his own observation in which it occurred in a single night in consequence of extreme grief.

However inexplicable this phenomenon appears to be, the authenticated examples are too numerous to admit of a reasonable doubt. Dr. Dunglison observes that the causes, when they come to be considered in reference to the structure and function of the hair, are not so preternatural as they at first appear; and that the change induced is only remarkable for its suddenness, since it is identical with that which occurs, sooner or later, to every individual.

Fig. 118.



Transverse section of a hair. After Todd and Bowman.

Fig. 118 represents a transverse section of a hair, in which the cortex is seen enveloping the fibrous structure, the latter being represented by an infinitude of points, while the centre is occupied by a mass of pigments. The latter has been often mistaken for a central cavity, and thus given rise to the mistaken idea that the hair is tubular.†

The hairs are abundantly reproduced after having been removed by violence; and it seems that nothing more is necessary for this purpose than the integrity of the follicle. In those instances in which the hair has grown again after long-continued baldness, it is supposed that an atrophied condition of the follicles has been superseded by an active condition of that organ, sometimes spontaneous, and sometimes induced by artificial means.

Weber and Dieffenbach ascertained by experiment that hairs torn up from one part of the body would grow again by insertion in another; but whether the follicle was reproduced seems not to have been ascertained. Mandl ascertained another remarkable fact; viz. that hairs that have been cut off become again pointed in the course of a few weeks.‡

The shape of the hair varies in different parts of the body; thus it is cylindrical on the head; but the beard and pubic hairs, those of the axillary region, of the eyebrows, the entrance to the nose and ears, present an oval transverse sec-

* Todd and Bowman. Phys., p. 418. † Ibid., Figs. 87, 88.

‡ Anatomie générale, p. 316.

tion.* The cranial hairs of a Bushman-Hottentot boy who visited this city early in the present year (1848) were invariably of a flattened lenticular form; they were set in the scalp in distinct wiry tufts, and more closely interwoven than any negro hair that has come under my observation.† The texture of the hair varies greatly in different nations. In the Caucasian race it is for the most part long, soft and curling, and of many shades of color; and it retains these characters in that race in defiance of climate or locality. In the Mongolian, Indian and Malay, the hair is almost invariably long, lank and black, equally in the torrid and the frigid zones. In the true negro, on the contrary, the hair has all the appearance of wool, although its ultimate texture, as revealed by the microscope, appears to be the same as in the other races. That climate is not the cause of this condition of the hair, may be inferred from many facts, among which we shall be content to mention three. 1. The Tasmanian negroes of Van Dieman's Land are as woolly-headed as any existing people, and yet, as heretofore observed, they inhabit a cold climate; while the Malays who inhabit under the equator in the same longitudes have remarkably straight hair. 2. The continent of America produces every known temperature; and yet among her multitudinous savage tribes, not one has woolly or even crispy hair. It is always long and straight. 3. If there was any latent power in the intertropical climate of this continent to render the hair long and lank, as in the Indian, we ought by this time to have seen some evidences of it in the negroes, who, with their ancestors and descendants, have inhabited Saint Domingo for three centuries; but, on the contrary, the hair of these people is as intractably woolly as it is among the cognate tribes in the heart of Africa.

"The hairs are entirely insensible, and, excepting in their bulbous portion, are not liable to disease. Dr. Bostock affirms that under certain circumstances they are subject to a species of inflammation, when vessels may be detected, at least in some of them, and they become acutely sensitive. The sensibility of the hair under any known circumstance may, however, be doubted. Bichat and Gaultier were of the opinion of Dr. Bostock; misled, apparently, by erroneous reports concerning the plica polonica; but Baron Larrey has satisfactorily shown that this affection is confined to the bulbs, and that the hairs themselves continue totally devoid of sensibility."‡

THE NAILS.

These are horny plates placed on the dorsal surfaces of the fingers and toes; they are convex, elastic, transparent, and have a root, body and free extremity. The root and lateral portions are lodged in the skin. The free surface is smooth or longitudinally striated; and towards the root is the *lunule*, the segment of a circle, much whiter than the other parts. The root has a thin margin

* Von Behr. Handbook of Anatomy, § 26.

† Prof. C. D. Meigs first pointed out to me this peculiarity in the hair of the Bushman boy; and I have since ascertained that it is common to the affiliated tribes.

‡ Dunglison. Human Physiology, i. p. 96.

which is received into a groove of the true skin, which performs the functions of a follicle. This follicular duplication is about two lines in depth; it contains numerous filiform papillæ which are sunk in the edge of the root and are the source of the growth of the nails, in the same manner that other papillæ serve for the development of the hair. This structure is extremely vascular, and is called the matrix from its being the organ from which the nail is produced. Although, as Mr. Hassell remarks, it is certain that the longitudinal growth of a nail is owing to the development of cells at its root, yet it is also evident that its thickness is increased by the formation of cells on its under surface, which double development is thought to explain why the nail is thinnest at its root, where only a single method of growth prevails. The earliest period of uterine life in which the nails are seen is the third month; at which period they consist of nucleated cells, and rather resemble soft epidermis than the hard and horny texture of fully developed nails.* Even in adult age young cells are always to be discovered at the edge of the root, which become horny in successive layers. When a nail has been entirely eradicated it is rarely replaced by a perfect structure, although it is always regenerated in a greater or less degree.

The epidermis is continuous with the nail wherever the two come in contact; in fact the one is but an altered form of the other; and the nails are but cells which have dried into laminæ, each of which probably indicates a period of growth. The nail is closely adherent by its margin to the epidermis, so that after a certain degree of maceration they separate together from the cutis.

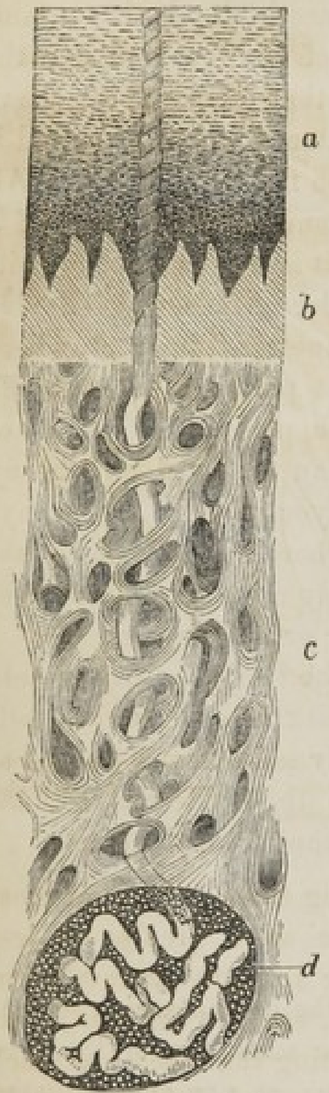
THE SUDORIFEROUS GLANDS.

These are also called the sudoriparous glands, and are the organs which secrete the perspiratory fluid. They are either embraced in the substance of the true skin or they project into the subcutaneous cellular tissue, or are even situated entirely in it, so that the skin is merely perforated by the excretory ducts. Each of these glandules is formed by the convolution of a single tube, which is again constituted of two laminæ; the outer one is derived from the basement membrane and consequently continuous with the external surface of the papillæ, and is in contact with its blood-vessels. The second layer is derived from an involution of the epidermis. The gland thus formed terminates while yet within the skin or the subcutaneous tissue, in a tortuous duct which traverses the several dermoid coverings until it reaches the surface of the epidermis. Here the orifice expands somewhat in a trumpet-like form and opens rather obliquely on the surface, being covered by a process of the epidermis that serves the purpose of a valve. This oblique perforation of the duct arises from its spiral course—which is more obvious in the cuticle than elsewhere, and hence also the valvular orifice.

These glandulæ are so immensely numerous that Dr. Erasmus Wilson estimates their number at 3528 in a square inch of surface on the palm of the hand; and according to the same authority, about 2800 may be regarded as

* Hassell. Microscopic Anatomy, p. 256.—Gerber. General Anatomy, p. 151.

Fig. 119.



The sudoriferous glands.

the average number of pores on each square inch of the body. The sudoriferous glands, as their name imports, secrete the perspiration, which finds its way to the surface through the efferent duct. When this halitus escapes in the state of simple vapor it is called *insensible perspiration;* but when the amount becomes so profuse as to wet the skin, it is termed the sensible perspiration.

Two illustrations, Figs. 119, 120, derived from the admirable work of Todd and Bowman, will serve to convey an idea of the structure and function of several of the dermoid organs.

Fig. 119. Vertical section of the sole of the foot. At *a* is seen the epidermis, more scaly towards the surface, and charged with pigment below; *b* is the papillary body, with its conical terminations projecting into the cuticle; *c* represents the cutis vera, as formed of fibrous tissue into a complex network, and having at its base the convoluted tube which constitutes the sudoriferous gland *d*. It is embedded in globules of fat, and sends out a duct that can be traced in a spiral form through all the dermoid laminæ until it opens on the surface of the cuticle.

But besides the functions resulting from the two forms of organization just mentioned, the skin possesses the power of absorbing both liquids and vapors, although this power is less active in man than in some of the lower animals. That the surface of the human body possesses the faculty of imbibition is proved by numerous facts. Thus not only water, but substances dissolved in it, may be introduced in this way; for the urine is found tinged with madder, rhubarb and turmeric after a person has bathed in water in which they have been dissolved. Garlic applied externally affects the breath when none of it has been inhaled into the lungs; and gallic acid has been detected in the urine after its endermic application. So, also, while the endermic action of some medicines may be attributed to nervous influence, that of others can be referred only to the process of absorption. How else can we explain the endermic medication from aloes, gamboge and digitalis?

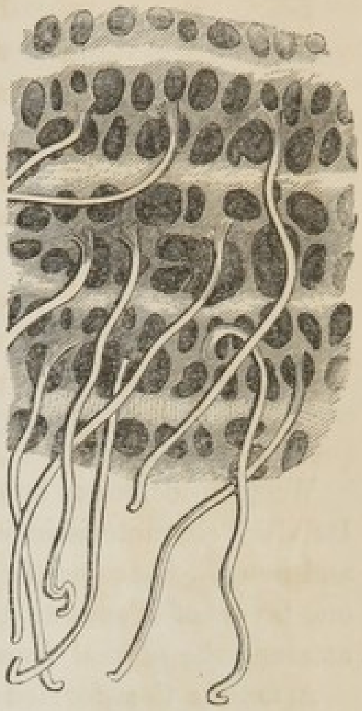
The principal, probably the sole agents of this function on the surface of the body are the lymphatic vessels, which are active in proportion to the tenuity or absence of the cuticle.

The perspiration, as above stated, may be insensible or sensible. The former is a constant exhalation from the healthy skin, and is greater at a high than at a low temperature. The loss by this function, together with that from the mucous membrane of the lungs, has been variously estimated at from two to five pounds *per diem;* of which two-thirds are due to the cutaneous surface.

More profuse or *sensible* perspiration results chiefly from high temperatures, especially when these are combined with humidity; and it is also augmented by depressing emotions of the mind and especially by grief and terror.

The use of this secretion is twofold. In the first place it serves to eliminate certain morbid fluids from the system, as observed in some forms of inflammatory fever; and it also tends, in the normal state, to reduce the heat of the surface and equalize temperature by evaporation. By the presence of the perspiratory secretion the skin is kept soft and pliant, and more readily adapts itself to the various movements of the parts beneath.

Fig. 120.



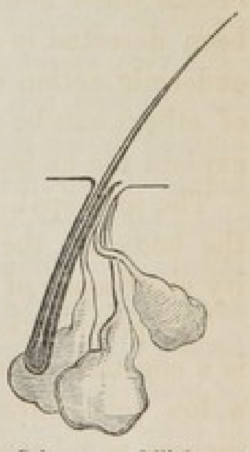
Processes of cuticle which line the sudoriferous ducts. After Todd and Bowman.

Fig. 120 shows the inner surface of the cuticle, as detached by maceration from the palm of the hand. It also shows the double rows of cells in which the papillæ have been lodged, and the processes of the cuticle which line the sudoriferous ducts in their course through the skin.*

SEBACEOUS GLANDS.

These are wholly distinct from the sudoriferous organs, being least abundant where the latter abound, and *vice versâ*. They are absent on the soles and palms, and particularly numerous on the face, scalp, anus, scrotum and axilla: the glandules of the glans penis and the meatus auditorius belong to the same series, and the Meibomian glands are also placed among them. In their most simple form they are mere dilated crypts, which lie at a greater or less depth in the substance of the true skin, each one being lined by an involution of the epidermis. Sometimes they consist only of short, straight follicles, their tubes resembling those of the sudoriferous glands, excepting that they are much less twisted. In other instances they are composed of several distinct sacculi, clustered around the end of a common duct into which they open. Sometimes the duct performs the double office of an excretory canal and a sheath for the hair, and opens either on the general surface and in conjunction with the hair, or into the hair-follicle, according to its greater proximity to the one or the other.†

Fig. 121.



Sebaceous follicles of the nose, with one of the hairs. After Todd and Bowman.

Fig. 121 represents three sebaceous follicles taken from the nose, with an attendant hair. The ducts in this instance open upon the cuticle.

The further and obvious function of the skin when regarded collectively, is to protect the contained organs from exposure or violence. Hence it is less sensitive on surfaces that are most exposed to the action of physical agents, as the palms of the hands and soles of the feet; while, on the other hand, parts that screened from atmospheric changes and other hardening processes retain a much higher sensibility.

* Todd and Bowman. Physiology, vol. i, Figs. 79, 83.

† Wagner. Elements of Physiology, p. 388.

MYOLOGY.

DESCRIPTION OF THE MUSCLES.

What in common language is called flesh, is termed muscle by anatomists. Its vital characteristic is contractility, which enables it to act on other parts and hence to become the organ of locomotion. Its obvious structure is fibrous; one layer of filaments being placed on another until the collective mass has attained the normal dimensions.

A muscle thus formed is composed of distinct fibres of the color of the blood; strong and unyielding during life, but readily torn after they have lost their vitality. Another step in the examination shows that these fibres are disposed in *fasciculi* or bundles, lying parallel to each other in the direction in which the muscle is to act. In some muscles they extend its whole length, which is the usual and most simple arrangement. In other instances they pursue an oblique course from their origin to their insertion; and again, in a few examples, they present a double obliquity by inclining from each side to a common central tendon, where they meet at an angle, the fibres of each side preserving their parallel course: these are called penniform muscles. Muscles are frequently composed of subordinate fasciculi which run in various directions, converging or radiating according to the point to be acted upon; and occasionally the fasciculi decussate each other.

A very slight dissection shows that these fasciculi are reducible into simple fibres which are not round but angular; and if the fibres themselves are examined under the microscope, they prove to be composed of fibrillæ or filaments of extreme tenuity. In other words the fibrillæ are collected into fibres; these by aggregation form fasciculi, which last in greater or less number constitute the obvious mass of every muscle. The muscles have various forms according to the contractile functions they have to act; some are simply fusiform; others are flattened or cylindrical; and some are compound, having two or more bellies. There is a remarkable discrepancy in the length and breadth of these organs; and while many are straight, a few, even of the striated muscles, are orbicular.

Each muscle has its origin and insertion; the former being intended to designate a fixed point from which the contractions are exerted; while the place of insertion is that which is to be moved. It often happens, however, that both

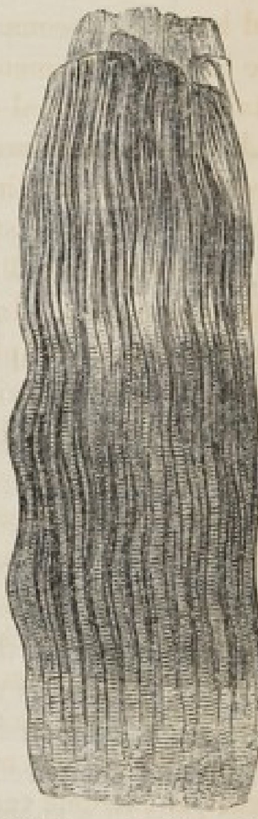
points are movable; whence it follows that the terms in question are convertible according to the part which is to be acted upon. Muscles that are mutually opposed in their actions are called antagonists; such are the flexors and extensors of the trunk and extremities.

The muscles are divided according to their peculiar functions into three great classes—those of animal life, those of organic life, and those that constitute an intermediate link.

MUSCLES OF ANIMAL LIFE.

These organs are strictly under the influence of the will, being contracted or relaxed at pleasure, whence also the name of *voluntary muscles*. Their fibres are of a dark-red color and possess great strength, for their tendons have been known to yield before the muscle itself would give way. The fasciculi of which they are formed seldom cross each other, but are parallel and intimately united; and under the microscope their fibres present a striated appearance, which is characteristic and serves to distinguish them from the muscles of organic life. Their length is usually that of the parent muscle; hence in the sartorius they are about two feet long, while in the stapedius they are less than two lines. These primitive muscular fibres are not round, but angular from being closely packed together; and their diameter in man varies from the $\frac{1}{80}$th to the $\frac{1}{400}$th of an inch.*

Fig. 122.



Striated muscular fibre. From Wagner.

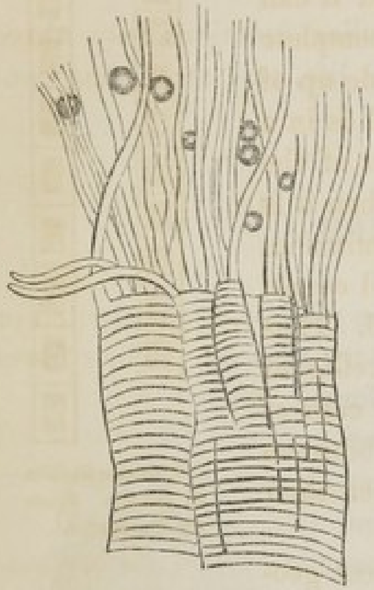
A microscopic examination of these fibres proves that the smallest of them visible to the naked eye, consists itself of a fasciculus of parallel filaments which is marked by both longitudinal and transverse striæ, as seen in Fig. 122, which represents a muscular fibre $\frac{1}{30}$th of a line in diameter, highly magnified. The fibrillæ are distinctly seen below, and the characteristic transverse striæ are everywhere apparent.

A yet closer inspection resolves the fibres into *fibrillæ*, by the former splitting in a longitudinal direction. This is admirably exemplified in Fig. 123, in which a smaller primitive fibre, very highly magnified, is separated at its upper end into its elementary fibrils; the intervening globules being blood-corpuscles, which are about twice the diameter of the former. "It not unfrequently happens, however, that when a fibre is drawn apart, its contents separate in the direction of its transverse striæ forming a series of discs, as shown in Fig. 124. This cleavage is just as

* Wagner. Physiology, p. 648.

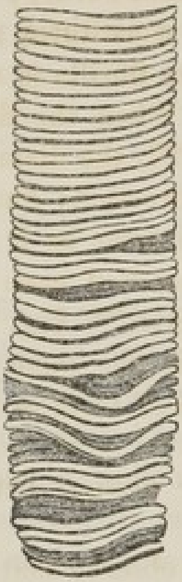
natural as the former, though less frequent; hence it is as proper to say that the fibre is a pile of discs as that it is a bundle of fibrillæ: but in fact it is neither the one nor the other, but a mass in whose structure there is an intimation of the existence of both, and a tendency to cleave in two directions. If there were a general disintegration all along the lines in both directions, there would result a series of particles, which may be termed *primitive particles* or *sarcous elements*, the union of which constitutes the mass of fibre. These elementary particles are arranged and united together in two directions. All the resulting discs, as well as fibrillæ, are equal to one another in size, and contain an equal number of particles. The same particles compose both. To detach an entire fibrillæ is to abstract a particle of every disc; and *vice versâ*."*

Fig. 123.



Elementary muscular fibrillæ. After Dr. Skey.

Fig. 124.



A muscular fibre, showing the separation into discs. From Dr. Skey.

Fig. 125.

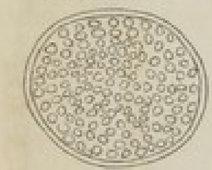


Fig. 125. A disc of the fibre represented in Fig. 124, seen on its face, and showing the elementary fibrillæ of which it is composed.

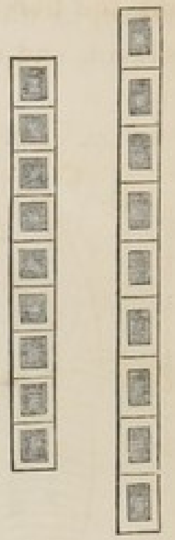
Nevertheless it must be admitted that the separation of fibres into fibrillæ is in accordance with the whole structure of muscle, which displays in its ultimate filaments the same arrangement that characterizes all its previous conditions; and this mode of division takes precedence of the discoidal one, inasmuch as the latter is only consequent to a certain degree of decomposition; whereas the filamentous subdivision is always attainable.

When the primary fibril, or that filament which is incapable of further subdivision, is subjected to the action of a powerful microscope, it is seen to be cylindrical and composed of distinct cells arranged in a linear series. Bauer saw these cells in a spheroidal form, and he compares them to the beads on a necklace. Other microscopists, on the contrary, maintain that the margin of the fibrilla is nearly straight, and that the beaded appearance is an optical illusion. Dr. Carpenter is of this opinion. He remarks that when this muscular element is carefully examined, it is found to present an alternation of light and dark spaces "corresponding with the transverse *striæ* of the fibre and the lighter intervals between them. Moreover, each of the light spaces is seen to be crossed by a delicate but distinct line, separating it into two equal parts; and upon

* Carpenter. Principles of Physiology, § 226.—Todd and Bowman. Physiolog. Anat., p. 152.

attentive examination, a transparent border, equal in breadth to either of these parts, is seen at the *sides*, as well as between the *ends*, of the dark spaces. Thus each dark space is completely surrounded by this pellucid border; and it can scarcely be doubted that the whole constitutes a complete though minute *cell*, and that the entire fibrilla is made up of a linear aggregation of such cells. When the fibril is in a state of relaxation, as seen in Fig. 127, the diameter of the cells is greatest in the longitudinal direction; but when it is contracted, the fibril increases in diameter as it diminishes in length, so that the transverse diameter of each cell equals or even exceeds the longitudinal diameter."* Fig. 126. Thus the act of muscular contraction, adds the same intelligent observer, seems to consist in a change of form in the cells of the ultimate fibrillæ consequent upon an attraction between the walls of their two extremities, or perhaps between their nuclei.

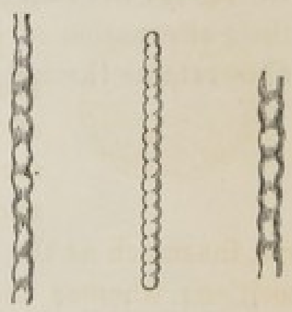
Fig. 126. Fig. 127.



Ultimate fibrillæ of muscle. From Dr. Carpenter.

We may be permitted, however, to observe that these geometrical forms appear to be inconsistent with analogy in other organic structures, and are probably in part due to the refraction of light in the use of very powerful glasses. The observations of Gerber, which present an intermediate arrangement between those of Bauer and Carpenter, may perhaps convey a more correct and definite idea of the real form of the muscular elements, as exhibited in the annexed illustrations. Thus, Fig. 128 represents three primary filaments magnified seven hundred diameters: the one on the left hand is a primary fibre in a state of relaxation; the central figure is a similar fibril in a state of contraction; and the one on the right is another fibril, which appears shortly sinuous, or even twisted like a cord, rather than composed of globules connected together in rows.† The shortening of the fibril, in the second of these examples, corresponds with the observation of Dr. Carpenter, and confirms the general physiological inference drawn by him as above stated.

Fig. 128.



Ultimate or primary muscular filaments. From Gerber.

DEVELOPMENT OF MUSCULAR FIBRE.

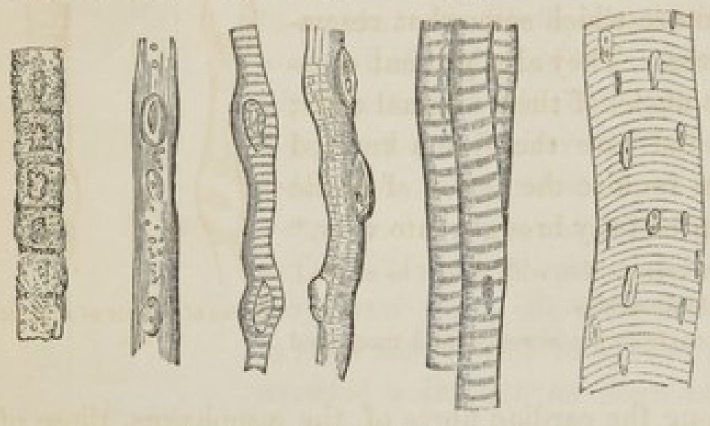
The sarcolemma, or investing sheath of the muscular fibre, appears to be formed before any traces of the fibres themselves are visible. It originates from cells placed in lines and end to end; the proximate parietes of these cells are absorbed or removed, and a simple tube is thus formed for the reception of the muscular fibrillæ.

* Carpenter. Principles of Physiology, § 230.

† Gerber. General Anatomy, p. 35, and Fig. 82, 1, 2, 3.

The first stage of muscular development consists of a finely granular substance, in which are seen nucleoli and cytoblasts arranged in a linear series or column, and united at the points of contact to form the elementary fibre.

Figs. 129. 130. 131. 132. 133. 134.



Primitive fibres of striated muscle.

Fig. 129 represents the first arrangement of primitive cells after Schwann; and Fig. 130 shows a partial union between them, the nuclei being separated and some of them broken up, at the same time that there is some trace of those longitudinal lines that indicate the future fibrils. A further growth develops the transverse striæ, as in Fig. 131, in which also a few of the nuclei remain and swell the fibre; and in Fig. 132, both the transverse and longitudinal lines are distinctly seen. As the muscle approaches its maturity, the nuclei disappear, as in Fig. 133, or can only be brought into view by the use of acids applied to the fibre. This last fact is illustrated in Fig. 134.*

It appears, says Dr. Carpenter, that there is no difference in the early stage of development between the animal and organic muscular fibres. Both are simple tubes containing a granular matter in which no definite arrangement can be traced, and presenting enlargements owing to the presence of the nuclei. But whilst the striated fibre goes on in its development until the fibrillæ, with their alternation of light and dark spaces, are fully produced, the non-striated fibre retains throughout life its original embryonic character.†

MUSCLES OF ORGANIC LIFE.

To this class belong all the involuntary muscles, which, being in connection with the organic or ganglionic system of nerves, perform certain functions wholly independent of the will. They have no tendons; and their fibres are generally of a pale red color and a granular consistence. They are mostly destitute of transverse striæ, and are not definitely separable into fibrillæ or discs. The fibres are arranged, like those of the voluntary muscles, into parallel fasciculi, but these last are generally interwoven into a network without having any fixed points of attachment; being sometimes bent or even crimped and collected into flattened cords. They form, under the mucous membranes, interstices of greater or less size and of a reticulated form, in which are embedded the mucous glands; in other instances they are disposed in layers of straight or of curved fibres, one over the other, so as to decussate at various angles and to anastomose together.

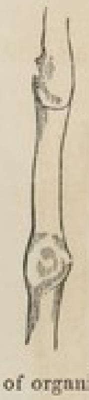
* Todd and Bowman. Physiology, p. 157.

† Principles of Physiology, § 236.

More closely examined, each fibre presents a series of tubes in which the longitudinal striæ are very indistinct, and do not separate into distinct fibrillæ. They are less in size than the fibres of animal life, their diameter being from $\frac{1}{3000}$th to $\frac{1}{2000}$th part of an inch. They sometimes present markings that indicate an internal granular structure which somewhat resembles the striæ of the animal fibres. They also present occasional nodosities, which are the nuclei of their original cells; these have an elongated form and give the fibre a knotted appearance, but they sometimes require the action of acetic acid on the fibre before they can be fully brought into view.*

Fig. 135.

Fig. 136.



Fibres of muscle of organic life.

Fig. 135 represents a muscular fibre of organic life, with two of its nucleoli, from the urinary bladder; magnified 600 diameters.

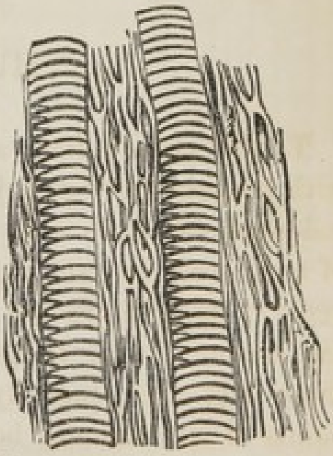
Fig. 136 is another organic fibre, taken from the stomach and magnified as in the preceding example.

To this class of muscles belong the cardiac fibres of the œsophagus, those of the stomach, intestines, the bladder and pregnant uterus. The organic fibres are also found in the trachea and bronchial tubes, ureters, and the hepatic and pancreatic ducts, the vesiculæ seminales, vas deferens, and the middle coat of the veins and lymphatics.

MIXED ANIMAL AND ORGANIC FIBRES.

We have seen that the true voluntary muscle is always marked by transverse striæ; yet some muscles that belong to the organic series are also partially striated. Thus the fibres of the heart, a strictly involuntary muscle, consist of transversely streaked primary fasciculi, yet divide again and again like the prongs of a fork, and combine in the manner of net-like organic muscles in other parts.† So also the esophagus, within an inch of the stomach, has the same mixed character; and such fibres are further seen in the iris, in the muscles of the ear and in the sphincter ani.

Fig. 137.



Blended organic and animal fibres. From Dr. Skey.

Fig. 137. Muscular structure from the lower part of the œsophagus, showing the blending of fibres of animal and organic life. The fibres of animal life are detected by their transverse striæ; the others are interposed between them.

* Carpenter. Principles of Physiology, § 234.

† Gerber. General Anatomy, p. 238.

BLOOD-VESSELS OF MUSCLES.

The arterial and venous branches for the most part accompany each other, and with each artery are associated two veins called *venæ comites*. The arteries, which are derived from the proximate large trunks, bifurcate in the cellular envelopes of the large fasciculi, where they divide and subdivide in order to supply the smaller sheaths until the capillary twigs are finally lost between the laminæ of the sarcolemma that binds the fibrillæ together. It is in this manner that the vessels supply the muscles without penetrating their proper substance; whence the remark of Dr. Carpenter, that its tissue is as extra-vascular as cartilage or dentine; and that the nutriment required for its growth must be conveyed by absorption through the sarcolemma itself.

Fig. 138.

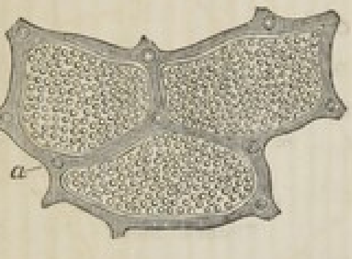
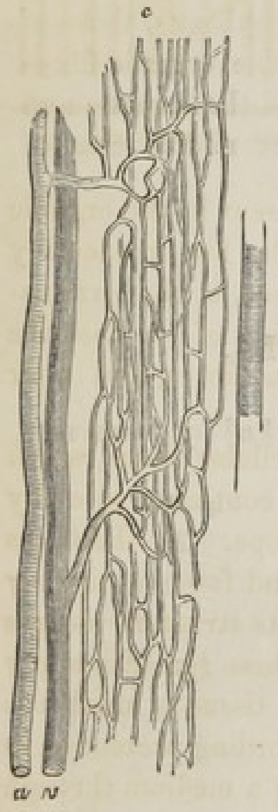


Fig. 139.



Anastomosing capillary vessels of muscular fibre.

These capillary vessels are longitudinal and transverse, thus following the course of the elementary fibres, so that when a fasciculus of these is cut across the vessel is seen to occupy the interstice between three or more fibres, as exemplified in Fig. 138.*

This drawing, from Todd and Bowman, also represents, in a very satisfactory manner, the multitudinous fibrillæ which sometimes enter into the composition of an elementary fibre; and it also shows the proper sarcolemma, and exterior to this again, the thicker sheath of simple cellular tissue.

The anastomosing capillaries are exhibited in the vertical section, Fig. 139; *a*, artery; *v*, vein; *c*, capillaries.

NERVES.

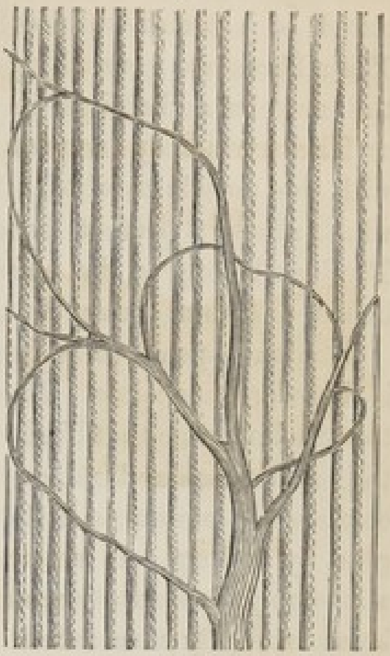
Nerves, chiefly of the motor class, are abundantly distributed to the voluntary muscles; yet so far as observation has extended, they do not appear to enter the proper muscular tissue, but, like the blood-vessels, to lie on the outside of the sarcolemma of the several fibres, whence it follows that their influence must be exerted through this envelope. The larger trunks send off branches which take a curvilinear direction and return to the same trunk or to an adjacent one. In this loop-like course they accompany, to some extent, the minute blood-vessels, but do not accurately follow them in their last windings, since their distribution is in a different figure.†

* Todd and Bowman, p. 153.

† Todd and Bowman. Physiolog. Anat., p. 168.—Carpenter. Physiology, § 240.

The annexed drawing, Fig. 140, illustrates the loop-like termination of the nerves in the voluntary muscles.

Fig. 140.



Loop-like termination of nervous filaments. From Mandl.

The muscles of organic life, on the other hand, are sparingly supplied with nerves, and these are almost exclusively of the sensory class and derived from the sympathetic ganglia.

THE SARCOLEMMA.

The elementary polygonal fibre, as already stated, is composed of *ultimate fibrillæ* which are bound together by a delicate, transparent, structureless sheath called *sarcolemma*, or myolemma. It is entirely distinct from the cellular tissue that forms the envelope of the ordinary muscular fasciculi: it isolates each primitive fasciculus, and we may infer that it also gives off a sheath to each fibril; but the latter supposition is not susceptible of demonstration. The sarcolemma, so distinct in the muscles of animal life, is absent in the organic fibres, or at least cannot be shown to exist in them. It is also but erroneously supposed by some anatomists that the sarcolemma is continuous, at the termination of muscular fibres, with tendon itself; so that in this view of the case the whole muscle is penetrated by minute fasciculi of tendinous fibres, and their aggregation is its proper tendon.

The muscular fasciculi are bound together by areolar or cellular tissue, which also separates them from other muscles; and this tissue is continued to every fibre, which thus derives a sheath from the common envelope. As the fibres approach the extremity of the muscle, they become fewer and fewer until they give place to the areolar tissue, which by a condensation of its structure merges gradually into the medium of attachment called *tendon*. These remarks apply chiefly to the muscles of animal life, in which the cellular tissue is much the most abundant, and in which it performs the triple office of affording protection to the fibres, admitting free motion between them and furnishing a medium through which the blood-vessels and nerves can be distributed to the muscles without being subjected, with the latter, to constant and variable movements. This idea, observes Dr. Bowman, is supported by the fact, that very little areolar tissue is found in the heart and in the other organic muscles in which the contractions are slowly and evenly progressive.*

TENDONS.

These cords belong, as heretofore stated, to the class of *white fibrous tissues*, and serve to connect the muscles with bones or with some other parts. They are divided into simple fascicular or cord-like tendons; and into aponeuroses

* Cyclopædia of Anatomy, No. xxiv. p. 516.

or fasciæ. The simple tendons are rounded or flattened, more or less elongated, of a bluish-white color, opaque, inelastic and possessing great strength. Their fibres are generally parallel to the muscular fibres; being thus straight in the sartorius and oblique in the penniform muscles. Where they pass over bones or hard parts they are protected by synovial sheaths or bursæ; and in common with the muscle to which they belong, they have an envelope of areolar tissue which allows a perfect freedom of motion in relation to the surrounding parts. Tendons belong to the class of passive organs and serve to attach muscles to bones, and thus convey to the latter the contractile power of the former.

Tendon appears to be destitute of any vital property; it has no nerves and is therefore insensible. It receives very few blood-vessels and these enter through the areolar tissue that binds the fibres together. Its circulation is consequently of the extra-vascular kind, or that which is accomplished by simple imbibition. Its composition embraces little else than gelatin, whence it is readily converted into glue by boiling. It resists decomposition in a remarkable manner; and after a prolonged desiccation of many centuries resumes its physical characters on being carefully macerated. This observation has been fully realized by experiment on the tendons of embalmed bodies from the Egyptian catacombs.

APONEUROSES OR FASCIÆ, which will be fully noticed in another section of this work, are merely expansions of flat and broad tendons which support the organs they surround. They are either entirely tendinous, their fasciculi running in the same direction as in the oblique muscles of the abdomen, or their component fibres cross in different directions, as seen in the tendinous portion of the diaphragm.

Over the sheaths of cellular membrane that surround some muscles, are placed other sheaths of a tendinous nature which serve to give points of origin and attachment to the muscles, keep them in their places and support them in their more violent contractions.

AREOLAR AND ADIPOSE TISSUES.

AREOLAR OR CELLULAR TISSUE.

Though not strictly in place, (for it belongs to the fibrous class,) we take this occasion to introduce this all-pervading element, which insinuates itself into the structure of the other tissues, and is, to a certain extent, the bond and envelope of them all.

Areolar tissue is composed of varying proportions of white and yellow elastic fibrous tissues. Under the microscope it presents a most delicate interlacement of fibres of different sizes running in every direction,—straight, branching, waved and tortuous. The white fibrous element is seen in large wavy bands which diverge and reunite, with intermixed smaller fibres. The yellow elastic element, on the other hand, forms long branching filaments, curling upon each other and anastomosing in every direction. Their size is variable; and they

form, with the associated fibres, a network of great intricacy, highly extensible and elastic.

It thus appears that the term *cellular* tissue is not strictly applicable to this structure, for the interstices are of all sizes and forms, and bear no relation to *cells* as we now understand them.

This tissue is found everywhere in the human organization. It is largely furnished to the subcutaneous surface generally, in order to facilitate motion. It is the matrix, as we have seen, for the primitive muscular fibres, and the medium through which the blood-vessels, nerves and absorbents are conveyed to the muscles; at the same time that it furnishes sheaths for the protection and transmission of these several parts. Hence its seeming vascularity; but very few of the capillaries terminate in the cellular tissue itself. A similar remark is applicable to the nerves; for although these abound in this membrane, they seem all to pass through without remaining in it; hence it may be cut or otherwise wounded in a living animal without giving pain, provided the nervous trunks are avoided. Boiling in water converts it into gelatin, and acetic acid causes it to assume the appearance of jelly. It invests all the glands and viscera, sending processes within for enveloping every lobule and acinus; it forms the connecting layer of the mucous and serous membranes, and in like manner sustains and unites all the multiform organs of the body. It is constantly moistened by an albuminous exudation, which in undue quantity constitutes anasarca. This tissue is of variable density in different parts; it is abundantly but loosely collected in the axilla, under the subscapularis muscle, behind the kidneys, &c., but is much more condensed where it connects the mucous and serous membrane to contiguous parts; and from these conditions it undergoes a gradual transition into the true fibrous tissue.

"When examined under the microscope the cellular tissue is seen to be made up of exceedingly fine, transparent, and seemingly homogeneous filaments. These are seldom single, being mostly united into bundles and filamentous laminæ of various sizes, which to the naked eye appear as simple threads and fibres. Though the bundles may intersect in every direction, the filaments of the same bundle run nearly parallel to each other, and no one filament is ever seen to divide into branches, or to unite with another. The associated filaments take an alternate bending or waving course as they proceed along the bundle, but still maintain their mutual parallelism. This wavy aspect, which is very characteristic of these filaments, disappears on stretching the fasciculus, but returns again when it is relaxed."*

The cellular tissue of all parts of the body communicates freely; whence it happens that in anasarca or general dropsy the water gravitates to depending parts, as the feet and legs. It may be in like manner inflated by inserting a tube into any one of its meshes.

A difference of opinion exists in relation to the origin of this and the other forms of fibrous tissue. Some authors insist that it is derived, like the tissues in general, from the metamorphosis of cells; but it may, with more reason, be regarded

* Quain and Sharpey. Anatomy, ii. p. 114.

as a mere coagulation of the formative plasma, which is known to arrange itself into fibres by its own inherent power. This idea is exemplified in the spontaneous coagulation of the fibrin of the blood, and in the exudations that take place upon inflamed surfaces.

ADIPOSE TISSUE.

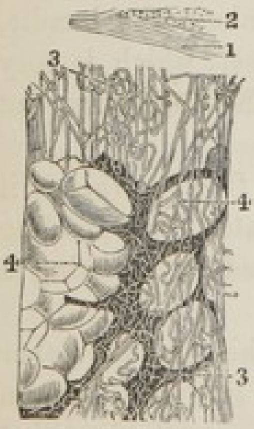
The fat, or adipose matter, is contained in cells, which are either sparsely distributed in the areolar tissue, or collected into masses of considerable size. These fat-cells are generally spheroidal, but sometimes assume very irregular forms when aggregated and pressed together. The interstices between them are occupied by areolar tissue, through which blood-vessels are freely conducted to the proximate cells.

Each of these cells may be regarded as a modified gland, which has the power of secreting and retaining its own fat; for although the latter is always fluid at the ordinary temperatures of the living body, it has no power of transudation; and since the cells do not, like those of areolar tissue, communicate with one another, the gravitation of their contents to depending parts is altogether prevented.

The chemical composition of fat presents three principal component parts, called stearine, margarine and oleine. *Stearine* is the most solid of these and at the same time the most abundant. Its physical characters resemble those of spermaceti, and like the latter it crystallizes after solution in boiling alcohol or ether. *Margarine* is closely allied to stearine, and appears chiefly to differ from it in being more soluble in alcohol and ether. *Oleine* is the fluid part of fat, retaining its consistence at zero of Fahrenheit. All these substances are neutral compounds, formed by the union of stearic, margaric and oleic acids respectively, with a base termed glycerin.*

The *uses* of the adipose matter are various. It serves to fill up the interstices between movable parts wherein other tissues are not necessary, thus preserving to the former their prominent appearance in health: whence a due distribution of fat is an essential element of personal beauty. "It also assists in the retention of the animal temperature by its non-conducting power; and it serves as a reservoir of combustible matter, at the expense of which the respiration may be maintained when other materials are deficient." The latter provision is exemplified in hybernating animals, and in herbivorous animals when food is scanty in winter. It is, moreover, a resource for the human system when the latter is deprived of its customary aliment by disease or accident; under which circumstances the body may be said "to live upon itself;" but the extent to which this provision is available is uncertain, and must of course differ greatly in different individuals.

Fig. 141.



Adipose and areolar tissue. From Mandl.

Fig. 141. Fat-cells lodged in areolar tissue. 1, fasciculus of areolar tissue; 2, the same in a more amorphous state; 3, 3, areolar tissue, isolated and interlaced; 4, 4, fat-cells.

* Carpenter. Elements of Physiology, § 261.

CLASSIFICATION OF THE MUSCLES.

The number of muscles in the human body has been so variously estimated, that on this point no two anatomists entirely agree. What some regard as a single muscle, others describe as several; thus, the triceps adductor femoris is one muscle or three at option. The rectus femoris may be one or four. Meckel describes five scaleni, while most anatomists limit them to two. So multiplied are these examples, that while Chaussier restricts the numerical series to 300, Meckel and others augment them to 527, and few anatomists enumerate less than 400. Cruveilhier has laid down the following rules for the government of this question, and which may be adopted with advantage: 1, when a number of fasciculi unite and form a mass, which is isolated throughout, and performs at the same time a separate and collective function, those fasciculi should be regarded as a single muscle. 2. A muscle should also be considered distinct and separate when it is even in part isolated, provided it is free at the most movable of its attachments.

In the effort to be guided as nearly as possible by this rule, we have described four hundred and seventy-six distinct muscles, of which four hundred and sixty-four are in pairs and twelve single.

The following tabular synopsis, which is modified from one in common use,* will serve to indicate the names and number of each group of muscles.

MUSCLES OF THE HEAD.

1. Cranial region.	Occipito-frontalis.
2. Auricular region.†	Attolens aurem, Attrahens aurem, Retrahens aurem.
3. Tympanic region.	Tensor tympani, Laxator tympani, Stapedius.

MUSCLES OF THE FACE.

1. Palpebral region.	Orbicularis oculi, Corrugator supercilii, Levator palpebræ superioris, Tensor tarsi.
2. Ocular region.	Rectus superior, Rectus inferior, Rectus internus, Rectus externus, Obliquus superior, Obliquus inferior.

* Paxton's Anatomy, i. p. 153.

† The obscure intrinsic muscles of the ear are omitted in this place, but will be noticed in the special description of the ear.

3. Nasal region.	Pyramidalis nasi, Compressor naris, Levator labii superioris alæque nasi, Depressor naris.
4. Superior maxillary region.	Levator anguli oris, Zygomaticus major, Zygomaticus minor, Orbicularis oris.
5. Inferior maxillary region.	Depressor anguli oris, Depressor labii superioris, Levator labii inferioris, Buccinator, Masseter.
6. Temporo-maxillary region.	Temporalis.
7. Pterygo-maxillary region.	Pterygoideus externus, Pterygoideus internus.
8. Lingual region.	Hyo-glossus, Genio-hyo-glossus, Stylo-glossus, Lingualis, Verticales linguæ, Superficialis linguæ.
9. Palatine region.	Circumflexus palati, Levator palati, Azygos uvulæ, Palato-pharyngeus, Constrictor isthmi faucium.

MUSCLES OF THE NECK.

1. Anterior cervical region.	Platysma myoides, Sterno-mastoideus.
2. Superior hyoid region.	Digastricus, Stylo-hyoideus, Mylo-hyoideus, Genio-hyoideus.
3. Inferior hyoid region.	Omo-hyoideus, Sterno-hyoideus, Sterno-thyroideus,
4. Pharyngeal region.	Constrictor pharyngis inferior, Constrictor pharyngis medius, Constrictor pharyngis superior, Stylo-pharyngeus.

5. Laryngeal region.	Thyreo-hyoideus, Crico-thyroideus, Crico-arytenoideus posticus, Crico-arytenoideus lateralis, Thyreo-arytenoideus, Arytenoideus obliquus, Arytenoideus transversus, Thyreo-epiglottideus, Aryteno-epiglottideus.
6. Deep cervical region.	Rectus capitis anticus major, Rectus capitis anticus minor, Longus colli.
7. Lateral cervical region.	Scalenus anticus, Scalenus medius, Scalenus posticus, Rectus capitis lateralis.

MUSCLES OF THE TRUNK.

1. Anterior thoracic region.	Pectoralis major, Pectoralis minor, Subclavius.
2. Lateral thoracic region.	Serratus magnus.
3. Intercostal region.	Intercostales externi, Intercostales interni, Triangularis sterni, Levatores costarum.
4. Diaphragmatic region.	Diaphragma.

MUSCLES OF THE ABDOMEN.

1. Abdominal region.	Obliquus externus, Obliquus internus, Transversalis abdominis, Cremaster, Rectus abdominis, Pyramidalis.
2. Lumbar region.	Psoas magnus, Psoas parvus, Iliacus internus, Quadratus lumborum.
3. Anal region.	Levator ani, Coccygeus, Sphincter ani, Transversus perinei.

4. Urino-genital region.	Erector penis,	Male.
	Accelerator urinæ,	
	Transversus perinei,	
	Erector clitoridis,	Female.
	Sphincter vaginæ,	

MUSCLES OF THE POSTERIOR TRUNK.

1. Lumbo-dorsal region.	Trapezius, Latissimus dorsi.
2. Dorso-cervical region.	Rhomboideus, Levator scapulæ, Cervicalis descendens, Serratus posticus superior, Serratus posticus inferior, Splenius, Complexus, Trachelo-mastoideus.
3. Occipito-cervical region.	Rectus capitis posticus major, Rectus capitis posticus minor, Obliquus capitis superior, Obliquus capitis inferior.
4. Vertebral region.	Longissimus dorsi, Sacro-lumbalis, Spinalis dorsi, Transversalis colli, Semi-spinalis cervicis, Semi-spinalis dorsi, Multifidus spinæ, Interspinales, Intertransversales.

MUSCLES OF THE SUPERIOR EXTREMITIES.

Muscles of the Shoulder.

1. Posterior scapular region.	Supra-spinatus, Infra-spinatus, Teres major, Teres minor.
2. Subscapular region.	Subscapularis.
3. Scapulo-humeral region.	Deltoides.

Muscles of the Arm.

Brachial region.	Coraco-brachialis, Biceps flexor cubiti, Brachialis anticus, Triceps extensor cubiti.

Muscles of the Forearm.

1. Anterior cubital region. *Superficial layer.*	Pronator teres, Flexor carpi radialis, Palmaris longus, Flexor carpi ulnaris, Flexor digitorum sublimis.
2. Anterior cubital region. *Deep-seated layer.*	Flexor digitorum profundus, Flexor longus pollicis, Pronator quadratus.
3. Posterior cubital region. *Superficial layer.*	Supinator longus, Extensor carpi radialis longior, Extensor carpi radialis brevior, Extensor digitorum communis, Extensor minimi digiti, Extensor carpi ulnaris.
4. Posterior deep cubital region. *Deep-seated layer.*	Supinator radii brevis, Extensor ossis metacarpi pollicis, Extensor major pollicis, Extensor minor pollicis, Indicator.

Muscles of the Hand.

1. External palmar region.	Abductor brevis pollicis, Opponens pollicis, Flexor brevis pollicis, Adductor pollicis.
2. Internal palmar region.	Palmaris brevis, Abductor minimi digiti, Flexor proprius minimi digiti, Adductor metacarpi minimi digitii, Lumbricales.
3. Middle palmar region.	Abductor vel prior indicis, Adductor vel posterior indicis, Abductor medii digiti, Adductor medii digiti, Adductor digiti annularis, Abductor digiti annularis, Abductor minimi digiti.

MUSCLES OF THE INFERIOR EXTREMITIES.

Hip and Thigh.

1. Gluteal region.	Gluteus maximus, Gluteus medius, Gluteus minimus.
2. Pelvo-trochanteric region.	Pyriformis, Obturator internus, Obturator externus, Gemellus superior, Gemellus inferior, Quadratus femoris.
3. Anterior femoral region.	Sartorius, Tensor vaginæ femoris, Rectus femoris, Vastus internus, Vastus externus, Cruræus.
4. Internal femoral region.	Pectineus, Gracilis, Adductor longus, Adductor brevis, Adductor magnus.
5. Posterior femoral region.	Biceps flexor cruris, Semitendinosus, Semimembranosus.

Muscles of the Leg.

1. Anterior crural region.	Tibialis anticus, Peroneus tertius, Extensor longus digitorum pedis, Extensor proprius pollicis pedis.
2. Peroneal region.	Peroneus longus, Peroneus brevis.
3. Posterior crural region.	Gastrocnemius externus, Gastrocnemius internus, Plantaris, Popliteus, Flexor longus digitorum pedis, Tibialis posticus, Flexor longus pollicis pedis.

Muscles of the Foot.

1. Dorsal region.	Extensor brevis digitorum pedis, Interossei externi.

2. Plantar region.	Flexor brevis digitorum pedis, Abductor pollicis pedis, Abductor minimi digiti pedis, Flexor accessorius, Flexor digitorum accessorius, Lumbricales pedis, Flexor brevis pollicis pedis, Transversalis pedis, Interossei interni.

MUSCLES OF THE HEAD.

1. CRANIAL REGION.

OCCIPITO-FRONTALIS.

Origin—by two fasciculi of fleshy and tendinous fibres from the superior semicircular ridges of the occiput. These muscular bellies are from an inch to two inches in length; and from their margin a tendinous expansion is given off which adheres firmly to the skin, but moves freely over the cranium. At the upper part of the forehead, and nearly on a line with the anterior margin of the scalp, two fleshy bellies are formed; these cover the frontal bone by descending in straight fibres, which come into contact below.

Insertion—by its fleshy fibres into the corrugator supercilii and orbicularis muscles at their upper margin, and to the root of the nasal bone and the contiguous surface of the os frontis. It is also firmly attached to the skin that covers these parts.

Action—to raise and depress the skin of the forehead, and with it the eyebrows. Fig. 144, 4.

Remarks.—The occipito-frontalis covers the top of the cranium; it is separated from the pericranium only by loose cellular tissue, which enables it to be freely moved under the fingers. It is attached to the skin by a much denser cellular membrane, which gives passage to the nerves and blood-vessels of the scalp.

Besides the name of *epicranius* as a synonym for this muscle, its posterior fasciculi are sometimes called *occipitalis,* and the anterior *frontalis.*

I have in my possession several skulls in which the parietal bones between the sagittal and squamous sutures are deeply impressed, or rather excavated, seemingly by the action of the posterior bellies of this muscle and its tendon. In this way I have known a skull to be reduced from a quarter of an inch in thickness to the thinness of paper, while the internal table has remained unchanged. Examples are recorded in which the occipito-frontalis was muscular from its origin to its insertion.

2. AURICULAR REGION.

SUPERIOR AURIS.—ATTOLENS AUREM.

Origin—by a triangular base from the margin of the aponeurosis of the occipito-frontalis muscle, of which it appears to be an appendage.

Insertion—by converging fibres into the upper part of the concha.

Action—to elevate the ear.

This muscle, which is very thin, lies upon the temporal fascia, and is covered by the skin. Fig. 144, 2.

ANTERIOR AURIS.—ATTRAHENS AUREM.

Origin—from the outer edge of the occipito-frontalis muscle and the adjacent cellular tissue, whence the fibres converge to be *inserted* into the front of the helix. It is immediately beneath the skin.

Action—to draw the ear forwards and upwards. Fig. 144, 1.

POSTERIOR AURIS.—RETRAHENS AUREM.

Origin—by three muscular slips from the base of the mastoid process. They are inserted into the posterior surface of the concha.

Action—to draw the auricle backwards.

The auricular muscles are merely rudimentary in man. They may be regarded as dilators of the external ear. Fig. 144, 3.

3. TYMPANIC REGION.

There are three muscles within the tympanum—the tensor tympani, laxator tympani and stapedius. These will be described with the other appendages of the internal ear.

MUSCLES OF THE FACE.

1. PALPEBRAL REGION.

CORRUGATOR SUPERCILII.—SUPERCILIARIS.

Origin—from the internal angular process of the os frontis, whence the fibres pass obliquely upwards and outwards in a conical form towards the superciliary ridge.

Insertion—into the inner, inferior margin of the occipito-frontalis and the

superior edge of the orbicularis, where these muscles intermix their fibres on the superciliary ridge.

Action—to draw down the eyebrows, as in frowning, and to throw the contiguous skin into vertical wrinkles. Fig. 142, 1.

This muscle is sometimes called *fronto-superciliaris*. Its long action impresses an expression of severity and even of fierceness.

Remarks.—It is connected to the occipito-frontalis, orbicularis oculi, and pyramidalis muscles; it covers the supra-orbitar and frontal arteries, and the frontal branch of the ophthalmic nerve.

Fig. 142.

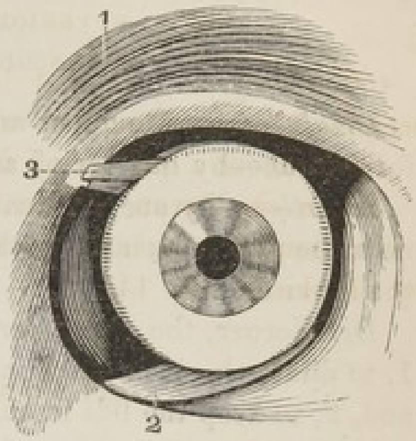


Fig. 142. 1, corrugator supercilii; 2, obliquus inferior; 3, trochlea and tendon of obliquus superior.

ORBICULARIS OCULI.

Origin—from the upper end of the nasal process of the superior maxillary bone, from the internal angular process of the frontal bone, and from the upper margin of the palpebral ligament. From these points the muscle forms into a broad fasciculus of fibres which passes outwards under the skin of the eyelid, and over the superior tarsus cartilage to the external angle of the eye, whence they curve inwards and cover the lower tarsus until they terminate at the inner canthus. This muscle completely surrounds the eye, or rather the orbit, its inferior margin extending downwards over the upper part of the cheek.

Insertion—at the inner canthus of the eye into the margin of the orbitar process of the superior maxillary bone, its contiguous nasal process and into the inferior margin of the palpebral ligament.

Action—to close the eyelids. By pressing back the ball of the eye, it also compresses the lachrymal gland and causes a flow of the tears. Fig. 144, 5.

This muscle is also called the *orbicularis palpebrarum*, *sphincter palpebrarum* and *naso-palpebraris*.

LEVATOR PALPEBRÆ SUPERIORIS.

Origin—from the upper margin of the optic foramen at the bottom of the orbit, and from the sheath of the optic nerve, from whence it passes forwards over the levator oculi muscle, becoming gradually broader to its anterior extremity which lies under the orbicularis oculi.

Insertion—by a broad thin tendon into nearly the whole length of the upper eyelid.

Action—to raise the upper eyelid, and consequently to open the eye. The passive closure of the eye in sleep is due to the relaxation of this muscle; but active occlusion depends on the orbicularis oculi. Fig. 143, 1.

This muscle has a synonym in *orbito-palpebralis.*

Remarks.—It is covered by the orbital periosteum; and it covers the rectus superior of the eye and the conjunctiva.

TENSOR TARSI.—HORNER'S MUSCLE.

Origin—from the upper and posterior part of the os unguis; whence passing forward about a quarter of an inch, it bifurcates.

Insertion—by one bifurcation into the upper lachrymal duct, terminating near the punctum; and by the other bifurcation into the corresponding part of the lower duct.

Dr. Horner, the discoverer of this muscle, considers its action to be twofold: 1, to dilate the lachrymal sac by drawing its orbital parietes from the nasal; and, 2, to keep the lids in contact with the ball of the eye.*

2. OCULAR REGION.

RECTUS SUPERIOR.—LEVATOR OCULI.

Origin—from the upper margin of the optic foramen, from the contiguous sheath of the optic nerve, and from the inner margin of the sphenoidal fissure.

Insertion—by a broad, thin aponeurotic tendon into the ball of the eye about three lines behind the cornea.

Action—to roll the ball of the eye upwards, whence the synonym of *musculus superbus.* It covers the optic nerve and the eyeball. Fig. 143, 4.

RECTUS INFERIOR.—DEPRESSOR OCULI.

Origin—by a tendinous root common to this muscle and the internal and external recti, called the *ligament of Zinn;* from the inferior margin of the optic foramen and also from the sheath of the optic nerve.

Insertion—into the ball of the eye about two lines behind the cornea.

Action—to draw the eye downwards, giving an expression of meekness, whence it is sometimes called *musculus humilis.* Fig. 143, 5.

RECTUS INTERNUS.—ADDUCTOR OCULI.

Origin—from the common tendon and from the sheath of the optic nerve.

Insertion—into the ball of the eye, about two lines from the cornea.

Action—to draw the eye directly inwards towards the nose. It has a synonym in *musculus amatorius.*

* Horner's Special Anatomy and Histology, ii. p. 425.

RECTUS EXTERNUS.—ABDUCTOR OCULI.

Origin—by two heads, one from the common tendon, the other from the margin of the optic foramen: the nasal nerve and the third and sixth nerves pass between its heads.

Insertion—into the outer surface of the ball of the eye, about two lines behind the cornea.

Action—to draw the eye outwards, whence its name of abductor. From its peculiar expression, especially when conjoined with contraction of the brow, it is sometimes called *musculus indignatorius.* Fig. 143, 6.

OBLIQUUS SUPERIOR.—TROCHLEARIS.

Origin—from the margin of the optic foramen and from the optic sheath, whence it passes forwards to the trochlea near the internal angle of the os frontis, through which it sends a rounded tendon; the latter is then reflected upon itself at an acute angle so as to be directed downwards, outwards and backwards, and having got beneath the rectus superior, is *inserted* into the sclerotic coat near the entrance of the optic nerve.

Action—to roll the eye downwards and outwards. It gives a sentimental expression to the eye, and is hence called the *musculus patheticus;* and the trochlear or pathetic nerve is exclusively distributed upon it. The *trochlea* or pulley is a small annular cartilage at the inner superior margin of the orbit: it is attached by ligaments, and the action of the parts is facilitated by a synovial membrane. Fig. 143, 2, 3.

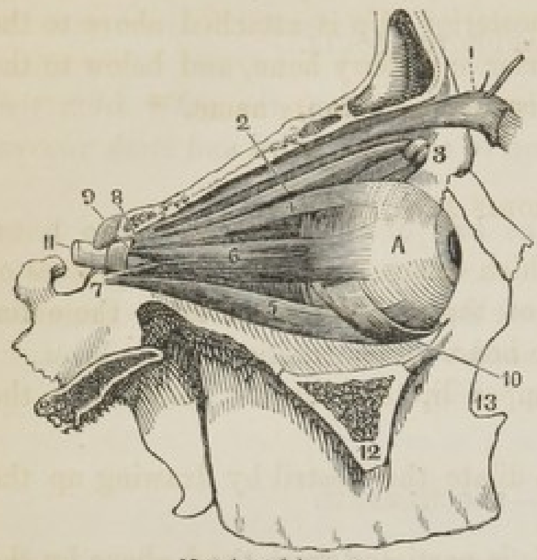
OBLIQUUS INFERIOR.

Origin—from the inner margin of the maxillary bone near the lachrymal groove; and passing beneath the rectus inferior, is *inserted* into the outer and posterior part of the eyeball not far from the entrance of the optic nerve.

Action—to roll the ball of the eye obliquely inwards and downwards. Fig. 142, 2, and Fig. 143, 10.

Remarks.—These muscles, as just described, are inserted in front of the transverse diameter of the eye and are reflected upon the ball, as will be evident on drawing the eye in a direction opposite to that in which the muscles act. If they were not thus reflected, their action would only be to draw the eyeball forcibly backward; but in consequence of the reflection they are capable of rotary motion. Thus, observes Cruveilhier, the superior and inferior recti rotate the eyeball upon its transverse axis, while the internal and external recti rotate it upon its vertical axis. After either of these motions are effected, the eye is drawn backward; and the direct movement backward is produced by the simultaneous action of the four muscles. The action of any two proximate muscles enables the eye, and consequently the pupil, to pass over all the radii of a circle represented by the base of the orbit. The sixth nerve, *abducens*

Fig. 143.



Muscles of the eye.

oculi, is distributed exclusively on the rectus externus; and the third nerve, or motor oculi, supplies the three other recti muscles, the levator palpebræ and the obliquus inferior. No other muscles in the body receive such large nerves in proportion to their size as those of the eye.*

Fig. 143. Muscles of the eyeball. A, ball of the eye; 1, levator palpebræ superioris; 2, obliquus superior, or trochlearis; 3, trochlea of the last named muscle; 4, rectus superior; 5, rectus inferior; 6, rectus externus; 7, ligament of Zinn; 8, origin of the superior oblique muscle; 9, origin of the rectus externus; 10, obliquus inferior; 11, optic nerve; 12, malar bone, divided; 13, upper maxillary bone.

3. NASAL REGION.

PYRAMIDALIS NASI.—FRONTO-NASALIS.

Origin—from the inferior margin of the occipito-frontalis muscle, whence it descends in a thin triangular fasciculus over the nasal bones to be *inserted* into the upper edge of the compressor naris. It is frequently described as an appendage of the occipito-frontalis.

Action—to draw down the integuments of the forehead, and thereby assist the occipito-frontalis; it also elevates the skin of the nose. Fig. 144, 6.

Its anterior surface is connected with the skin; and behind, it has the corrugator supercilii, os frontis and nasal bones.

COMPRESSOR NARIS.—TRANSVERSALIS NASI.

Origin—by a narrow slip from the root of the ala nasi, where it is connected with the levator labii superioris; from this point it radiates so as to cover the dorsum of the nose, and derives some additional fibres from the extremity of the nasal bone.

Insertion—into the corresponding muscle of the opposite side, over the suture that separates the nasal bones.

Action—to compress the nostril by approximating the alæ towards the septum of the nose; but it dilates these parts when it acts in common with the occipito-frontalis muscle, which sends down a slip that is inserted into the upper margin of the compressor naris. The latter also wrinkles the skin of the nose. Fig. 144, 13.

Remarks.—Some obscure fibres on the alæ of the nostril are called the *dilatator naris*. It is formed of two slips, of which the anterior one "extends

* Cruveilhier, Anatomy, p. 650.

between the lateral and alar cartilages at about midway between the lip and the attached margin of the nose. The posterior slip is attached above to the margin of the nasal process of the superior maxillary bone, and below to the small cartilages of the ala nasi. Its use is expressed in its name."*

LEVATOR LABII SUPERIORIS ALÆQUE NASI.

Origin—by two fleshy slips, one of which comes from the nasal process of the upper maxilla at the internal angle of the eye, the other from the outer margin of the orbitar process of the same bone.

Insertion—by the first slip into the upper lip, and by the second into the outer part of the ala nasi.

Action—to raise the upper lip, and to dilate the nostril by drawing up the ala of the nose. Fig. 144, 7.

Remarks.—The levator labii superioris is partially overlapped above by the orbicularis oculi, and it covers the compressor naris and the nasal process of the upper maxilla.

DEPRESSOR LABII SUPERIORIS ALÆQUE NASI.—DEPRESSOR NARIS.

Origin—from the alveolar margin of the incisor and canine teeth, whence it runs upward at the side of the furrow of the lip.

Insertion—into the upper lip and ala nasi.

Action—to draw down the lip and ala nasi. This muscle is also called the *myrtiformis*. It lies upon the maxillary bone and is covered by the orbicularis oris. It is blended with the fibres of the compressor naris.

4. SUPERIOR MAXILLARY REGION.

LEVATOR ANGULI ORIS.—CANINUS.

Origin—by fleshy fibres from the upper maxillary bone beneath the infra-orbitar foramen.

Insertion—into the angle of the mouth, where it joins and partially decussates the antagonist muscle.

Action—to raise the corner of the mouth. Fig. 144, 8.

Remarks.—Above it is covered by the levator labii superioris and the infra-orbitar vessels and nerve. It covers the buccinator muscle and the proximate surface of the superior maxilla.

ZYGOMATICUS MAJOR.

Origin—from the posterior and inferior surface of the malar bone in front of its zygomatic suture, from whence it descends obliquely forwards.

* Wilson's Anatomy, i. p. 192.

Insertion—into the corner of the mouth, where its fibres are blended with those of the orbicularis oris and depressor anguli oris.

Action—to draw the angle of the mouth upwards and outwards, as expressed in smiling or laughing. Fig. 144, 10.

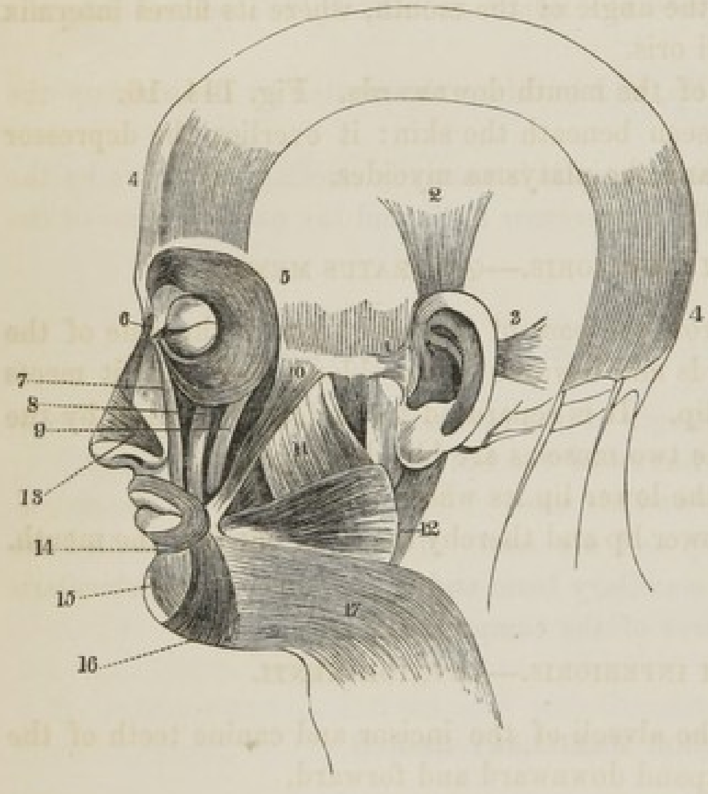
ZYGOMATICUS MINOR.

Origin—from the malar bone, but higher up than the former muscle. It descends obliquely downwards and forwards, being long and slender.

Insertion—into the upper lip above the corner of the mouth, where its fibres mix with those of the levator anguli oris.

Action—to assist the zygomaticus major in raising the corner of the mouth, and drawing it somewhat outward. Fig. 144, 9.

Fig. 144.



Muscles of the face.

Fig. 144. Muscles of the face. 1, Anterior auris; 2, superior auris; 3, posterior auris; 4, occipito-frontalis; 5, orbicularis oculi; 6, pyramidalis nasi; 7, levator labii superioris; 8, levator anguli oris; 9, zygomaticus minor; 10, zygomaticus major; 11, masseter; 12, buccinator; 13, compressor naris; 14, orbicularis oris; 15, depressor labii inferioris; 16, depressor anguli oris; 17, platysma myoides.

ORBICULARIS ORIS.

This muscle, which is also called the *labialis* and *sphincter labiorum*, surrounds the mouth and enters largely into the structure of the lips. It arises from the corners of the mouth and among the fibres of the various muscles which terminate there, so as to form two curved muscles, one in the upper and the other in the lower lip, the fibres of which decussate each other at the angles of the mouth.

Action—to close the mouth, and to enable the lips to embrace any substance placed between them. It also enters largely into the diversified expressions of the countenance, and in no one respect exhibits more varied adaptations than in the performance on wind instruments. Fig. 144, 14.

Remarks.—The orbicularis oris is the sphincter of the mouth, and the essential component structure of the lips. It is covered by the skin and covers the

mucous membrane of the mouth. It receives into its periphery the fibres of the surrounding muscles, which meet here as in a common centre.

5. INFERIOR MAXILLARY REGION.

DEPRESSOR ANGULI ORIS.—TRIANGULARIS.

Origin—broad and fleshy from the base of the lower jaw at the side of the chin, whence its fibres run upward both vertically and obliquely to converge into a narrow fasciculus.

Insertion—by its apex into the angle of the mouth, where its fibres intermix with those of the levator anguli oris.

Action—to draw the corner of the mouth downwards. Fig. 144, 16.

Remarks.—It is distinctly seen beneath the skin: it overlies the depressor labii inferioris, the buccinator and the platysma myoides.

DEPRESSOR LABII INFERIORIS.—QUADRATUS MENTI.

Origin—broad and fleshy from the base of the lower jaw at the side of the chin. It runs obliquely upwards and inwards in an oblong form until it meets its fellow in the middle of the lip. It is separated below from its fellow by the point of the chin, but above the two muscles are blended together.

Insertion—into the side of the lower lip its whole length.

Action—to draw down the lower lip and thereby to aid in opening the mouth. Fig. 144, 15.

LEVATOR LABII INFERIORIS.—LEVATOR MENTI.

Origin—from the roots of the alveoli of the incisor and canine teeth of the lower jaw, whence the fibres expand downward and forward.

Insertion—into the lower lip and contiguous integuments by an angular termination.

Action—to raise the chin and the lower lip, which last it may assist in inverting. It also wrinkles the skin over the chin.

BUCCINATOR.

Origin—from a ridge between the last molar tooth and the coronoid process of the lower jaw, and from the upper maxilla between the last molar tooth and the pterygoid process of the sphenoid bone. From these points its fibres, which are straight, pass forward adhering to the lining membrane of the mouth.

Insertion—into the corner of the mouth, where the fibres intersect each other.

Action—to draw the corner of the mouth backward and to contract the cavity of the mouth. Fig. 144, 12.

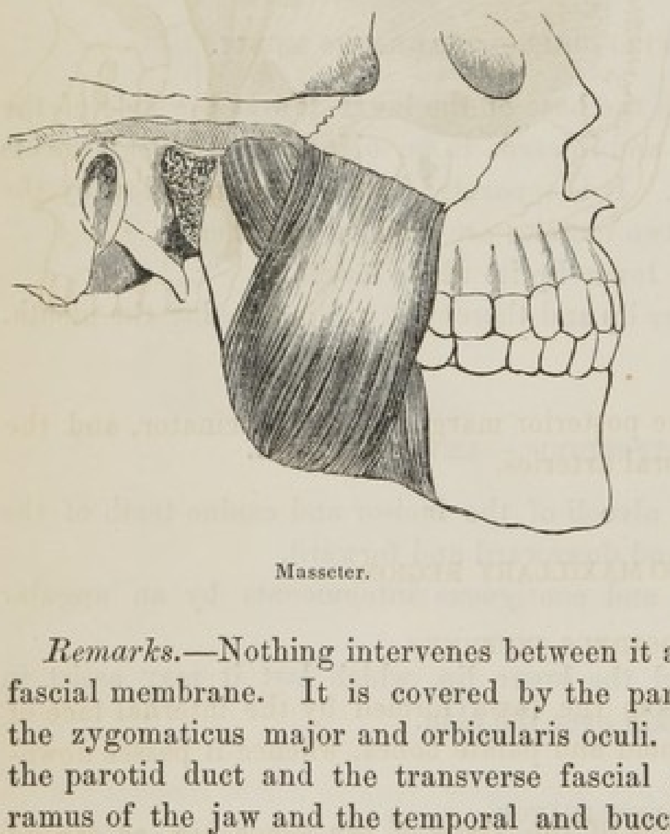
Remarks.—It is covered behind by the ramus of the lower jaw, the masseter

and a small part of the temporal muscle, from which parts it is separated by a mass of fat. Further forward it is covered by the two zygomatic muscles, and at the commissure of the mouth by the levator anguli oris and the depressor anguli oris. The parotid duct runs for some distance parallel with the fibres of the buccinator and then perforates it opposite the second molar tooth of the upper jaw. The facial artery and vein cross the muscle near the commissure. It covers the lining membrane of the mouth, from which it is separated by a thick layer of mucous glands.

MASSETER.

Origin—by a double plane of fibres; one of these, the external layer, arises by an aponeurosis from the tuberosity of the upper maxilla, the lower border of the malar bone and the zygoma. The internal layer arises from the posterior face of the zygoma.

Fig. 145.



Masseter.

Insertion — by its external plane, which runs backward, into the ramus and angle of the lower jaw: by its internal plane, which runs forward, it is inserted into the anterior margin of the coronoid process of the lower jaw. The fibres of the two bellies decussate each other. Fig. 145.

Action—to aid the temporalis in drawing up the lower jaw: when the external layer of fibres acts alone, it protrudes the jaw; while the internal fibres, acting by themselves, draw it backward.

Remarks.—Nothing intervenes between it and the skin excepting a delicate fascial membrane. It is covered by the parotid gland behind, and above by the zygomaticus major and orbicularis oculi. It is crossed at right angles by the parotid duct and the transverse fascial artery. The masseter covers the ramus of the jaw and the temporal and buccinator muscles, from which last it is separated by a mass of fat.

6. TEMPORO-MAXILLARY REGION.

TEMPORALIS.

Origin—fleshy from the side of the cranium marked by the semicircular ridge that extends from the inferior margin of the parietal bone behind to the external angle of the os frontis before; and from the whole cranial surface between this ridge and the zygoma.

The temporal fascia is a dense membrane attached also to the semicircular ridge, from whence it descends to be attached to the whole upper margin of the zygoma. The temporal muscle is attached to, and may be said to arise from, the whole inner surface of this fascia, which binds it firmly to the side of the head. The fibres run, according to the point of origin, forward, vertical and backward. The latter arrangement is seen in the anterior portion of the muscle, which generally forms a distinct fasciculus.

Insertion—by converging tendinous fibres, which pass under the zygoma, into the whole of the coronoid process of the lower jaw almost to the last molar tooth.

Fig. 146.

Temporalis.

Action—to draw the lower jaw directly upward. Fig. 146.

Remarks.—The temporalis muscle lies immediately beneath the skin. It is partially covered by the tendinous expansion of the occipito-frontalis, and by the anterior and superior auricular muscles. The masseter muscle and the zygoma conceal it in front. Beneath it are placed the external pterygoid muscle, the posterior margin of the buccinator, and the internal maxillary and deep temporal arteries.

7. PTERYGO MAXILLARY REGION.

PTERYGOIDEUS INTERNUS.

Origin—tendinous and fleshy from the fossa formed by the internal face of the pterygoid process of the sphenoid and palate bones, whence it passes downward and outward.

Insertion—into the internal face of the angle of the lower jaw, as far as the groove for the inferior maxillary nerve.

Action.—To shut the lower jaw, at the same time that these muscles acting separately have an oblique or lateral motion. Fig. 147, 2.

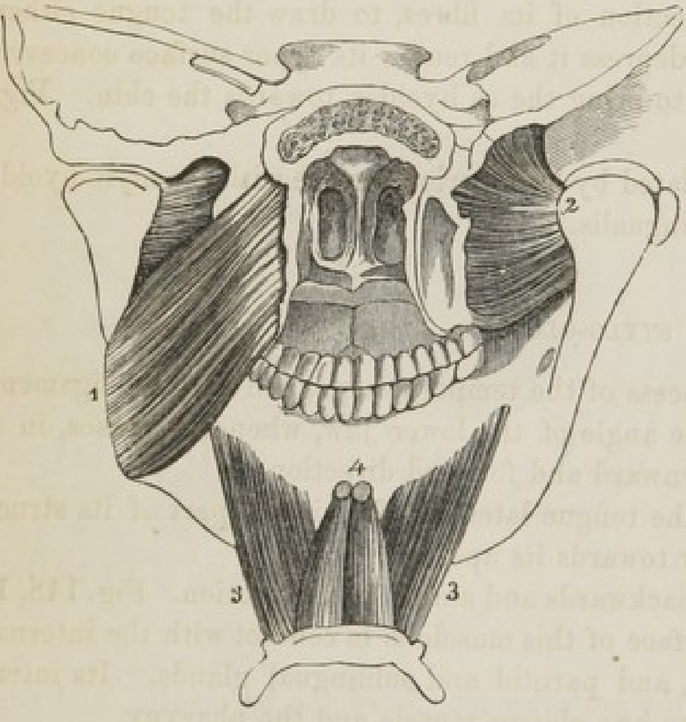
Remarks.—The internal pterygoid is internally in relation with the tensor palati and superior constrictor of the pharynx. On its outside are the ramus of the lower jaw, the external pterygoid muscle, the inferior maxillary nerve and the internal maxillary artery. The internal pterygoid is a thick quadrilateral muscle, and so strongly resembles the masseter that it has been called the internal masseter. Synonym—*pterygoideus magnus.*

PTERYGOIDEUS EXTERNUS.

Origin—from the outside of the pterygoid process of the os sphenoides, and from the spinous and temporal processes of the same bone. The fibres pass thence horizontally outwards and a little backwards.

Insertion—into the neck of the lower jaw and the contiguous capsular ligament.

Fig. 147.



Pterygoid muscles, &c.

Action—to draw the lower jaw forwards and protrude it beyond the upper maxilla; but when the two muscles act alternately, they produce a grinding motion. Fig. 147, 1. Synonym—*pterygoideus parvus*.

Remarks.—The external pterygoid muscle has the ramus of the lower jaw, the temporal muscle and the internal maxillary artery on its outside; on its inside the internal pterygoid; and above, the zygomatic fossa.

Fig. 147. 1, pterygoideus externus; 2, pterygoideus internus; 3, mylo-hyoideus; 4, genio-hyoideus.

8. LINGUAL REGION.

HYO-GLOSSUS.

Origin—from the cornu and half the base of the os hyoides, its fibres running upwards and a little outwards, within the stylo-glossus, as far as the tip of the tongue.

Insertion—into the side of the tongue near the stylo-glossus, some of the fibres extending to the middle of the tongue; others rise vertically at its base, and some are blended with the superficial lingual muscle.

Action—to depress the margin of the tongue and thereby render its dorsum convex. Fig. 148, 5, 6.

Remarks.—The hyo-glossus is connected by its external surface with the digastric, stylo-hyoideus, stylo-glossus and mylo-hyoideus muscles, and with the sublingual gland. It is connected internally with the constrictor pharyngis medius, lingualis and genio-hyo-glossus muscles. The hyo-glossus is

sometimes described as two muscles under the names of *basio-glossus* and *cerato-glossus*.

GENIO-HYO-GLOSSUS.

Origin—from the posterior tubercle of the chin in common with the genio-hyoideus, its fibres spreading out like a fan.

Insertion—into the tongue its whole length, and into the base of the os hyoides.

Action—according to the direction of its fibres, to draw the tongue either forwards or backwards; also to depress it and render its upper surface concave; and when the jaws are closed, to bring the os hyoides towards the chin. Fig. 148, 7.

Remarks.—This muscle is related by its exterior surface with the mylo-hyoid, stylo-glossus, hyo-glossus and lingualis.

STYLO-GLOSSUS.

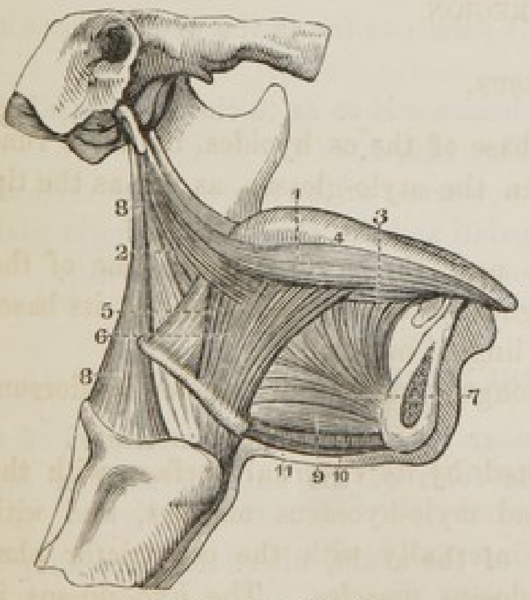
Origin—from the styloid process of the temporal bone, and from the ligament connecting that process with the angle of the lower jaw, whence it passes, in a slender rounded form, in a downward and forward direction.

Insertion—into the root of the tongue laterally, forming a part of its structure and terminating insensibly towards its apex.

Action—to draw the tongue backwards and aid its lateral motion. Fig. 148, 1.

Remarks.—The external surface of this muscle is in contact with the internal pterygoid, the gustatory nerve, and parotid and sublingual glands. Its internal aspect is in relation with the hyo-glossus muscle and the pharynx.

Fig. 148.



Muscles of the tongue.

LINGUALIS.

Origin—from the root of the tongue laterally, whence it passes forwards between the genio-hyo-glossus and hyo-glossus, with both which its fibres intermix.

Insertion—into the apex of the tongue.

Action—to elevate the point of the tongue, contract its substance and curve it backwards. Fig. 148, 3.

Fig. 148. Muscles of the tongue, &c. 1, stylo-glossus; 2, stylo-hyoideus; 3, lingualis; 4, dorsum of the tongue; 5, 6, hyo-glossus; 7, genio-hyo-glossus; 8, stylo-pharyngeus; 9, genio-hyoideus; 10, raphe of the mylo-hyoideus; 11, digastricus.

SUPERFICIALIS LINGUÆ ET VERTICALES LINGUÆ.

These and other elementary or intrinsic muscles of the tongue will be described with that organ.

9. PALATINE REGION.

CIRCUMFLEXUS PALATI.

Origin—from the spinous process of the sphenoid bone, from the Eustachian tube, and from the fossa navicularis of the internal pterygoid process; it runs along the pterygoideus internus over the hook of the internal plate of the pterygoid process, on which its tendon acts as a pulley, and subsequently expands into a broad muscle.

Insertion—into the velum palati and lunated edge of the palate bones as far as their connecting suture.

Action—to stretch or extend the velum palati. Fig. 149, 2.

Remarks.—The vertical portion of this muscle, which is also called the *peristaphylinus externus*, is in relation, by its exterior surface, with the internal pterygoid. On its inside it has the levator palati, from which it is separated by the superior constrictor of the pharynx. A synovial bursa is placed between the tendon of the circumflexus and the inner plate of the pterygoid process on which it plays. Synonym—*tensor palati.*

LEVATOR PALATI.

Origin—from the point of the petrous portion of the temporal bone, and from the proximate Eustachian tube at its cartilaginous portion.

Insertion—broad and fleshy into the soft palate as far as the uvula, where it joins its fellow.

Action—to draw the velum upwards and backwards so as to close the opening of the nostrils in the act of deglutition. Fig. 149, 1.

Remarks.—It is covered by the mucous membrane of the fauces. Its vertical portion is in relation with the circumflexus palati and the pharynx; its horizontal portion with the palato-pharyngeus. Synonym—*peristaphylinus internus.*

CONSTRICTOR ISTHMI FAUCIUM.

Origin—from the side of the tongue, near its root; being constituted of a few fibres that pass upwards between the folds of the anterior arch of the palate.

Insertion—into velum palati at the base of the uvula, where its fibres mingle with those from the opposite side.

Action—to close the opening between the mouth and pharynx, by bringing the tongue and palate together. Synonym—*palato-glossus*.

Fig. 149.

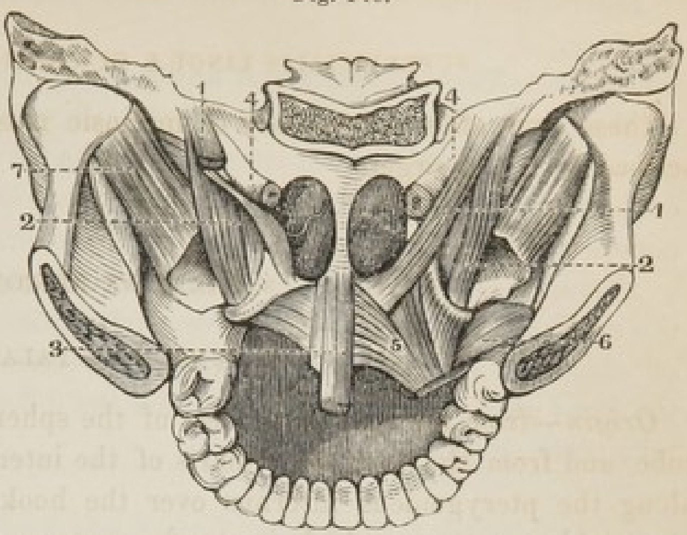


Fig. 149. Muscles of the fauces, &c. 1, levator palati; 2, circumflexus palati; 3, azygos uvulæ; 4, Eustachian tube; 5, palato-pharyngeus, divided; 6, mylo-hyoid attachment of constrictor superior; 7, part of pterygoideus externus.

PALATO-PHARYNGEUS.

Origin—within the duplicature of the posterior arch of the palate and at the root of the uvula, forming a thin fasciculus of fibres that nearly covers the lateral part of the pharynx.

Insertion—into the margin of the upper and back part of the thyroid cartilage, and the space between the middle and lower constrictors of the pharynx.

Action—to depress the palate and force the food into the pharynx. Fig. 149, 5.

AZYGOS UVULÆ.

Origin—from the posterior termination of the suture between the palate bones, or in other words, from the spinous process of the palate, by two very delicate fasciculi which are placed side by side on the median line.

Insertion—into the uvula as far as its apex.

Action—to draw up or contract the uvula. Fig. 149, 3.

The double form of this muscle, which is also called *palato-staphylinus*, explains the occasional bifurcation of the uvula. Synonym—*levator uvulæ*.

MUSCLES OF THE NECK.

1. ANTERIOR CERVICAL REGION.

PLATYSMA MYOIDES.

Origin—by delicate fleshy beginnings from the cellular tissue that covers the pectoralis major and deltoid muscles, below the clavicle. The fibres unite to form a very thin, pale muscular expansion that passes upwards adhering to the skin of the front and side of the neck.

Insertion—into the side of the lower jaw and the adjacent integuments of the face.

Action.—These fibres, which are strongly developed in the inferior animals by the name of the *cutaneous muscle*, are often delicate and even obscure in man, and their action must consequently be very inconsiderable. The platysma evidently assists in depressing the lower jaw and the lower lip; and when the mouth is closed, draws up the skin of the neck. Fig. 144, 17.

Remarks.—These muscles cover the anterior region of the neck excepting the median line, where they leave a triangular interval of dense fibrous tissue of which the apex is above. Cruveilhier remarks that this interval constitutes the *linea alba* of the neck, from which the different layers of the cervical fascia take their origin.*

STERNO-CLEIDO-MASTOIDEUS.

Origin—tendinous and fleshy from the top of the sternum, and fleshy from the sternal end of the clavicle. These two heads are at first entirely separate, but a little above the clavicle they unite to form a strong, straight muscle that runs obliquely upward and outward.

Insertion—by a tendinous extremity into the mastoid process of the occipital bone, which it completely envelopes, and into the contiguous part of the superior ridge of the occiput.

Action—to draw the head downwards when both muscles act, or to one side when only one contracts; their alternate contraction assists in rolling or rotating the head.

Remarks.—The skin and platysma myoides cover this muscle. Its internal surface overlies the sterno-clavicular articulation, the muscles of the infrahyoid region, (the sterno-hyoideus, omo-hyoideus, sterno-thyroideus and thyro-hyoideus.) It also covers the accessory nerve, the pneumogastric, sympathetic, hypoglossal and cervical nerves; together with the internal jugular vein and the lower part of the common carotid artery. The parotid gland lies on the upper margin of the anterior border of this muscle; and its posterior border is the anterior boundary of the lateral triangle of the neck.

2. SUPERIOR HYOID REGION.

DIGASTRICUS.

Origin—fleshy from the groove at the base of the mastoid process and from the anterior margin of that process, whence it runs downwards and forwards and becomes tendinous; this tendon, which is strong and round, perforates the stylo-hyoideus muscles, and is then attached by a ligament to the hyoid bone. From this point a second fleshy belly is formed, which passes upwards and forwards.

* Anatomy, p. 224.

Insertion—into a rough sinuosity at the inside of the base of the lower jaw at its symphysis.

Action—to open the mouth by drawing the lower jaw downwards and backwards; and when the jaws are fixed, to raise the os hyoides and with it the throat, as in swallowing. Fig. 150, 12, 13.

Remarks.—The digastricus lies beneath the platysma and stylo-mastoid muscles, and the parotid and submaxillary glands. It covers the styloid and mylo-hyoid muscles, the internal jugular vein, the internal and external carotid arteries and the hypoglossal nerve. A synovial bursa is placed at the point where this muscle is attached to the os hyoides.

STYLO-HYOIDEUS.

Origin—from the inferior half of the styloid process, and going downwards and forwards is split for the passage of the digastric muscle.

Insertion—into the os hyoides where the base and cornu meet.

Action—to draw the os hyoides upwards and backwards. Fig. 148, 2, and 150, 15.

Remarks.—It is covered by the posterior belly of the digastricus, and its connections are the same as those of the latter muscle. There is sometimes a second stylo-hyoid muscle, which Santorini has called *stylo-hyoideus nanus.*

MYLO-HYOIDEUS.

Origin—broad and thin from the ridge at the inside of the lower jaw between the last molar tooth and the middle of the chin, where it joins its fellow of the opposite side; its fibres pass downwards and forwards behind the digastric muscle and converge to a tendinous median line.

Insertion—into the inferior margin of the os hyoides. Fig. 147, 3.

Action—to draw the os hyoides upwards and forwards, and to protrude the tongue. It suspends the latter organ and forms the floor of the mouth.

Remarks.—It is covered by the platysma myoides and digastric muscles, and by the submaxillary gland. Its internal surface is in connection with the genio-hyoides, the genio-hyo-glossus and the stylo-glossus: it in like manner covers the lingual and hypoglossal nerves and the duct of the submaxillary gland; and its upper surface is overlaid by the mucous membrane of the mouth. It forms the floor of the mouth and assists in suspending the tongue.

GENIO-HYOIDEUS.

Origin—tendinous from the tubercle on the inner surface of the lower jaw near its symphysis; after which, becoming fleshy, it passes downwards and backwards at the inner side of the mylo-hyoideus.

Insertion—into the base and body of the os hyoides.

Action—to draw the os hyoides upwards and forwards. Fig. 147, 4.

The genio-hyoideus has the mylo-hyoid muscle on its exterior surface, and it covers the hyo-glossus.

3. INFERIOR HYOID REGION.

OMO-HYOIDEUS.

Origin—from the upper margin of the scapula near the semilunar notch, whence it passes obliquely upwards and forwards. It is a long and very slender muscle which becomes tendinous where it passes under the sterno-mastoideus; above the latter muscle it again becomes fleshy and is partially covered by the platysma myoides.

Insertion—into the base of the os hyoides near its cornu.

Action—to draw the os hyoides downwards; but if one muscle only contracts, that bone will be drawn to one side. Fig. 150, 8.

Remarks.—The relations of the omo-hyoideus are numerous and varied. We shall notice the more important of them. It is covered at its inferior part by the trapezius muscle; its middle where it is tendinous, crosses the great vessels of the neck and is concealed by the sterno-mastoid muscle; and its upper margin is overlaid by the platysma myoides. It covers the scaleni, the internal jugular vein, the common carotid artery and the brachial plexus of nerves.

STERNO-HYOIDEUS.

Origin—from the inner margin of the upper bone of the sternum, and from the proximate parts of the clavicle and cartilage of the first rib.

Insertion—into the base of the os hyoides.

Action—to draw the os hyoides towards the sternum. Fig. 150, 9.

Remarks.—This is a small, flat fasciculus of muscular fibres, which is covered by the platysma myoides and sterno-mastoid muscles; and it covers the crico-thyroid and thyro-hyoid ligaments.

STERNO-THYROIDEUS.

Origin—from the upper and inner margin of the sternum and from the cartilage of the first rib, whence it runs upwards along the front and side of the trachea and thyroid gland, and behind the sterno-hyoideus.

Insertion—into the inferior edge of the thyroid cartilage.

Action—to draw down the cartilage and consequently the larynx towards the sternum. Fig. 150, 10.

Remarks.—It is covered by the sterno-hyoid, omo-hyoid and sterno-mastoid muscles; and it overlies the trachea and thyroid gland, the lower part of the larynx, the sheath of the carotid artery, and internal jugular vein, together with the subclavian vein and vena innominata. The middle thyroid vein is seen at its inner margin.

THYRO-HYOIDEUS.

Origin—from the side of the thyroid cartilage above the insertion of the sterno-thyroideus, of which it appears to be a prolongation.

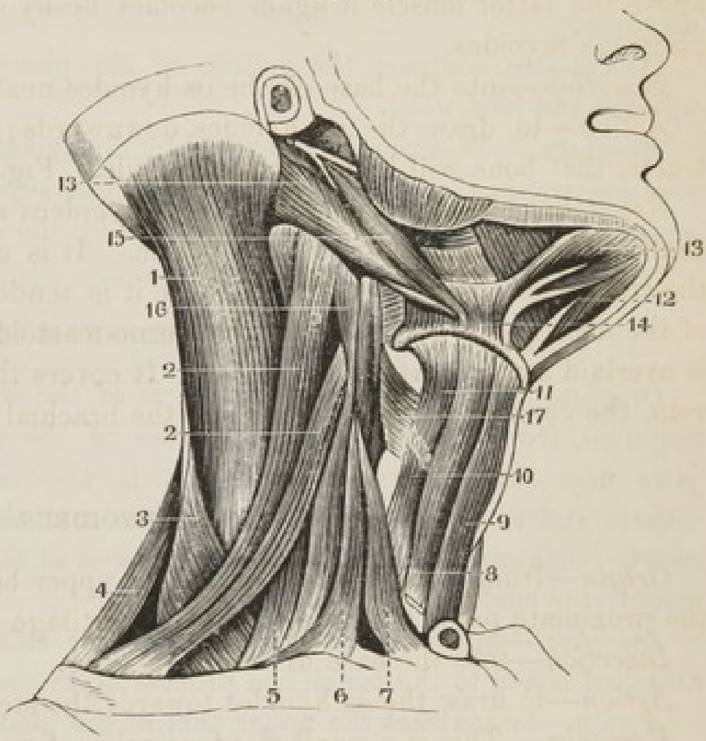
Insertion—into part of the base and most of the cornu of the os hyoides.

Action—to depress the os hyoides, or to raise the thyroid cartilage; in other words to approximate these parts. Fig. 150, 11.

Remarks.—It is partially covered by the sterno-hyoid and omo-hyoid muscles; and its internal surface is connected with the thyroid cartilage, and the thyro-hyoid ligament. The superior laryngeal artery and nerve are also beneath it.

Fig. 150. 1, splenius capitis; 2, levator scapulæ; 3, serratus posticus superior; 4, rhomboideus minor; 5, scalenus posticus; 6, scalenus medius; 7, scalenus anticus; 8, omo-hyoideus, cut off below; 9, sterno-hyoideus; 10, sterno-thyroideus; 11, thyro hyoideus; 12, digastricus of left side; 13, digastricus of right side; 14, tendinous attachment of os hyoides and digastricus; 15, stylo-hyoideus; 16, rectus capitis anticus major; 17, constrictor pharyngeus inferior.

Fig. 150.



Muscles of the neck, &c.

4. PHARYNGEAL REGION.

CONSTRICTOR PHARYNGIS INFERIOR.

Origin—from the sides of the thyroid and cricoid cartilages; the superior fibres running very obliquely upwards, cover the under part of the constrictor medius; the inferior fibres pursue a horizontal course and cover the upper part of the esophagus.

Insertion—into its fellow at the median vertical line at the back of the pharynx, where the muscles from opposite sides intermingle their fibres.

Action—to contract the lower part of the pharynx, and to draw it upwards and backwards.

Remarks.—This muscle is covered externally by the sterno-thyroid; it covers the middle constrictor, stylo-pharyngeus and palato-pharyngeus; and it is lined

by the common mucous membrane of these parts. The recurrent laryngeal nerve runs under the lower edge of this muscle previous to entering the larynx.

CONSTRICTOR PHARYNGIS MEDIUS.

Origin—from the cornu and appendix of the os hyoides, and from the ligament between the upper cornu and the thyroid cartilage; from which points it spreads out and presents two terminal portions.

Insertion—into its fellow at the tendinous vertical line behind, and by its upper end into the cuneiform process of the occiput in advance of the foramen magnum.

Action—to contract the middle of the pharynx and draw the os hyoides upward and backward.

Remarks.—This muscle is covered by the hyo-glossus and partially by the inferior constrictor; and in turn it overlies the superior constrictor, stylo-pharyngeus and palato-pharyngeus. It is lined by the common mucous membrane.

CONSTRICTOR PHARYNGIS SUPERIOR.

Origin—from the cuneiform process of the occiput in front of the foramen magnum, from the pterygoid processes of the sphenoid bone and from both jaws near the last molar tooth; it is also connected with the buccinator muscle and with the root of the tongue and the palate. Its fibres pass in a nearly horizontal direction, and are covered at their lower edge by those of the constrictor medius.

Insertion—into its fellow of the opposite side at the median line, which is attached above to the cuneiform process of the occiput.

Action—to contract the upper part of the pharynx, and thereby to direct the food towards the esophagus.

STYLO-PHARYNGEUS.

Origin—from the root of the styloid process at its inner side, taking a direction downwards and forwards.

Insertion—into the pharynx, along which it expands between the middle and upper constrictors, and into the posterior edge of the thyroid cartilage.

Action—to elevate and open the pharynx, and at the same time to draw up the larynx.

Remarks.—The stylo-pharyngeus, before entering the pharynx, is in contact with the stylo-glossus, the parotid gland and external carotid artery. On its inner surface are the internal carotid and internal jugular vein. When it gets within the pharynx it is covered by the middle constrictor. Its inner surface is connected with the superior constrictor, the palato-pharyngeus and the mucous membrane of the pharynx.

5. LARYNGEAL REGION.

The following are the intrinsic muscles of the larynx, and will be described with that structure.

Crico-thyroideus—Crico-arytenoideus posticus—Crico-arytenoideus lateralis — Thyro-arytenoideus — Arytenoideus obliquus — Thyro-arytenoideus — Arytenoideus transversus—Thyro-epiglottideus—Aryteno-epiglottideus.

6. DEEP CERVICAL REGION.

LONGUS COLLI.

Origin—tendinous and fleshy from the side of the bodies of the three upper dorsal vertebræ, and from the transverse processes of the four lower vertebræ of the neck.

Insertion—into the front of the bodies of all the cervical vertebræ by small tendons which are covered by muscular fibres.

Action—to bend the neck forwards and to one side. Fig. 151, 6, 7.

RECTUS CAPITIS ANTICUS MAJOR.

Origin—fleshy and tendinous from the anterior part of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ; its fibres running upwards and a little inwards so as to cover the outer margin of the longus colli.

Insertion—into the cuneiform process of the occipital bone in front of its condyle.

Action—to bend the neck and depress the head. Fig. 151, 3.

RECTUS CAPITIS ANTICUS MINOR.

Origin—fleshy from the front of the atlas near its transverse process, whence its fibres run obliquely to the outside of the former muscle.

Insertion—into the occipital bone, in front of the condyloid process.

Action—to bend the neck and bow the head. Fig. 151, 4.

7. LATERAL CERVICAL REGION.

SCALENUS ANTICUS.

Origin—tendinous and fleshy from the upper part of the first rib near its cartilage.

Insertion—into the transverse process of the fourth, fifth, and sixth cervical vertebræ by as many tendons. Fig. 150, 7, and Fig. 151, 9.

Remarks.—The scalenus anticus is nearly concealed by the sterno-mastoid,

and crossed by the omo-hyoideus, with which and the clavicle it forms a triangular area in which lie the subclavian artery and the axillary plexus of nerves.

SCALENUS MEDIUS.

Origin—from the upper and outer part of the first rib, from its tubercle to its cartilage.

Insertion—into the transverse processes of all the cervical vertebræ by as many tendons. Fig. 150, 6.

The subclavian artery passes over the first rib between the scalenus anticus and scalenus medius, together with the nerves that form the brachial plexus.

Remarks.—This muscle is separated below from the scalenus anticus by the subclavian artery, and above by the cervical nerves, just after their exit from the intervertebral foramina.

SCALENUS POSTICUS.

Origin—from the upper face of the second rib near its tubercle.

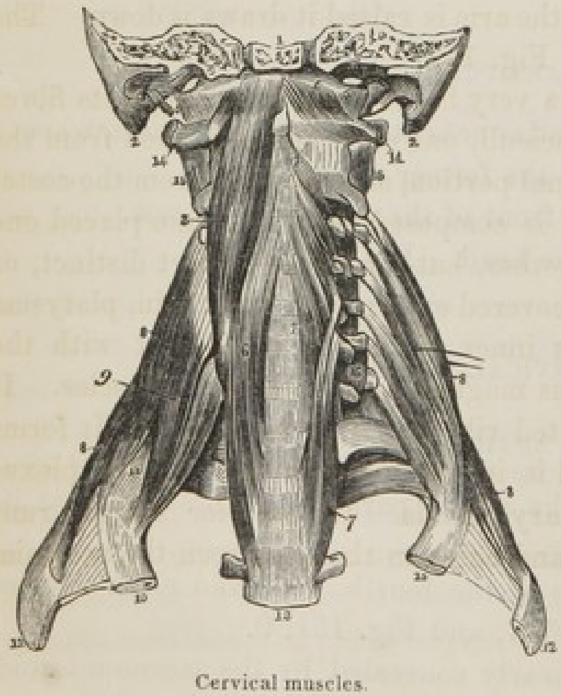
Insertion—into the transverse processes of the fifth and sixth cervical vertebræ.

Action of the scaleni muscles—to bend the neck to one side, or when the neck is fixed, to elevate the ribs. Fig. 150, 5, and Fig. 151, 8.

Some anatomists in describing the three preceding muscles, reverse their origin and insertion.

Remarks.—Chaussier regards the scaleni as constituting but a single muscle; Albinus, on the other hand, described them as five distinct muscles. Anatomists of the present day generally consider them as three muscles.

Fig. 151.



Cervical muscles.

RECTUS CAPITIS LATERALIS.

Origin—fleshy from the transverse process of the atlas in front, whence it passes obliquely outwards.

Insertion—into the occipital bone at the outside of the condyle, and behind the jugular fossa.

Action—to draw the head to one side. Fig. 151, 5.

Fig. 151. 1, basilar process of the occipital bone; 2, mastoid process; 3, rectus capitis anticus major; 4, rectus capitis anticus minor; 5, rectus capitis lateralis; 6, longus colli, right side; 7, same, left side; 8, 8, scalenus posticus; 9, scalenus anticus; 10, first rib; 11, passage of the subclavian artery; 12, second rib; 13, third dorsal vertebra; 14, transverse process of the atlas; 15, first inter-transversalis muscle; 16, sixth inter-transversalis muscle.

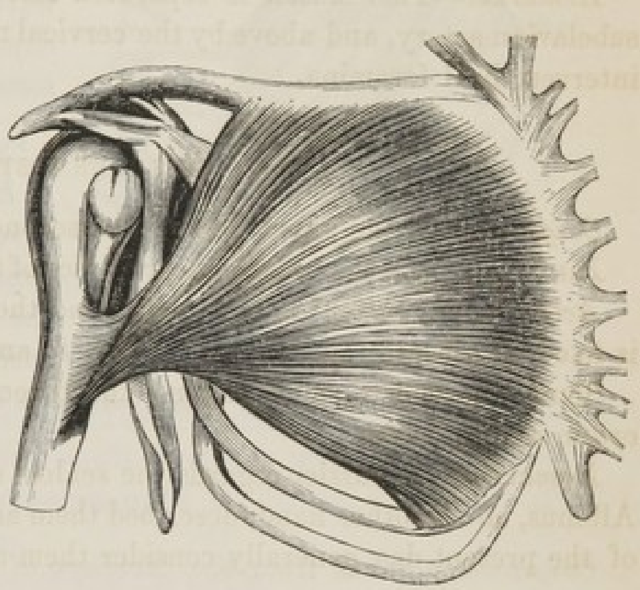
MUSCLES OF THE TRUNK.

1. ANTERIOR THORACIC REGION.

PECTORALIS MAJOR.

Origin—from the sternal half of the clavicle, and from the anterior margin of the two upper bones of the sternum their whole length; fleshy from the cartilages of the fifth and sixth ribs, where it is blended with the fibres of the external oblique muscle. The fibres, having the appearance of a double muscle, converge towards the axilla, where they send off a broad, flat twisted tendon.

Fig. 152.



Pectoralis major.

Insertion—into anterior or outer margin of the bicipital groove of the os humeri, by a flat tendon about an inch and a half in length, which is continuous with the anterior edge of the tendon of the deltoides.

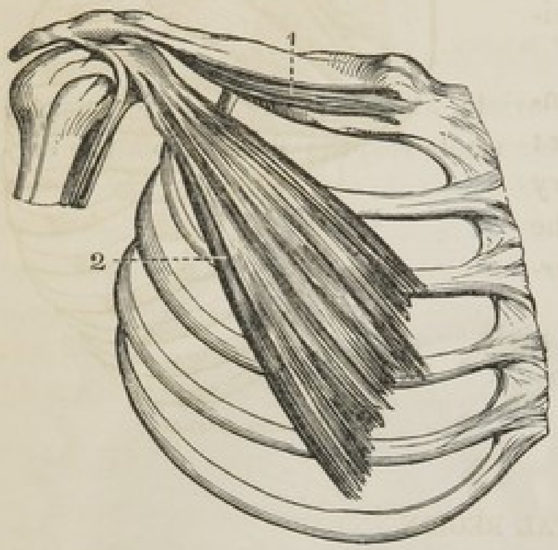
Action—to draw the arm inwards and forwards across the sternum, whence it has been called the adductor of the arm. When the arm is raised it draws it down. The action of both muscles folds the arms. Fig. 152.

Remarks.—The pectoralis major has a very broad base, from which its fibres converge in three distinct triangular fasciculi, one of which is formed from the clavicular portion, a second from the sternal portion, and the third from the costal origin of the muscle. The tendon itself is composed of two laminæ placed one before the other, sometimes blended together, but for the most part distinct, or united only at their lower edges. It is covered externally by the skin, platysma myoides and the mammary gland. Its inner surface is in contact with the pectoralis minor, the subclavius, serratus magnus and intercostal muscles. It also covers the sternum, and the associated ribs and their cartilages. It forms the anterior boundary of the axilla, and is in relation with the brachial plexus and axillary vessels and with the axillary glands. Its exterior margin runs parallel to the front edge of the deltoid, and between them are seen the acromial artery and cephalic vein.

PECTORALIS MINOR.

Origin—tendinous and fleshy in a serrated manner from the third, fourth and fifth ribs near their cartilages, whence its fibres pass obliquely upwards and outwards like a flattened cone.

Fig. 153.



Subclavius and pectoralis minor.

Insertion—by a short, flat tendon into the inner facet of the coracoid process of the scapula. Fig. 153, 2.

Action—to draw the scapula downwards and inwards, and thereby to depress the apex of the shoulder. In some degree it also raises the ribs.

Fig. 153. 1, subclavius; 2, pectoralis minor.

Remarks. — The pectoralis minor covers the proximate ribs, and partially conceals the intercostal muscles and the serratus magnus. Its posterior surface is also in relation with the axillary artery and nerves. This muscle is covered by the pectoralis major.

SUBCLAVIUS.

Origin—tendinous from the cartilage of the first rib, becoming soon fleshy and running outwards under the clavicle.

Insertion—into the under margin of the clavicle almost from its head to the coracoid process of the scapula.

Action—to draw the clavicle downwards. Fig. 153, 1.

Remarks.—The subclavius is covered above by the clavicle, and separated from the first rib by the axillary vessels and brachial plexus of nerves. A synovial bursa is occasionally found between the tendon of the subclavius and the first rib.

2. LATERAL THORACIC REGION.

SERRATUS MAGNUS.

Origin—by fleshy digitations from the nine superior ribs, of which the lower five are interlocked with those of the external oblique. It runs obliquely upwards and backwards upon the side of the thorax, and between it and the subscapularis.

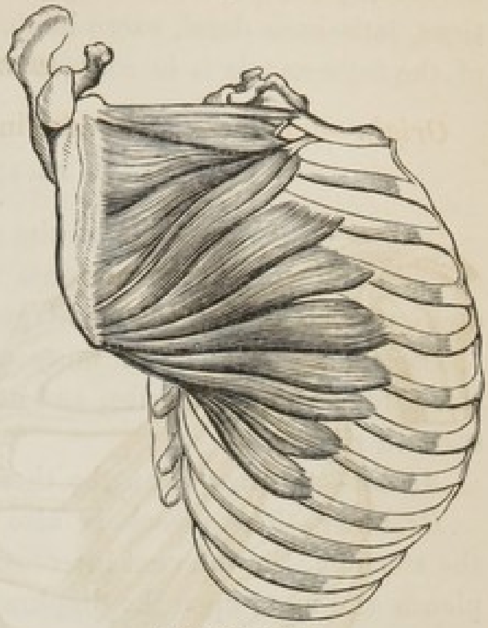
Insertion—fleshy into the whole length of the base of the scapula, and is in a

manner folded round it, between the insertion of the rhomboideus and the origin of the subscapularis.

Action—to draw the scapula forwards and downwards, and to assist in elevating the ribs and thereby dilating the thorax; whence its importance as a muscle of respiration.

Remarks.—This muscle is partly concealed by the pectoralis major and minor: it is in relation above with the axillary vessels and nerves, and behind with the subscapularis. It is also called the *serratus major anticus.*

Fig. 154.



Serratus magnus.

3. INTERCOSTAL REGION.

EXTERNAL INTERCOSTALS.

Origin—from the inferior margin of all the ribs excepting the twelfth, whence they run obliquely downwards and forwards from the spine to the junction of the ribs with their cartilages: from this point to the sternum their place is occupied by ligamentous membrane.

Insertion—into the upper margin of the rib below.

Action—to approximate the ribs; and according as the upper or lower ribs are fixed, they become muscles of inspiration or of expiration. "As the first rib is much more fixed than the last, it follows that it must serve as a fixed point for the first intercostal muscle, which will consequently raise the second rib; this will then become the fixed point for the third rib, and so on."*

INTERNAL INTERCOSTALS.

Origin—from the inferior edge of each rib, beginning at the sternum and extending to the angle of the rib, the fibres running downwards and backwards and completely decussating those of the external intercostals.

Insertion—like the preceding muscle into the upper edge of the rib below, but at its inner side.

Action—same as the former muscle.

Remarks.—The intercostals are separated by thin cellular tissue, which gives passage to the intercostal blood-vessels and nerves. They are more or less

* Cruveilhier, Anatomy, p. 223.

covered by the pectoralis major and minor, the serratus magnus, serratus posticus, latissimus dorsi, sacro-lumbalis and external oblique. The inner surface of the intercostals is in contact with the pleura.

TRIANGULARIS STERNI.

Origin—from the edge of the ensiform cartilage, and from the lower half of the middle bone of the sternum within the thorax, its fibres running upwards and outwards behind the cartilages of the ribs.

Insertion—by three or more angular digitations into the cartilages of the third, fourth and fifth ribs, and occasionally in like manner into the sixth and seventh ribs.

Action—to draw down the thorax and thereby to diminish its cavity.

Remarks—This muscle is also called the *sterno-costalis*. It is covered by the sternum, the internal intercostals and costal cartilages. It is lined by the pleura and rests upon the diaphragm.

LEVATORES COSTALUM.

Origin—from the transverse processes of the eleven upper dorsal and last cervical vertebræ, whence they run, twelve in number, obliquely downward and outward.

Insertion—into the rough surface between tubercle and angle of the rib below. The levatores of the inferior ribs send an accessory fasciculus downwards to be inserted into the second rib below their origin, thus making a double insertion; whence their greater length and their name of *levatores costarum longiores*. The shorter fasciculi are called *levatores costarum breviores*. The whole series is also called *supracostales*.

Fig. 155.

Fig. 155. 1, transverso-spinales, or multifidus spinæ; 2, levatores costarum.

Action—to assist the intercostals in elevating the ribs; and they are by some anatomists regarded as mere appendages of the former muscles.

4. DIAPHRAGMATIC REGION.

DIAPHRAGM.

The diaphragm forms a complete partition between the cavities of the thorax and abdomen. Its texture is both muscular and tendinous. It is remarkably convex above, where it is in contact with the lungs and pericardium; and correspondingly concave below, to accommodate itself to contiguous surfaces at the liver, stomach and spleen. Its upper surface is covered by the pleura, and the lower one by the peritoneum. The diaphragm is usually described as a double muscle in the following manner.

GREATER DIAPHRAGM.

Origin—by fleshy slips from the ensiform cartilage, and from the inner face of the cartilages of the seventh rib and all the false ribs. From these origins the fibres converge to a broad tendinous centre.

Insertion—into the circumference of the whole cordiform tendon.

This tendon is notched next the spine, and presents a pointed termination at the sternum. It is horizontal in the erect posture, and on a line with the lower end of the second bone of the sternum; but a part of the muscle itself reaches as high as the fourth rib. In the back part of this tendon is an irregular circular opening called the *foramen quadratum,* for the passage of the vena cava.

LESSER DIAPHRAGM.

Origin—by four pairs of crura on each side. The long crura come by tendinous slips from the front of the third and fourth lumbar vertebræ, and may be further traced to the first vertebra of this series. The second pair of crura is on the outside of the first, and originates from the ligamentous substance between the second and third vertebræ. The third pair of crura come from the sides of the second lumbar vertebra; and the fourth pair originates from the base of the transverse processes of the second lumbar vertebra. From these tendinous crura muscular bellies arise, and running upwards form two columns, one on each side, thus constituting the lesser muscle of the diaphragm.

Insertion—into the posterior edge of the great cordiform tendon at its notch.

This muscle has two foramina, viz: one behind, between the spine and the notch of the cordiform tendon, and to the left of the median line. This is the *foramen œsophageum,* which gives passage to the esophagus and the pneumogastric nerve. Nearly three inches below, and just in front of the three upper lumbar vertebræ, is another opening called the *hiatus aorticus,* which gives passage to the aorta, thoracic duct and great splanchnic nerve.

Action—The action of the collective parts of the diaphragm, is to enlarge the cavity of the thorax during inspiration by its muscular fibres contracting,

and thus reducing it from a convex to a plane surface, which is aided by a consentaneous yielding of the abdominal muscles. In the act of expiration the diaphragm again ascends in order to fill the vacuum caused by the escape of air from the lungs, at the same time that the abdominal muscles contract. These muscles are regarded as the antagonists of the diaphragm, but they act in concert in alvine dejection and vomiting.

Fig. 156.

The diaphragm.

Fig. 156. The diaphragm. 1, 2, 3, tendinous centre of the greater diaphragm; 5, 6, ligamentum arcuatum; 7, foramen of the lesser splanchnic nerve; 8, right crura; 9, fourth lumbar vertebra; 10, left crura; 11, hiatus aorticus; 12, foramen œsophageum; 13, foramen quadratum, for the passage of the vena cava; 14, psoas muscle; 15, quadratus lumborum; 16, transverse processes of the lumbar vertebræ.

Remarks.—The abdominal aspect of the diaphragm corresponds to the upper convex surface of the liver on the right side, and on the left side is contiguous to the spleen and greater end of the stomach. All this surface is covered by the peritoneum, excepting where the liver is itself in direct connection with the diaphragm. Its posterior and lower portions are in relation with part of the duodenum, the pancreas, kidneys and solar plexus of nerves. The thoracic surface is covered by the pleura and pericardium; it supports the heart, whence it happens that the pulsations of the latter are felt in the epigastric region. The lateral portions are convex, and receive and sustain the concave base of the lungs. The diaphragm is connected at its circumference with the transversalis abdominis, which last has the same costal attachments. Fig. 156.

MUSCLES OF THE ABDOMEN.

1. ABDOMINAL REGION.

The abdominal muscles are arranged in five pairs, viz:—1, the obliquus externus; 2, obliquus internus; 3, transversalis; 4, rectus; 5, pyramidalis.

OBLIQUUS EXTERNUS.

This muscle is so called from its superficial position and from the obliquity of its fibres, which last are broad and quadrilateral.

Origin—by muscular and tendinous digitations from the surfaces of the eight inferior ribs, near their cartilages, being blended above with fibres of the

pectoralis major, in the middle with those of the serratus major anticus, and the inferior one with digitations of the latissimus dorsi, which latter muscle overlaps it behind. The fibres of the external oblique mostly run downwards and inwards; posteriorly they are almost vertical; in the middle oblique, and in front nearly horizontal.

Fig. 157.

Obliquus externus.

Insertion—into the linea alba, where it joins its fellow of the opposite side; into the anterior half of the crista of the ilium; into the anterior superior spinous process of the ilium, and thence into the symphysis pubis and the contiguous body of that bone.

Action—to compress and sustain the abdominal viscera, and to aid in expelling the contents of the bowels and uterus. It also presses the diaphragm upwards, and brings the thorax directly forwards. If, however, the thorax be fixed, it draws the pelvis upwards. Fig. 157.

Remarks.—There are some important structures connected with the abdominal muscles, and especially with the external oblique, which may be briefly noticed in this place, but which will be more fully described under the head of *Aponeurology*.

The tendinous cord which is extended from the anterior superior spinous process of the ilium to the pubis, is called *Poupart's ligament:* as it approaches the os pubis, its fibres diverge so as to leave a triangular opening called the *external abdominal ring*, for the passage of the spermatic cord in the male, and the round ligament in the female. Its base is formed by the crista of the pubis; and its sides or *columns*, by the diverging fibres of the tendon of the external oblique, one band of which bounds it above, and is inserted into the symphysis pubis and into the pubis of the opposite side; while the other band bounds it below, and is attached to the spine of the pubis. From this last insertion the tendon is reflected outwards and backwards, to be inserted for about an inch into that part of the linea ileo-pectinea, called the crista of the pubis. This reflected portion of the tendon of the external oblique is *Gimbernat's ligament*.

The external oblique muscle is covered by the skin and superficial fascia, with more or less intervening fat. Internally it is in contact with the cartilages of the ribs, the internal oblique, rectus and pyramidalis muscles; and behind it is partially covered by the latissimus dorsi. Synonym—*obliquus descendens*.

OBLIQUUS INTERNUS.

Origin—from the posterior face of the sacrum, and from the three inferior lumbar vertebræ by their spinous processes, in common with the latissimus dorsi and serratus posticus inferior; from the entire crista of the ilium and the upper half of Poupart's ligament. The fibres for the most part run obliquely upwards and inwards until they meet the linea semilunaris, where the tendon begins, and adheres firmly to that of the obliquus externus. At this point the tendon separates into two laminæ; the anterior layer with the inferior portion of the posterior one, joins the tendon of the external oblique; and passes over and in front of the rectus muscle to be inserted in the linea alba. The posterior lamina joins the tendon of the transversalis to go behind the rectus; but this arrangement ceases about half way between the umbilicus and pubes, where only a few scattered fibres are to be found behind the rectus; for the principal part of it there passes before that muscle to be inserted in the linea alba. The deficiency of the sheath at this point is marked by a distinct lunated margin, which is arched in the direction of the pubes.

Fig. 158.

Obliquus internus.

Insertion—into the six inferior ribs at their cartilages, in part fleshy and in part tendinous; also into the side of the ensiform cartilage, and into the whole length of the linea alba.

Action—to assist the external oblique in all its directions. Fig. 158.

Remarks.—The fibres of this muscle for the greater part of its extent, run obliquely upwards and inwards; others are horizontal, and some are arched downwards. It is in relation externally to the obliquus externus, and internally to the transversalis. In front it is connected with the rectus and pyramidalis, and behind with the latissimus dorsi. Synonym—*obliquus ascendens.*

TRANSVERSALIS ABDOMINIS.

Origin—from the inner surfaces of the cartilages of the six or seven inferior ribs, where its fibres are blended with those of the diaphragm and intercostal muscles; also from the transverse processes of the last dorsal and four upper lumbar vertebræ; from nearly the whole length of the crista of the ilium at its internal margin, and from the anterior half of Poupart's ligament. The tendon

is united at the crista of the pubis, with that of the internal oblique, and the two together have received the name of the *conjoined tendon*, or aponeurosis, of these muscles.

Insertion—into the side of the cartilago-ensiformis, and into the linea alba its whole length.

Action—to support and compress the bowels.

Remarks.—The transversalis is connected by its external surface with the internal oblique. Internally it is covered by the fascia transversalis, which is interposed between it and the peritoneum.

The following points require to be studied in connection with the abdominal muscles.

Linea alba.—This is a medial or vertical white line, extending from the ensiform cartilage to the pubis, and formed by the junction of the three broad muscles from each side of the body. It has the skin in front, and behind it is in contact with the fascia transversalis, which separates it from the peritoneum. On the two sides it is enclosed between the recti muscles, and is hence broader above than below. About midway of the linea alba, is seen the depression called the umbilicus, now a mere cicatrix, but in the fœtal state an opening for the transmission of the umbilical cord. Fig. 159, 28, 29.

Linea semilunares.—These are two white lines on each side, formed by the tendon of the internal oblique muscle where it divides to enclose the rectus muscle. They are seen at the distance of two or three inches on each side of the linea alba, and extend from the cartilage of the eighth rib to the top of the pubis, forming an outward curve the whole distance. Fig. 159, 3, 4.

RECTUS ABDOMINIS.

Origin—from the anterior surface of the ensiform cartilage and its external ligament, and from the cartilages of the fifth, sixth and seventh ribs by distinct, fleshy digitations. Its fibres pass directly downwards in a flat fasciculus about three inches in breadth, which narrows towards the pubis, where it ends in a flat tendon. The rectus is enclosed in a sheath formed by the tendon of the internal oblique, which has been described with the latter muscle.

Insertion—into the symphysis of the pubis, and into the adjacent body of that bone.

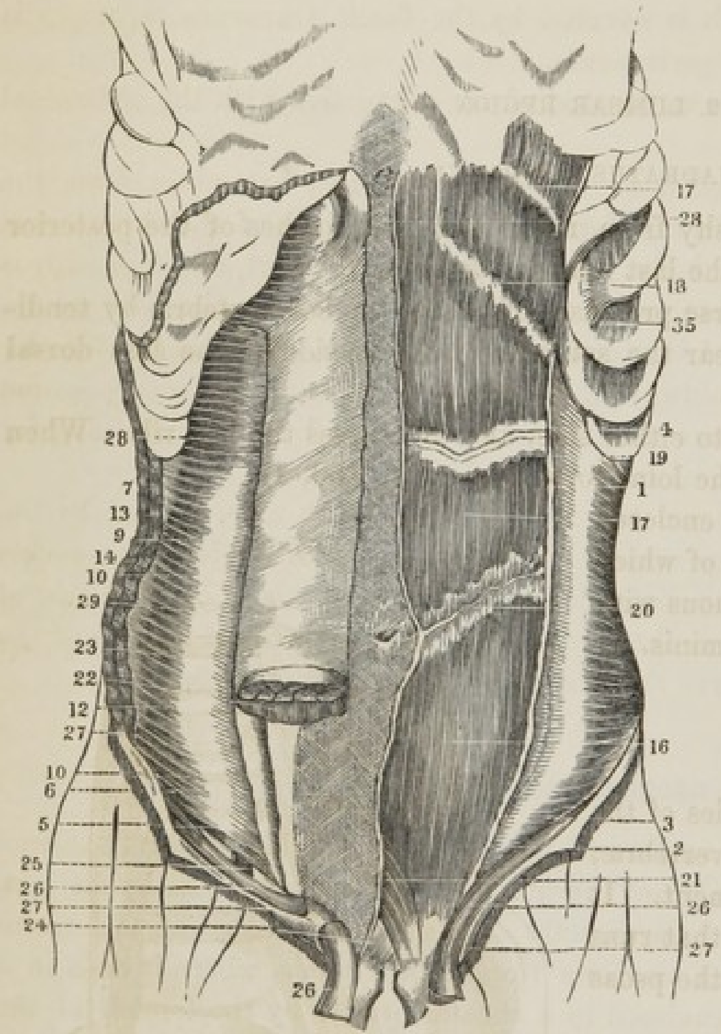
Action—to compress the contents of the abdomen; and to bend the body or to raise the pelvis, according to the points that may be fixed at the time.

Remarks.—The body of the rectus is marked by three or four tendinous intersections which cross it at right angles, and are called *lineæ transversæ*. They connect the muscle at these points to the anterior lamina of their sheath, at the same time that they are but slightly attached to the anterior lamina of their sheath. One of these transverse lines is nearly on a line with the lower margin of the ensiform cartilage; a second is formed half way between the latter and the navel; a third at the umbilicus; and between the umbilicus and the pubis is a fourth which is comparatively imperfectly developed. These lines

run across the abdominal muscles between the lineæ semilunares. Their use is supposed to be to increase the number of muscular fibres, and thereby to augment the force of the muscle. Fig. 159, 17, 18, 19, 20.

The origin and insertion of this muscle are often described reversely to those here given.

Fig. 159.



Abdominal muscles. After Bonamie and Beau.

Fig. 159. The rectus and other muscles of the anterior abdominal region. 1, 2, internal oblique muscle; 3, 4, linea semilunaris at which its aponeurosis separates into two laminæ to form the sheath of the rectus; 5, its superficial lamina, which blends in front of the rectus with 6, the tendon of the external oblique; 7, posterior layer, passing behind the rectus; 8, 9, 10, transversalis abdominis, of which the tendinous expansion, 10, divides into two portions opposite the outer edge of the rectus; the superior of these, 11, unites with the deep layer of the tendon of the internal oblique, and with the latter invests the upper three-fourths of the posterior face of the rectus; but the inferior portion, 12, passes in front of the rectus, uniting with the superficial lamina of the tendon of the internal oblique; 13, internal oblique, cut through; 14, external oblique; 15, 16, rectus abdominis; 17, 18, 19, 20, lineæ transversæ; 21, pyramidalis muscle; 22, the rectus, divided a little below the umbilicus to show the anterior and posterior portions of the sheath; the former existing over whole length of the muscle, being formed in its three superior fourths by the tendons of the internal and external oblique muscles, and in its inferior fourth by the tendons of the two obliques and transversalis. The posterior portion of the sheath is restricted to the three superior fourths of the muscle, and is formed by the internal oblique and transversalis; 23, part of the fascia transversalis; 24, external abdominal ring; 25, internal ring; 26, 26, cremaster; 27, 27, Poupart's ligament; 28, 28, linea alba; 29, umbilicus.

PYRAMIDALIS.

Origin—by a broad base of tendinous and fleshy fibres from the superior margin of the pubis, from its spine to the symphysis, having the rectus behind and the external oblique before. It runs upwards in a tapering form within the sheath of the rectus muscle.

Insertion—into the linea alba and inner edge of the rectus, about half way between the pubis and umbilicus.

Action—to assist the rectus muscle, of which it is a tensor, and to strengthen the lower part of the abdomen.

Remarks.—The pyramidalis is often wanting. Sometimes there are two on one side and one on the other, and occasionally they are of unequal size. It is covered in front by the tendons of the oblique muscles, and is in contact posteriorly with the rectus.

2. LUMBAR REGION.

QUADRATUS LUMBORUM.

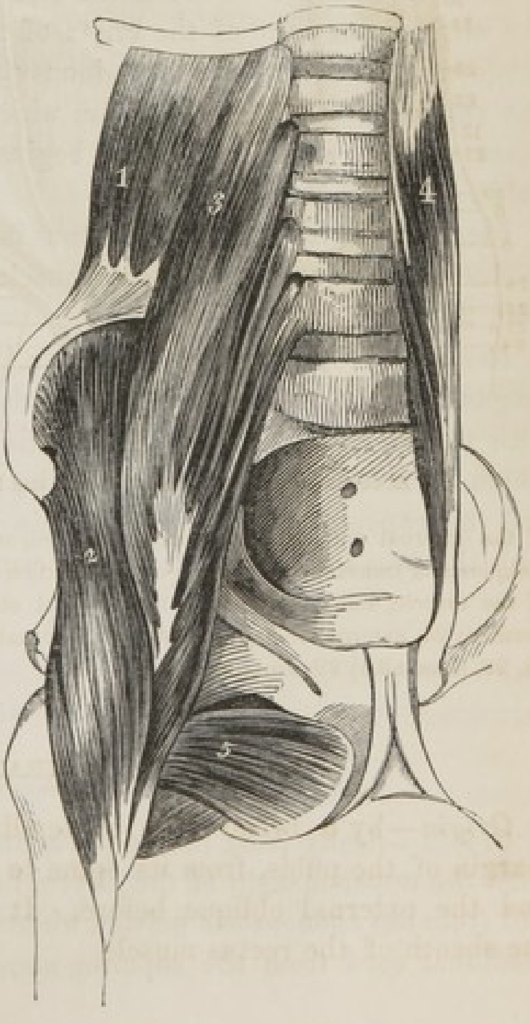
Origin—tendinous and fleshy from more than two inches of the posterior margin of the ilium as far as the last lumbar vertebra.

Insertion—into the transverse processes of all the lumbar vertebræ by tendinous slips; into the last rib near the spine and into the side of the last dorsal vertebra.

Action—to move the loins to either side, and to depress the last rib. When both muscles act, they bend the loins forwards. Fig. 160, 1.

Remarks.—This muscle is enclosed in a strong aponeurotic sheath, of which the posterior part is continuous with that of the transversalis abdominis.

Fig. 160.



PSOAS PARVUS.

Origin—fleshy from the sides of the last dorsal and first lumbar vertebræ, and the intervertebral ligament. It forms a long, slender tendon that runs along the internal margin of the psoas magnus.

Insertion—into the ileo-pectineal line of the pubes, at the junction of that bone with the ileum.

Action—to aid in bending the spine upon the pelvis; but its more obvious use, as suggested by Dr. Horner, is to draw up the femoral vessels in their sheath, and thereby lessen the liability to injury from great or sudden flexion. Fig. 160, 4.

Fig. 160. 1, quadratus lumborum; 2, iliacus internus; 3, psoas magnus; 4, psoas parvus, which has been inadvertently drawn with its insertion cut away; 5, obturator externus.

Remarks.—It lies upon the psoas magnus and is covered by the iliac fascia. This muscle is sometimes deficient.

PSOAS MAGNUS.

Origin—from the side of the bodies and from the transverse processes of the last dorsal and all the lumbar vertebræ, by an equal number of fleshy digitations, which unite in a strong, oblong muscle that bounds the upper part of the side of the pelvis, and passes down over the os pubis behind Poupart's ligament.

Insertion—tendinous and fleshy into the trochanter minor and for an inch below it into the shaft of the os femoris.

Action—to flex the thigh on the pelvis and turn it a little outwards; or, if the thigh is fixed, to bend the body forwards. Fig. 160, 3.

Remarks.—The anterior surface of the psoas magnus is covered by the peritoneum. Above it is in relation with the diaphragm, renal vessels and ureter, and the sympathetic nerve and its ganglia. The femoral artery rests upon it below; and so also the deep-seated vessels of the groin, and the inguinal glands.

ILIACUS INTERNUS.

Origin—fleshy from the transverse process of the last lumbar vertebra, from the whole inner edge of the crista of the ilium, and from the edge of that bone between its anterior superior spinous process and the acetabulum; and also from the entire concavity of the ilium which it consequently occupies. It joins the psoas magnus where the latter begins to become tendinous in front of the os pubis.

Insertion—with the psoas magnus into the trochanter minor.

Action—to assist the psoas muscle in flexing the thigh and pelvis. Fig. 160, 2.

Remarks.—A large synovial bursa is placed between this muscle and the psoas magnus and the capsular ligament of the hip-joint, and it sometimes communicates with the cavity of the joint. The iliacus is covered in front by the iliac fascia, which intervenes between it and the peritoneum. Behind, it has the os ilium and the capsular ligament of the hip-joint. Its internal margin is in relation with the psoas magnus muscle and crural nerve.

3. ANAL REGION.

LEVATOR ANI.

Origin—fleshy from the os pubis near its symphysis and above its arch, and from the upper margin of the thyroid foramen; from the spine of the ischium, and from the aponeurosis pelvica where this membrane is extended as a thickened semilunar cord from the superior margin of the thyroid foramen towards the

spinous process of the ischium.* Its fibres pass downwards in a converging direction to meet those of the opposite side.

Insertion.—Dr. Horner gives the following description of the several points of insertion: "The posterior fibres are inserted into the last two bones of the os coccygis; the middle and by far the greater number, are inserted into the semi-circumference of the rectum between its longitudinal fibres and the circular fibres of the sphincter ani; and finally, the most anterior fibres pass obliquely downwards and backwards on the side of the vesicle end of the membranous part of the urethra, and on the side of the prostate gland."*

Action—to support the contents of the pelvis in a sort of funnel-shaped muscular basin; and to retract the rectum after the evacuation of the feces. Again, by its pressure on the rectum, bladder, vesiculæ seminales and prostate gland, it exerts some influence in emptying those parts. Fig. 161, 5.

Remarks.—This muscle and the coccygeus constitute the floor of the pelvis. They form a semilunar plane from the lower margin of the pyriformis muscle to the pubic arch. Their upper surface is covered by the superior pelvic fascia, which intervenes between it and the peritoneum. Its lower surface is lined by the obturator fascia which separates it from the internal obturator muscle.

COCCYGEUS.

Origin—by a point from the spinous process of the ischium, whence it gradually expands so as to cover the inside of the posterior sacro-ischiatic ligament.

Insertion—into the side of the coccygeal bone its whole length.

Action—to bring the os coccygis forwards, and thereby to aid the levator ani in supporting the end of the rectum Synonym—*ischio-coccygeus.*

Some additional muscular fibres arise from the inferior bone of the sacrum, and are inserted into the fore and under part of the os coccygis. This fasciculus has been called the *curvator coccygis*, or *sacro-coccygeus.* Fig. 161, 6.

Remarks.—The internal or pelvic portion of the coccygeus assists the levator ani in forming the floor of the pelvis. It supports the rectum and is covered externally by the sacro-sciatic ligaments. By some anatomists it is regarded as a part of the levator ani.

SPHINCTER ANI.

Origin—by tendinous fibres from the point of the os coccygis, whence it runs forward on either side so as to surround the anus just within the integuments, constituting a broad, flat elliptical muscle.

Insertion—by a pointed termination into the acceleratores urinæ and transverse perineal muscles before.

Action—to close the anus; also to draw down the bulb of the urethra, and thus aid in the discharge of the urinary and seminal fluids. Fig. 162, 4.

* Horner's Special Anatomy, ii. p. 126.

The *sphincter internus* of some anatomists is nothing more than the band of fibres that surrounds the termination of the rectum, forming part of its muscular coat.

Remarks.—The internal surface of the sphincter ani embraces the lower part of the rectum, the lower circular fibres of which are seen within the sphincter, and are distinguished from it by their paleness. They constitute the *internal sphincter* of some authors. Its internal surface is in relation with the adipose tissue of the pelvis. Its upper margin is blended with the fibres of the levator ani.*

SPHINCTER ANI OF THE FEMALE.

Origin—as in the male.

Insertion—into the sphincter vaginæ and the dense white ligamentous membrane of the perinæum. This interlacing of the fibres of these two muscles is shown in Fig. 161, 9, 10, which point corresponds to the middle of the female perinæum.

Action—to close the anus.

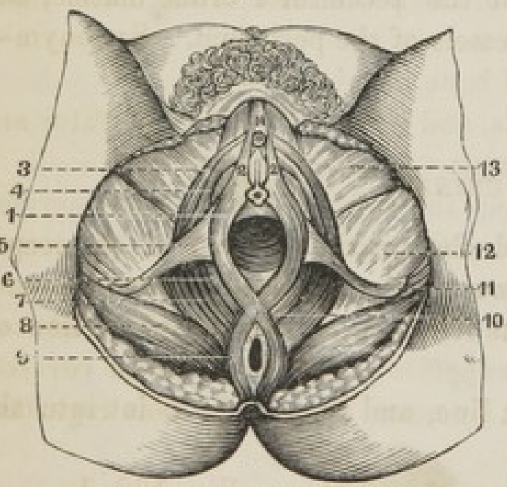
LEVATOR ANI OF THE FEMALE.

Origin—as in the male; but in its descent it embraces the inferior parts of the vagina, urethra and rectum, and its fibres are blended with those of the vagina.

Insertion—into the sphincter vaginæ and muscles of the perinæum, and into the extremity of the rectum and vagina.

Action—the same as in the male subject. It further assists in supporting and contracting the vagina. Fig. 161, 7.

Fig. 161.



Muscles of the female perinæum.

Fig. 161. Muscles of the female perinæum. 1, 2, 6, sphincter vaginæ; 3, 4, erector clitoridis; 5, 11, transversus perinæi; 7, levator ani; 8, gluteus maximus; 9, sphincter ani; 10, junction of the sphincter ani and sphincter vaginæ; 12, adductor tertius; 13, gracilis.

4. URINO-GENITAL REGION IN THE MALE.

THE CREMASTER.

Origin—by two fasciculi, one external, the other internal. The external fasciculus comes from the internal face of Poupart's ligament, as far back as the anterior superior spinous process of the ilium; the internal fasciculus arises from the spine of the pubis. A small slip, also derived from the pubis, runs upwards in an arched direction, and is blended with the external fasciculus.

* Cruveilhier. Anatomy, p. 381.

Insertion—in looped digitations into the tunica vaginalis testis and scrotum; at the lower part of which its fibres become pale, scattered and indistinct, and form what is called the *erythmoidal membrane.*

Action—to draw up the testicle. Fig. 159, 26.

Remarks.—This small muscle has given rise to great diversity of opinion in respect to its real origin and insertion. It is usually described as coming from the internal oblique and transversalis muscles; and according to Cloquet, fasciculi of these muscles, constituting a mere accessory slip, were drawn down by the testicle in its descent from the abdomen to the scrotum.

ERECTOR PENIS.

Origin—tendinous from the inner and anterior margin of the tuberosity of the ischium, from which point becoming fleshy, it runs upwards increasing in breadth until it reaches the crus penis, embracing its inner portion.

Insertion—by an expanded tendon into the membrane of the corpus cavernosum, on the side of which it is gradually lost.

Action—to compress the penis, so that the blood is forced into the anterior part of the corpora cavernosa and retained there; thus aiding and prolonging the erectile condition. Fig. 162, 2.

Remarks.—This muscle is in contact above with the crus and body of the penis; below, it is covered by the skin and superficial fascia. Between its inner margin and the contiguous border of the accelerator urinæ muscle, is a channel for the passage of the superficial vessels of the perineum. Synonym—*ischio-cavernosus.*

ACCELERATOR URINÆ.

Origin—from the crus of the penis and the proximate part of the corpus cavernosum, and from the inside of the ramus of the pubis. It forms a broad, thin, fleshy muscle that descends to meet its fellow in an anterior white line on the bulb of the urethra.

Insertion—into the above named median line, and by a fleshy point into the anterior margin of the sphincter ani.

Action—to propel the urine and semen into the urethra. Fig. 162, 1.

Remarks.—These muscles form a thin lamina of which the contiguous fibres are mixed along the median line, immediately beneath the bulb of the urethra. "By putting the two acceleratores on the sketch," observes Dr. Horner, "it will be seen that besides the origins mentioned, they arise also from each other by a tendinous membrane that is interposed between the corpus spongiosum and cavernosum; so that they literally surround the back part of the urethra, constituting a complete sphincter muscle for it."* These two muscles are often described as one. Synonym—*bulbo-cavernosus.*

* Special Anatomy and Histology, ii. p. 124.

TRANSVERSUS PERINÆI.

Origin—from the inner margin of the tuberosity of the ischium near the erector penis, its fibres passing across the perineum. It presents three fasciculi, of which the first is blended with the sphincter ani; the second with the accelerator urinæ, and the third covers the furrow on the inside of the erector penis.

Insertion—into the sphincter ani and accelerator urinæ where they join.

Action—to dilate the bulb of the urethra and retain it in its position.

There are often some accessory fibres to this muscle which run at its anterior margin, and more obliquely upwards, but have the same attachments and action. Fig. 162, 3. Synonym—*ischio-perinæalis.*

Remarks.—A second muscle of this kind sometimes exists on each side of the perineum, but in front of the proper transversus perinei. It is for the most part an obscure fasciculus of pale fibres, and is called *transversus perinei alter.*

IN THE FEMALE.

ERECTOR CLITORIDIS.

Origin—same as in the erector penis of the male, but the muscle is much smaller.

Insertion—into the body and crus of the clitoris.

Action—to erect the clitoris. Fig. 161, 3, 4.

This muscle is in fact double on each side, whence the French anatomists have given the two fasciculi the names of ischio-clitorideus and ischio-cavernosus, the former, 3, being on the outside, the latter, 4, on the inside.

SPHINCTER VAGINÆ.

Origin—from the anterior margin of the sphincter ani and from the dense cellular tissue that connects the latter muscle to the transversus perinæi. It forms a layer of fibres more than an inch in width that passes along the outer end of the vagina, surrounds its orifice, and covers the corpus cavernosum vaginæ.

Insertion—into the body of the clitoris where its crura unite.

Action—to compress the corpus cavernosum (plexus retiformis) and thereby to contract the external orifice of the vagina. It is also called the *compressor vaginæ.* Fig. 161, 1, 2, 6.

TRANSVERSUS PERINEI.

Origin—same as in the male.

Insertion—into the sphincter ani, and the contiguous parts of the sphincter vaginæ.

Action—upon the perinæum and anus as in the male. Fig. 161, 5, 11.

Fig. 162.

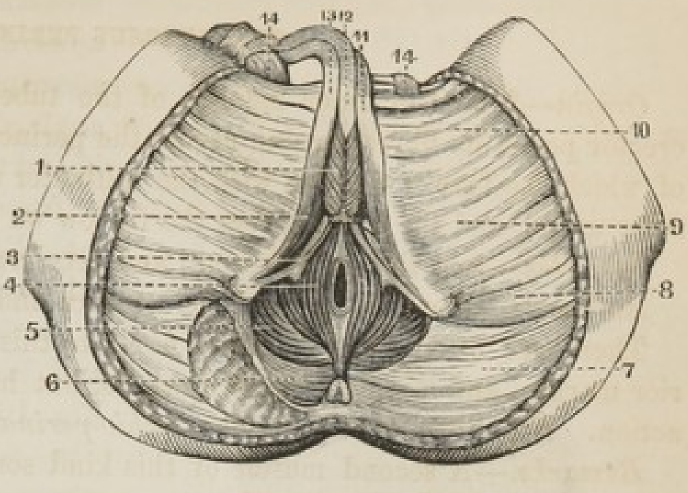


Fig. 162. Perineal muscles of the male. 1, accelerator urinæ; 2, erector penis; 3, transversus perinæi; 4, sphincter ani; 5, levator ani; 6, coccygæus; 7, glutæus maximus; 8, adductor tertius; 9, gracilis; 10, adductor primus; 11, 13, corpora cavernosa; 12, urethra; 14, 14, spermatic cords.

Muscles of the male perinæum.

MUSCLES OF THE POSTERIOR PART OF THE TRUNK.

1. LUMBO-DORSAL REGION.

TRAPEZIUS.

Origin—tendinous from the occipital protuberance, and from an inch of the superior semicircular ridge; from the five superior spinous processes of the neck by means of the ligamentum nuchæ; and from the spinous processes of the two lower cervical vertebræ and all those of the back. Through the whole of its origin it adheres to its fellow by tendinous membrane, and below partially overlaps the latissimus dorsi.

Insertion—fleshy into the external half or third of the clavicle, tendinous and fleshy into the acromion process, and the spine of the scapula its whole length.

Action.—The descending portion elevates the clavicle and the apex of the shoulder; but if the shoulder be fixed, this portion of the muscle draws the head to one side. The middle portion draws the scapula backwards: the lower part draws that bone downwards. Fig. 163, 2.

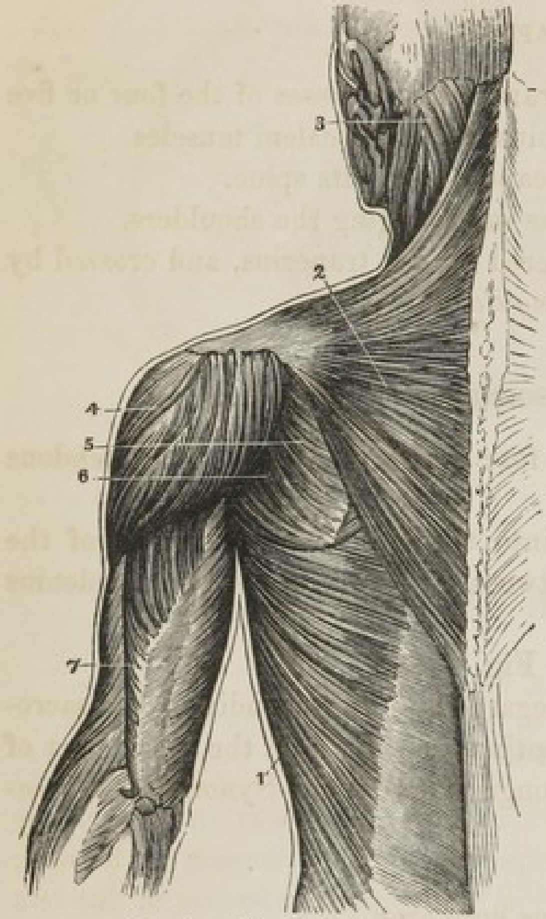
Remarks.—The trapezius is beneath the skin. It covers the complexus splenius, rhomboideus and levator scapulæ, in the neck; and the serratus posticus superior, supra-spinatus, the latissimus dorsi and the posterior spinal muscles, in the back.

LATISSIMUS DORSI.

Origin—by a tendinous expansion from the seven inferior spinous processes of the back, and by a strong aponeurotic membrane from the spinous processes of the lumbar and sacral vertebræ; also from the outer margin of the sacrum, from the posterior part of the spine of the ilium, and by four fleshy slips from

the four inferior ribs. The tendons by degrees terminate in a muscle of great breadth, of which the lower fibres run upwards and outwards, while those above pass transversely over the inferior angle of the scapula, deriving a slip from it, and then converge towards the axilla.

Fig. 163.



Muscles of the back, arm, &c.

Insertion—by a strong, flat tendon into the posterior margin of the bicipital groove of the humerus.

Action—to draw the arm downwards and backwards, and to roll it inwards. Fig. 163, 1.

Fig. 163. 1, latissimus dorsi; 2, trapezius; 3, splenius capitis; 4, deltoides; 5, infraspinatus; 6, teres minor; 7, triceps; 8, teres major.

Remarks.—This muscle is directly beneath the skin except at its upper part, where it is overlapped by the trapezius. It overlies the serratus posticus inferior, the intercostals, the serratus magnus, the rhomboideus and the teres major. It crosses the lower angle of the scapula. Its outer margin is in relation with the external oblique; and its upper tendinous portion is associated with the teres major in forming the posterior boundary of the axilla.

2. DORSO-CERVICAL REGION.

RHOMBOIDEUS MAJOR.

Origin—by a thin tendon from the spinous processes of the last cervical and four superior dorsal vertebræ.

Insertion—into the entire base of the scapula below its spine.

Action—to draw the scapula upwards and backwards.

RHOMBOIDEUS MINOR.

Origin—tendinous from the spinous processes of the three lower cervical vertebræ, its fibres passing obliquely downwards.

Insertion—into the base of the scapula where the rhomboideus major terminates, and opposite the spine.

Action—to assist the former muscle in drawing the scapula upwards and backwards.

Remarks.—These muscles are often described as one. They are overlaid by

the trapezius; and they cover the serratus posticus superior, part of the intercostals and the ribs. Behind they are in contact with the spinal muscles.

LEVATOR SCAPULÆ.

Origin—by distinct tendons from the transverse processes of the four or five upper cervical vertebræ, between the splenius colli and scaleni muscles.

Insertion—fleshy into the base of the scapula above its spine.

Action—to draw the scapula upwards, as in shrugging the shoulders.

Remarks.—The levator scapulæ is covered by the trapezius, and crossed by the sterno-mastoid muscle. Synonym—*angularis scapulæ.*

CERVICALIS DESCENDENS.

Origin—from the upper margin of the four superior ribs, the long tendons terminating in a small muscle.

Insertion—by three distinct tendons into the transverse processes of the fourth, fifth and sixth cervical vertebræ, between the levator scapulæ and splenius colli.

Action—to draw the neck backwards. Fig. 168, 1.

Remarks.—This muscle is sometimes regarded as an appendix of the sacro-lumbalis, with which it appears to be continuous. It is on the upper part of the thorax, between that muscle and the longissimus dorsi.—Synonym—*descendens cervicis.*

SERRATUS POSTICUS SUPERIOR.

Origin—by a thin tendon from the ligamentum nuchæ, over the spinous processes of the last three cervical and two upper dorsal vertebræ, the fibres running obliquely downwards.

Insertion—by fleshy slips into the second, third, fourth and fifth ribs, a little beyond their angles, and beneath the upper part of the scapula.

Action—to elevate the ribs. Fig. 164, 3.

SERRATUS POSTICUS INFERIOR.

Origin—by a tendon inseparably blended with that of the latissimus dorsi by the fascia lumborum; and from the spinous processes of the two inferior dorsal and three superior lumbar vertebræ.

Insertion—by fleshy slips into the under margin of the four inferior ribs, near their cartilages.

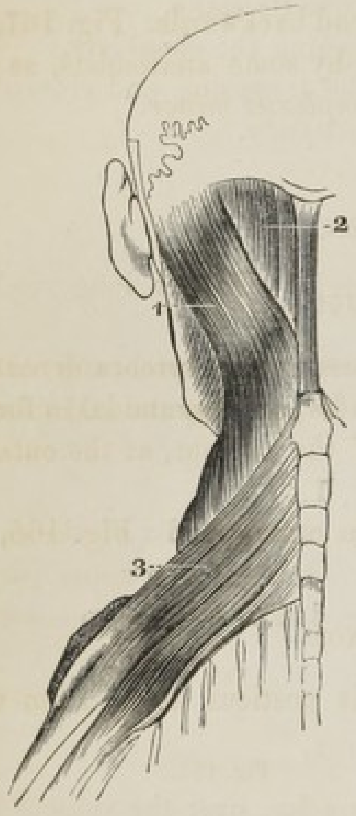
Action—to draw the ribs downwards.

Remarks.—The two serrati cover the latissimus dorsi, sacro-lumbalis and the intercostals. The serratus superior is covered by the rhomboidei, trapezius and serratus magnus; and it overlies the splenius capitis and transversalis cervicis. The serratus inferior is covered by the latissimus dorsi.

SPLENIUS CAPITIS.

Origin—tendinous from the spines of the four superior dorsal vertebræ, and tendinous and fleshy from those of the five inferior cervical, adhering to the ligamentum nuchæ, and receding from its fellow at the third cervical vertebra.

Fig. 164.



Insertion—by separate tendons into the transverse processes of two, three or even four of the upper cervical vertebræ, and by a fleshy portion into the back of the mastoid process and the contiguous surface of the occipital bone.

Action—to draw the head backwards; or when a single muscle acts, obliquely to one side. Fig. 164, 1.

Remarks.—That part of the muscle arising from the neck and inserted into the mastoid process has been called the splenius capitis; and the part that goes from the dorsal to the cervical vertebræ, the splenius colli. The splenius is covered by the trapezius, sterno-mastoid and levator scapulæ muscles; and it covers the complexus, longissimus dorsi, trachelo-mastoid and transversalis cervicis.

Fig. 164. 1, splenius capitis; 2, complexus major; 3, serratus posticus superior.

COMPLEXUS MAJOR.

Origin—tendinous from the seven superior dorsal and four inferior cervical vertebræ, and by a fleshy slip from the spinous process of the first dorsal vertebræ.

Insertion—into the occipital bone between the upper and lower semicircular ridges on each side of the dividing vertical ridges.

Action—to draw the head backwards, or to one side. Fig. 164, 2, and Fig. 167, 5.

Remarks.—The complexus has some accessory fasciculi which are liable to considerable variation. There is always one on the inner and another on the outer side: the former is much the largest, and the two induced Eustachius to call this muscle *biventer cervicis.* The complexus is concealed by the trapezius, splenius capitis, longissimus dorsi, transversalis cervicis and trachelo-mastoideus; and below it are the several recti and obliqui of the head. The muscles of the two sides are separated by the ligamentum nuchæ and a mass of adipose tissue.

TRACHELO-MASTOIDEUS.

Origin—from the transverse processes of the three upper dorsal and five inferior cervical vertebræ.

Insertion—by a thin tendon into the posterior margin of the mastoid process of the temporal bone, where it forms a small groove.

Action—to assist the complexus in drawing the head backwards. Fig. 167, 4.

Remarks.—The trachelo-mastoideus is regarded, by some anatomists, as an appendage of the longissimus dorsi. Synonym—*complexus minor.*

3. OCCIPITO-CERVICAL REGION.

RECTUS CAPITIS POSTICUS MAJOR.

Origin—fleshy and pointed from the spinous process of the vertebra dentata; it runs obliquely upwards and becomes gradually broader, and pyramidal in form.

Insertion—into the inferior semicircular ridge of the occiput, at the outside of the rectus minor.

Action—to draw the head backwards and assist in rotating it. Fig. 165, 2.

RECTUS CAPITIS POSTICUS MINOR.

Origin—at the inner edge of the rectus capitis posticus major from the posterior tubercle of the atlas, whence it spreads upwards in a pyramidal form towards the cranium.

Insertion—into the inner end of the semicircular ridge of the occiput, and the surface between the ridge and foramen magnum.

Action—to assist the former muscle in drawing the head backwards. Fig. 165, 1.

Fig. 165.

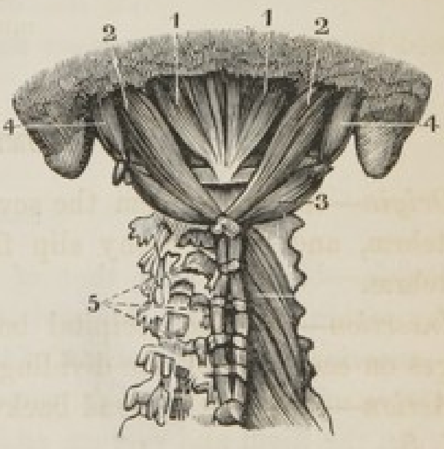


Fig. 165. 1, rectus capitis posticus minor; 2, rectus capitis posticus major; 3, obliquus capitis inferior; 4, obliquus capitis superior; 5, interspinales.

OBLIQUUS CAPITIS INFERIOR.

Origin—fleshy from the spinous process of the vertebra dentata, outside of the rectus major, forming a thick belly that runs upwards and outwards.

Insertion—into the back part of the transverse process of the atlas.

Action—to rotate the atlas, and with it, the head, on the vertebra dentata. Fig. 165, 3.

OBLIQUUS CAPITIS SUPERIOR.

Origin—from the transverse process of the atlas, running upwards and slightly inwards.

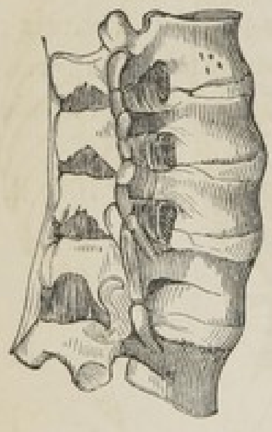
Insertion—into the outer end of the inferior semicircular ridge of the occiput, behind the mastoid process and beneath the splenius muscle.

Action—to draw the head backwards. Fig. 165, 4.

Remarks.—This and the three preceding muscles are covered by the trapezius; a strong layer of fascia being interposed between them. They, in turn, cover the atlas, axis and proximate parts of the occipital bone.

INTERSPINALES.

Fig. 166.



Interspinales lumborum.

The space between the spinous processes of the cervical vertebræ are occupied by small, quadrilateral muscular fasciculi, which arise from the upper part of each spinous process, and are double where the process is bifurcated.

Insertion—into the under part of each spinous process, immediately above that from which it originates.

Action—to draw the spinous processes together, and assist in sustaining the spine in the erect position. Fig. 165, 5.

Similar muscular fibres pass between the spinous processes of the lumbar vertebræ, whence they are called *interspinales lumborum*. Fig. 166.

In the dorsal vertebræ, these muscular fibres are replaced by tendons that connect the processes together.

4. OCCIPITO-CERVICAL REGION.

SACRO-LUMBALIS.

Origin—blended with that of the latissimus dorsi, tendinous without and fleshy within, from the side and all the spinous processes of the sacrum; from the posterior part of the crista of the ilium, and from the spinous and transverse processes of all the lumbar vertebræ. The common head fills up the space between the ilium and sacrum and the hollow of the loins. At the under part of the thorax this muscle begins to send off tendons, which are of considerable length and lie flat upon the ribs. Besides these various origins, six or eight fleshy bellies arise from the corresponding lower ribs, and terminate on the inner side of the muscle. They are called *musculi accessorii ad sacro-lumbalem.*

Insertion—into the angles of all the ribs by an equal number of fleshy digitations.

Action—to elevate the trunk and sustain it in the erect position. They also draw down the ribs. Fig. 167, 1, 2, 6, 8.

LONGISSIMUS DORSI.

Origin—in common with the sacro-lumbalis, forming a thick and powerful muscle that fills up the space between the spine and the angles of the ribs.

Insertion—into the transverse processes of all the dorsal vertebræ by small, double tendons, and by tendinous and fleshy slips into the lower edge of all the ribs (excepting the two inferior ones) near their tubercles.

Action—consentaneous with that of the sacro-lumbalis. Fig. 167.

Fig. 167.

Fig. 167. Third layer of muscles of the back. 1, 2, 6, 8, sacro-lumbalis muscle, turned outwards to separate it from the longissimus dorsi, which lies between it and the spine; 3, point at which these two muscles are blended in one, the *sacro-spinalis*; 4, complexus minor; 5, complexus major; 7, transversalis colli.

SPINALIS DORSI.

Origin—by tendinous slips from the spinous processes from the two upper lumbar and three lower dorsal vertebræ, its fibres being partially blended with those of the latissimus dorsi.

Insertion—by eight or nine tendons into the same number of upper dorsal vertebræ, excepting the first.

Action—to keep the spine erect.

Remarks.—The three preceding muscles—the sacro-lumbalis, longissimus dorsi and spinalis dorsi, are known by the collective name of *erector spinæ*.

TRANSVERSALIS CERVICIS.

Origin—from the transverse processes of the five upper dorsal vertebræ, by an equal number of fleshy slips; whence the belly thus formed runs upwards between the trachelo-mastoideus and splenius colli.

Insertion—by distinct tendons into the transverse processes of all the cervical vertebræ except the first and last.

Action—to draw the neck, and with it the head, backwards and obliquely to one side. Synonym—*transversalis colli.* Fig. 167, 7.

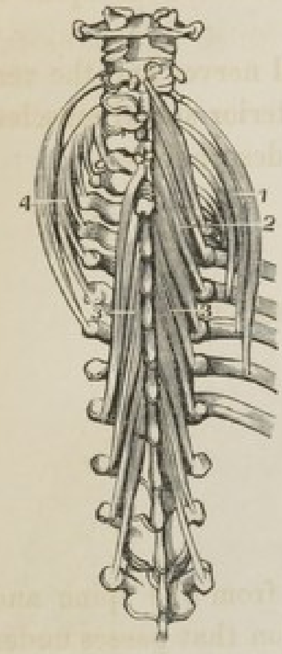


Fig. 168.

MULTIFIDUS SPINÆ *vel* TRANSVERSO-SPINALES.

Origin—from the back of the sacrum and its spinous processes, and from the adjacent crista of the ilium; from the oblique and transverse processes of all the lumbar vertebræ; from the transverse processes of all the dorsal and four inferior cervical vertebræ by as many distinct tendons, which become fleshy and run obliquely upwards and inwards.

Insertion—by distinct tendons into all the spinous processes of the loins and back, and five or six inferior of the neck.

Action—to draw or extend the spine obliquely backwards, and to aid in keeping it in the erect position. Fig. 155, 1.

Fig. 168. 1, descendens cervicis; 2, semi spinalis colli; 3, semi-spinalis dorsi; 4, transversalis colli.

Remarks.—Theile has described some deeper seated fasciculi by the name of *rotatores spinæ*.

SEMI-SPINALIS COLLI.

Origin—from the transverse process of the six superior dorsal vertebræ, by distinct tendons, and passes upwards between the complexus and multifidus spinæ, being more or less blended with the latter muscle.

Insertion—into the spinous processes of all the cervical vertebræ except the first and last.

Action—to extend the neck obliquely backwards. Fig. 168, 2.

Remarks.—This muscle, at its origin, is overlaid by the longissimus dorsi, and in the neck by the complexus. It covers the interspinales colli and the termination of the spinalis dorsi.

SEMI-SPINALIS DORSI.

Origin—from the transverse processes of the seventh, eighth, ninth, and tenth dorsal vertebræ, by distinct tendons which soon become fleshy.

Insertion—by distinct tendons into the spinous processes of the five or six superior dorsal and two inferior cervical vertebræ.

Action—to draw the spine obliquely backwards. Fig. 168, 3.

Remarks.—The origin of this muscle is beneath the longissimus dorsi, and its insertion is covered by the semi-spinalis colli. In the interval it lies between the longissimus dorsi and spinous processes of the vertebræ.

INTER-TRANSVERSALES.

These are short muscles much blended with tendinous matter, that connect

the transverse processes with each other. They are well defined in the neck and loins, but very obscure and tendinous in the back.

Action—to draw the transverse processes together, and to bend the spine to one side.

Remarks.—These fasciculi are separated by the cervical nerves and the vertebral artery. Behind they are in connection with the posterior spinal muscles, splenius, levator scapulæ, transversalis colli and cervicalis descendens.

MUSCLES OF THE SUPERIOR EXTREMITIES.

MUSCLES OF THE SHOULDER.

1. POSTERIOR SCAPULAR REGION.

SUPRA-SPINATUS.

Origin—fleshy, from the whole fossa supra-spinata, and from the spine and superior costa of the scapula: it terminates in a strong tendon that passes under the acromion process, and adheres firmly to the capsular ligament of the joint.

Insertion—tendinous into the inner face of the great tubercle of the os humeri.

Action—to raise the arm and turn it outwards. Fig. 169, 1.

Remarks.—The supra-spinatus is in relation exteriorly with the trapezius and deltoides, and with the coraco-acromial ligament. Its internal face is connected with the scapula and the capsular ligament of the shoulder-joint. Above, it is in contact with the omo-hyoid muscle and the supra-scapular nerve and vessels.

INFRA-SPINATUS.

Origin—from the dorsum of the scapula below its spine, from the spine itself as far as its cervix and from the margin of the bone. A strong central tendon is formed which goes under the acromion process adhering to the capsular ligament.

Insertion—into the middle facet of the great protuberance of the humerus.

Action—to roll the os humeri outwards and backwards, and to sustain the arm when raised. Fig. 169, 2.

Remarks.—The infra-spinatus is internally in connection with the scapula. Its external surface is covered, more or less, by the deltoid, latissimus dorsi and trapezius.

TERES MINOR.

Origin—from the fossa and margin of the inferior costa of the scapula, and from the cervix of the bone almost to its angle; it ascends along the under edge of the infra-spinatus and adheres to the capsular ligament.

Insertion—into the outer facet of the tuberosity of the os humeri.

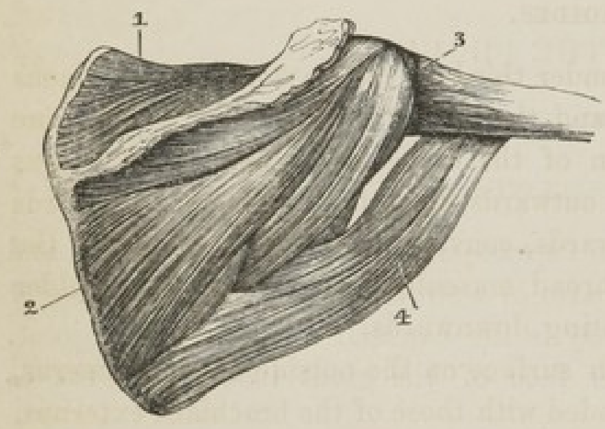
Action—to draw the humerus downwards and backwards and rotate it outwards. Fig. 169, 3.

Remarks.—The teres minor is strongly connected on its inner surface, to the scapula, the scapulo-humeral ligaments; and the long head of the triceps. Its upper margin meets the infra-spinatus; the lower, the teres major.

TERES MAJOR.

Origin—from the dorsum of the inferior angle of the scapula and a small part of its inferior costa. It sends off a broad flat tendon which accompanies that of the latissimus dorsi.

Fig. 169.



Muscles of the scapula.

Insertion—along with the latissimus dorsi, by a broad tendon into the ridge at the inner margin of the bicipital groove.

Action—to draw the humerus downwards and backwards, and to roll it inwards. Fig. 169, 4, and 170, 2.

Fig. 169. Muscles of the scapula; 1, supra-spinatus; 2, infra spinatus; 3, teres minor; 4, teres major.

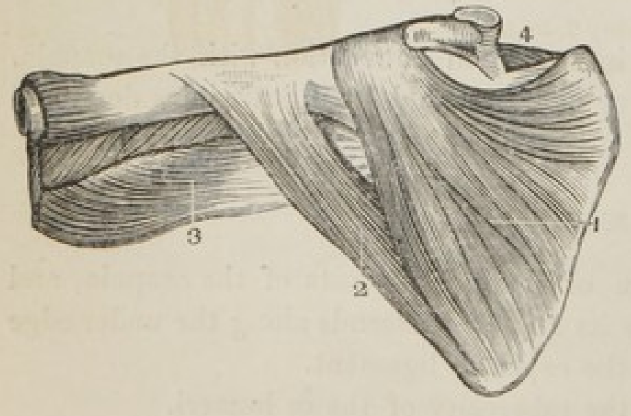
Remarks.—A synovial bursa is placed between the tendon of this muscle and the os humeri, and the proximate part of the tendon of the latissimus dorsi. The teres major is covered by the skin and by the latissimus dorsi. Its upper border meets the infra-spinatus; and the lower, the latissimus dorsi, teres major and long head of the triceps.

2. SUBSCAPULAR REGION.

SUBSCAPULARIS.

Origin—from the base of the scapula, its superior and inferior costa, and fleshy from the entire costal surface. These several portions run in a radiated manner between the scapula and the serratus major muscle, and form a strong tendon that is firmly connected with the capsular ligament.

Fig. 170.



Insertion—into the lesser tubercle at the head of the humerus.

Fig. 170. Muscles of the scapula. 1, subscapularis; 2, teres major; 3, part of triceps; 4, deltoides.

Action—to draw down the bone and roll it inwards. Fig. 170, 1.

Remarks.—There is a synovial bursa between the tendon of the subscapularis and the capsular ligament of the shoulder-joint, which frequently communicates with the articular cavity. The posterior surface of the muscle fills the subscapular fossa. In front it is connected with the serratus magnus; higher up it meets the axillary vessels and nerves, and the coraco-brachialis and deltoid muscles.

3. SUPERIOR SCAPULAR REGION.

DELTOIDES.

Origin—fleshy from the outer and under third of the clavicle, and tendinous and fleshy from the acromion process and the whole inferior edge of the spine of the scapula opposite to the insertion of the trapezius. From these various sources its fibres run from the clavicle outwards, from the acromion downwards and from the spine of the scapula forwards, converging towards the top of the shoulder, over which it forms a thick, broad muscular pad. From the shoulder it becomes triangular, the point presenting downwards.

Insertion—into the triangular, rough surface on the outside of the humerus, near its centre, where its fibres are blended with those of the brachialis externus, having the triceps extensor muscle on one side and the biceps flexor on the other.

Action—to raise the os humeri, and according to the direction of its fibres to move it a little forwards or backwards. Fig. 171, 163, 4, and 172, 2.

Remarks.—The deltoides is covered by the skin; it overlies the shoulder-joint, and consequently part of the several muscles that originate in or are connected with it. The anterior border is associated with the pectoralis major; and the cephalic vein lies between these two muscles. Its inferior angular termination is embraced in the bifid origin of the brachialis anticus.

Fig. 171.

Deltoides.

Fig. 171. The deltoides. 1, body of the muscle; 2, its insertion into the clavicle; 3, its insertion into the spine of the scapula; 4, its insertion into the humerus.

MUSCLES OF THE ARM.

1. ANTERIOR BRACHIAL REGION.

CORACO-BRACHIALIS.

Origin—tendinous and fleshy from the point of the coracoid process of the scapula in common with the short head of the biceps, to which it adheres for three or four inches.

Insertion—tendinous and fleshy into the internal side of the os humeri near its middle, whence it sends down an aponeurosis to the internal condyle of that bone.

Action—to draw the arm obliquely upwards and forwards.

Remarks.—A synovial bursa is occasionally found between the origin of the coraco-brachialis and the short head of the biceps muscle and the capsular ligament of the shoulder-joint. It is covered by the deltoid, pectoralis major and biceps; and it covers the subscapularis, latissimus dorsi and teres major. Above, it covers the axillary and brachial arteries, and the median and musculo-cutaneous nerves. It is perforated by the musculo-cutaneous nerve.

BICEPS FLEXOR CUBITI.

Origin—bifurcated; the outer and longer head commencing by a slender, round tendon from the upper margin of the glenoid cavity of the scapula, whence it perforates the capsular ligament so as to be within the joint, and is then confined in the bicipital groove by ligamentous fibres. The second or short head arises tendinous from the coracoid process of the scapula in common with the coraco-brachialis; and the two portions unite in a thick, fleshy muscle on the front of the humerus, below the middle of the bone.

Insertion—by a strong, rounded tendon into the tubercle at the upper and anterior part of the radius.

Action—to bend the forearm. Fig. 172, 3, and 174, 1.

Remarks.—A synovial membrane surrounds the tendon of the biceps where it passes over the head of the humerus. It is partially covered above by the pectoral and deltoid muscles, but below and during the greater part of its length it lies directly beneath the skin. Nearly half of its posterior surface is in contact with the humerus and shoulder-joint; the other and inferior half is in opposition with the brachialis internus. The brachial artery runs along its inner margin, which last is in contact below with the coraco-brachialis muscle. At the point of insertion, a synovial bursa is interposed between the tendon of the biceps and the cartilage that covers the tubercle of the radius.

BRACHIALIS ANTICUS.

Origin—fleshy, from the middle of the os humeri in front, on each side of the insertion of the deltoid, whence it is continued downward attached to the whole anterior surface of the bone, run over the capsular ligament of the elbow-joint, to which it firmly adheres.

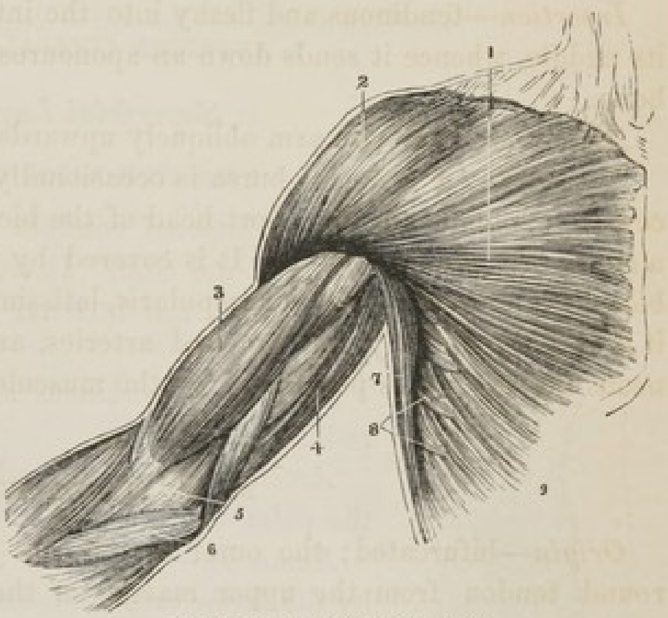
Insertion—by a strong tendon into the depression at the base of the coronoid process of the ulna.

Action—to flex the fore-arm. It also strengthens the capsular ligament. Fig. 172, 5, and 174, 2, 3, 4.

Fig. 172. 1, pectoralis major; 2, deltoides; 3, biceps flexor cubiti; 4, triceps extensor cubiti; 5, brachialis anticus; 6, pronator teres; 7, latissimus dorsi; 8, serratus magnus; 9, obliquus externus abdominis.

Remarks.—The brachialis anticus rests behind on the bone and capsular ligament of the elbow. In front it is beneath the skin and supports the brachial artery and median nerve. Its origin is embraced on each side by the terminal fibres of the deltoides. Synonym—*brachialis internus.*

Fig. 172.



Muscles of the arm and shoulder.

2. POSTERIOR BRACHIAL REGION.

TRICEPS EXTENSOR CUBITI.

Origin—by three distinct heads, the first of which, called the long head, *longus,* comes broad and tendinous from the costa of the scapula close to its cervix; the second or short head,—*brevis*—arises tendinous and fleshy from the upper end of the humerus behind; and the third head, called *brachialis externus,* has its origin from the inner side of the os humeri near the insertion of the teres major. About the middle of the bone the three heads unite in a large and powerful muscle that covers the whole posterior face of the bone to which also it firmly adheres.

Insertion—by a broad tendon (which covers the muscle for the greater part of its length), into the back part of the olecranon process, the ridge of the ulna and the condyles of the os humeri.

Action—to extend the forearm on the arm, and thereby to bring both parts

of the limb on a right line. It is consequently the antagonist of the biceps and the brachialis internus muscles. Fig. 172, 4.

Remarks.—The triceps is immediately beneath the skin and enveloping fascia. Its internal surface lies upon the os humeri, between which and the muscle there is a separation, by cellular tissue, for an inch above the elbow-joint. Higher up it covers the spiral nerve and arteria profunda. A small synovial bursa is generally found between the tendon of the triceps and the olecranon.

MUSCLES OF THE FOREARM.

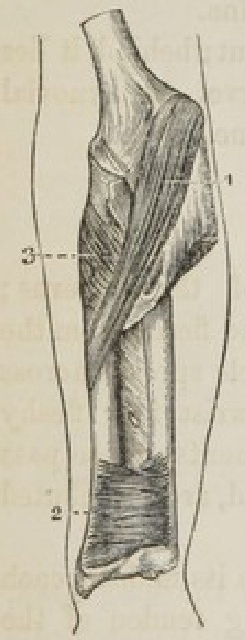
1. ANTERIOR CUBITAL REGION.

Superficial Layer.

PRONATOR RADII TERES.

Origin—fleshy from the internal condyle of the os humeri, and tendinous from the coronoid process of the ulna. It crosses the arm obliquely across the forearm at the internal edge of the brachialis internus muscle.

Fig. 173.



Muscles of the forearm.

Insertion—tendinous and fleshy into the middle of the radius behind.

Action—to roll the radius inwards and thereby to turn the palm of the hand backwards. Fig. 172, 6, and 173, 1.

Remarks.—The ulnar margin of this muscle is bounded by the flexor carpi radialis and palmaris longus. Its radial border forms, with the adjacent edge of the supinator longus, a triangular space in which are seen the brachial artery, median nerve and the tendon of the biceps.

Fig. 173. 1, pronator radii teres; 2, pronator quadratus; 3, supinator radii brevis.

FLEXOR CARPI RADIALIS.

Origin—tendinous and fleshy from the inner condyle of the os humeri, and from the fore and upper part of the ulna, between the pronator radii teres and flexor sublimis, to which it firmly adheres. It forms a long tendon that passes under the annular ligament of the wrist and over a groove in the trapezium.

Insertion—into the fore and upper part of the metacarpal bone of the fore-finger.

Action—to bend the hand on the wrist.

Remarks.—The anterior surface of this muscle is beneath the skin; the posterior surface is in contact with the flexor sublimis, flexor longus pollicis, pronator quadratus and the joint of the wrist. Between the tendon and the trapezium is a synovial membrane.

PALMARIS LONGUS.

Origin—by a small tendon from the inner condyle of the humerus, and soon becoming fleshy, sends off a long, slender tendon.

Insertion—into the annular ligament of the wrist and into the aponeurosis palmaris.

Action—to bend the hand and stretch or extend the aponeurosis palmaris. Fig. 174, 25, 28.

Remarks.—This muscle is sometimes absent. Its position is between the flexor carpi radialis and ulnaris, and it lies on the flexor sublimis.

FLEXOR CARPI ULNARIS.

Origin—tendinous from the inner condyle of the humerus, and by a fleshy slip from the olecranon within; also, from the inner margin of the ulna to within three or four inches of the wrist, and from the aponeurosis of the forearm.

Insertion—by a rounded tendon into the pisiform bone which serves as a pulley, and into the base of the fifth metacarpal bone.

Action—to draw or bend the hand in the direction of the ulna.

Remarks.—This muscle has the skin and integuments in front; behind, it lies on the flexor profundus and overlaps the ulnar artery and nerve. A synovial membrane is interposed between the tendon and the os pisiforme.

FLEXOR DIGITORUM SUBLIMIS.

Origin—tendinous and fleshy from the inner condyle of the humerus; tendinous from the base of the coronoid process of the ulna, and fleshy from the front of the radius near its tubercle; from which point the muscle spreads across the upper part of the forearm. Some distance above the wrist four fleshy bellies are formed which send off an equal number of ligaments; these pass under the annular ligament, and reaching the palm of the hand, are distributed to the fingers.

Insertion—into the second phalanx from its upper part to its middle, each tendon being first split for the passage of the corresponding tendon of the flexor profundus.

Action—to bend the second phalanx of the fingers on the first, and the hand on the forearm. Fig. 174, 28.

2. ANTERIOR CUBITAL REGION.

Deep-Seated Layer.

FLEXOR DIGITORUM PROFUNDUS.

Origin—fleshy from the upper and external margin of the ulna, from the base of the coronoid process, and from the ulnar part of the interosseous liga-

ment and the ulna half way down. It lies beneath the flexor sublimis, and like that muscle divides into four tendons before it passes under the annular ligament, and these, on reaching the palm of the hand, pass through the slits in the tendons of the flexor sublimis.

Insertion—into the root of the third phalanx of each finger.

Action—to bend the last phalanges of the fingers, and to flex the hand on the forearm.

Remarks.—This muscle, at its upper end, encloses the insertion of the brachialis internus; the posterior surface is in contact with the ulna, interosseous ligament and pronator quadratus. The anterior face is overlaid by the other flexors of the forearm, and is in contact with the ulnar artery and the ulnar and median nerves. A large synovial bursa is interposed between the tendons of this muscle and the front of the radius and anterior capsular ligament.

FLEXOR LONGUS POLLICIS.

Origin—from the front of the radius below its tubercle, from the middle two-thirds of this bone and from the interosseous ligament, together with a fleshy slip from the internal condyle of the humerus.

Insertion—after passing under the annular ligament, into the last phalanx of the thumb at its base.

Action—to bend the last joint of the thumb upon the first, this again upon the first metacarpal bone, and thus to assist in flexing the hand upon the forearm. Fig. 174, 26.

Remarks.—This muscle is covered anteriorly by the flexor carpi radialis, flexor sublimis and partially by the pronator teres and the radial vessels. It covers the radius and the interosseous ligament, from which it is separated above by the interosseous vessels and nerves, and below by the pronator quadratus. Its tendon is received into a muscular groove in the muscles of the ball of the thumb. An extensive synovial bursa also surrounds the tendon; and another between this tendon and the capsular ligament of the wrist and os trapezium.

PRONATOR QUADRATUS.

Origin—broad, tendinous and fleshy from a ridge at the under and inner part of the ulna, the fibres, which are about two inches in width, passing directly across the arm.

Insertion—into the front of the radius.

Action—to rotate the radius inwards and thereby to pronate the hand, or in other words, to turn its back upwards. 173, 2, and 175, 1.

Remarks.—This muscle is covered by the flexor digitorum profundus, flexor longus pollicis and flexor carpi radialis. It overlies the interosseous ligament and the bones of the forearm.

3. POSTERIOR CUBITAL REGION.

Superficial Layer.

EXTENSOR DIGITORUM COMMUNIS.

Origin—tendinous from the external condyle of the humerus, and fleshy from the fascia of the contiguous muscles. It passes down on the back of the arm, and on approaching the wrist splits into four tendons, which pass under the posterior annular ligament and through a groove in the radius. On the back of the hand the tendons become flat, diverge, and near the roots of the fingers send off transverse connecting fibres.

Insertion—into the posterior face of all the bones of the four fingers by a tendinous expansion which is much thickened at the sides of the joints.

Action—to extend all the fingers.

Remarks.—A small synovial bursa is interposed between the tendon of this muscle and the round head of the radius. It is covered by the skin and fascia; its inner surface is associated with the supinator brevis, with all the long extensors of this region and with the posterior interosseous artery. On its radial side are the extensor carpi radialis longior and brevior; and on its inner or ulnar margin it is in contact with the extensor minimi digiti and extensor carpi ulnaris.

EXTENSOR CARPI ULNARIS.

Origin—tendinous from the external condyle of the humerus, fleshy from the middle of the ulna and intermuscular ligament. It terminates in a round tendon that passes through a groove on the back of the ulna.

Insertion—into the back part of the metacarpal bone of the little finger near its base.

Action—to assist the two former muscles in extending the wrist and hand, and bending them backwards.

Remarks.—This muscle is covered only by the skin. A synovial membrane separates the tendon from the annular ligament. It is covered by the skin and common fascia, and it is connected beneath to the supinator brevis and the extensor muscles of the forearm. On its radial side is the extensor digitorum communis, and extensor minimi digiti; and on its ulnar side is the anconeus.

EXTENSOR MINIMI DIGITI.

Origin—in common with the extensor communis, forming a delicate fleshy belly that becomes tendinous as it approaches the wrist. The tendon passes through a separate ring of the annular ligament, where it is provided with a synovial bursa, and then joins the fourth digital tendon of the extensor digitorum communis.

Insertion—in common with the tendon of the extensor communis into the back of the two last phalanges of the fingers.

Action—as its name expresses, to extend the little finger.

Remarks.—A synovial bursa is placed between the tendon of this muscle and the annular ligament.

ANCONEUS.

Origin—by a tendinous and fleshy point from the external condyle of the humerus at its posterior aspect. The fibres diverge, the upper ones being horizontal, the others more or less oblique.

Insertion—into the outer or radial aspect of the olecranon, and into the adjacent border of the ulna itself.

Action—to assist in extending the forearm upon the arm, and *vice versâ;* and from its oblique position it can also rotate the forearm inward.

Remarks.—It is covered by an extension of the sheath of the triceps, and in turn partly covers the elbow-joint, the annular ligament of the radius, the ulna, and a small portion of the supinator brevis muscle. A synovial bursa intervenes between the anconeus and the head of the radius.

SUPINATOR RADII LONGUS.

Origin—fleshy from the ridge of the os humeri above its external condyle, nearly to the middle of the bone. It forms a thick muscle which terminates about the middle of the radius in a long, slender tendon.

Insertion—into the outside of the radius above its styloid process.

Action—to roll the radius outwards, and consequently to present the palm of the hand forwards. Fig. 174, 5, 9.

Remarks.—The supinator radii longus is directly beneath the skin and fascia; and it covers the humerus, the extensor carpii radialis longior and brevior, and the supinator radii brevis. Above, its inner margin is in contact with the brachialis anticus.

EXTENSOR CARPI RADIALIS LONGIOR.

Origin—broad and fleshy from the lower part of the ridge of the os humeri above its external condyle. It sends off above the middle of the radius a long, flat tendon that descends on the back of the radius and passes over a groove in the bone and under the posterior annular ligament.

Insertion—into the back of the metacarpal bone of the forefinger, near the thumb.

Action—to extend the wrist and hand and draw them backward. Fig. 174, 7, 15.

Remarks.—The belly of this muscle is placed between the supinator radii longus and the extensor carpi radialis brevior.

EXTENSOR CARPI RADIALIS BREVIOR.

Origin—from the external condyle of the humerus and contiguous capsular ligament. Its fleshy belly passes down on the back of the radius and its tendon under the posterior annular ligament.

Insertion—into the back of the metacarpal bone of the middle finger near its base.

Action—to assist the former muscle in extending the hand and wrist, and drawing them backwards. Fig. 174, 6, 14.

Remarks.—Where the tendons of this and the preceding muscle cross the extensor ossis metacarpi pollicis, there is placed a synovial bursa which is common to them both; and another exists where they cross behind the tendon of the extensor major pollicis manus.

4. POSTERIOR DEEP CUBITAL REGION.

Deep-Seated Layer.

SUPINATOR RADII BREVIS.

Origin—tendinous from the external condyle of the humerus, and fleshy from the ridge at the outer and upper part of the ulna and from the interosseous ligament, its fibres passing obliquely over the outer edge of the radius.

Insertion—into the upper and back part of the radius, and into its tubercle.

Action—to rotate the radius outwards, and supinate the hand. Fig. 173, 3.

Remarks.—This is a triangular muscle, lying in contact with the bones and covered by the supinator radii longus and the extensors.

EXTENSOR MINOR POLLICIS MANUS.

Origin—tendinous from the back of the ulna below its middle, and from the contiguous interosseous ligament, adhering to the radius as it descends and forming a tendon that runs through the groove on the styloid margin of the radius.

Insertion—into the first phalanx of the thumb, its tendon going as far as the root of the second phalanx.

Action—to extend the first phalanx. Synonym—*extensor primi internodii pollicis.*

Remarks.—It is connected by its interior surface with the extensor minimi digiti, and extensor digitorum communis. Its inner surface is in contact with the radius, ulna and interosseous ligament, and at the wrist with the radial artery.

EXTENSOR MAJOR POLLICIS MANUS.

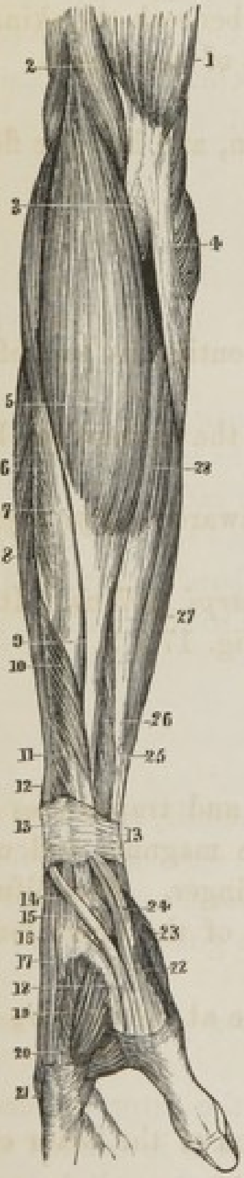
Origin—tendinous and fleshy from the back of the ulna above its middle, from the contiguous surface of the radius and from the interosseous ligament; its tendon passing in a groove on the back of the radius.

Insertion—into the tubercle at the back and base of the second phalanx of the thumb.

Action—to extend the last bone of the thumb. Synonym—*extensor secundi internodii pollicis.*

Remarks.—There is a synovial bursa between the tendon of this muscle and the metacarpal bone of the thumb. Its connections are nearly similar to those of the preceding muscle. It is placed between the extensor minor pollicis and extensor indicis.

Fig. 174.



Muscles of the radial region of the forearm.

EXTENSOR OSSIS METACARPI POLLICIS.

Origin—fleshy from the middle of the posterior surface of the ulna, radius and interosseous ligament, and forming a ligament that plays in a groove of the styloid margin of the radius.

Insertion—into the trapezium, and base of the metacarpal bone of the thumb.

Action—to extend the metacarpal bone of the thumb.

Remarks.—This muscle is covered above by the extensor digitorum communis, but it is subcutaneous on the outer face of the radius. A synovial membrane exists between the tendon and the radius.

Fig. 174. 1, belly of the biceps flexor cubiti; 2, brachialis anticus; 3, its proper tendon; 4, its reflected tendon; 5, supinator radii longus; 6, extensor carpi radialis brevior, with its tendon, 14; 7, extensor carpi radialis longior, the fleshy belly being above, the tendon below, which latter is inserted at 15; 8, extensor digitorum communis; 9, tendon of the supinator radii longus; 10, adductor longus pollicis; 11, extensor brevis pollicis, which terminates in a slender tendon, 24; 12, extensor longus pollicis, with the terminal portion of its tendon, 18; 13, posterior annular ligament; 16, tendon of the extensor indicis; 17, tendon given off by the extensor digitorum communis to the index finger; 19, 20, first dorsal interosseous muscle; 21, its insertion; 25, tendon of the palmaris longus; 28, its fleshy belly; 26, flexor longus pollicis; 27, flexor digitorum sublimis.

INDICATOR.

Origin—by a fleshy slip from the back of the ulna near its middle, and the contiguous interosseous ligaments on the inside of the extensor major pollicis. It forms a tendon that passes through the fossa that lodges the extensor digitorum communis, beneath the annular ligament.

Insertion—with part of the extensor digitorum communis into the back of the fore-finger from the first to the third phalanx.

Action—to extend the fore-finger, as in pointing; whence its name. Synonym—*extensor indicis.*

Remarks.—A bursa is interposed between the tendon of the indicator and the annular ligament. This tendon rests upon the metacarpal bone of the fore-finger and second interosseous muscle.

MUSCLES OF THE HAND.

1. EXTERNAL PALMAR REGION.

ABDUCTOR POLLICIS MANUS.

Origin—tendinous and fleshy from anterior annular ligament, and from the ends of the trapezium and trapezoides, being immediately beneath the skin.

Insertion—into the outside of the base of the first bone of the thumb.

Action—to draw the thumb from the fingers.

Remarks.—This muscle is immediately beneath the skin, and has the flexor brevis pollicis at its inner margin.

OPPONENS POLLICIS.

Origin—from the point of the trapezium and from the contiguous part of the anterior annular ligament.

Insertion—tendinous and fleshy into the radial edge of the metacarpal bone of the thumb, from its base to its head.

Action—to draw the metacarpal bone of the thumb inwards. Synonym—*flexor ossis metacarpi pollicis.*

Remarks.—This muscle is also called *flexor ossis metacarpi pollicis.* It lies between the abductor pollicis and flexor brevis pollicis. Fig. 175, 2.

FLEXOR BREVIS POLLICIS.

Origin—by two heads; the first, from the trapezium and trapezoides and from the anterior annular ligament: the second, from the magnum and unciforme and the base of the metacarpal bone of the middle finger. This bifurcation is formed by a groove for the passage of the tendon of the flexor longus pollicis.

Insertion—by its first head into the outer sesamoid bone at the thumb; and by its second head into the inner sesamoid bone.

Action—to bend the first phalanx of the thumb.

Remarks.—It covers the adductor pollicis and the tendon of the flexor carpi radialis, and is covered by the palmar fascia.

ADDUCTOR POLLICIS MANUS.

Origin—fleshy from the whole ulnar edge of the metacarpal bone of the middle finger, whence its fibres converge in a triangular form.

Insertion—tendinous into the inner margin of the base of the first phalanx of the thumb, above the sesamoid bone.

Action—to draw the thumb towards the fingers. Fig. 175, 4.

Remarks.—It is partially covered by the lumbricales and the tendons of the flexor digitorum profundus; and it covers the first two interosseous spaces.

2. INTERNAL PALMAR REGION.

PALMARIS BREVIS.

Origin—from the anterior ligament of the wrist and from the inside of the aponeurosis palmaris, being divided into small fasciculi that lie immediately beneath the skin.

Insertion—into the skin and cellular tissue at the inner margin of the hand.

Action—to contract the skin of the palm.

Remarks.—This muscle is subcutaneous and adheres firmly to the skin. It covers the ulnar artery and nerve, from which it is separated by the palmar fascia.

LUMBRICALES.

Origin—four in number, from the outside of the tendons of the flexor profundus beneath the anterior annular ligament.

Insertion—by small, flattened tendons into the middle of the back of each of the first phalanges of the fingers, in common with the tendons of the extensor communis.

Action—to flex the first phalanges. They also bind the flexor and extensor tendons together and prevent their displacement.

ABDUCTOR MINIMI DIGITI.

Origin—fleshy from the pisiform bone and from the contiguous portion of the annular ligament of the wrist.

Insertion—tendinous into the inner or ulnar side of the first phalanx of the little finger.

Action—to draw the little finger from the rest.

Remarks.—It is covered by the external palmar fascia and overlies the opponens minimi digiti.

ADDUCTOR METACARPI MINIMI DIGITI.

Origin—fleshy, from the hook of the unciform bone and the contiguous annular ligament.

Insertion—by tendinous and fleshy fibres into the forepart of the metacarpal bone of the little finger its whole length.

Action—to flex the metacarpal bone and with it the little finger, and to approximate this finger to the others. Synonym—*opponens minimi digiti.*

Remarks.—It lies upon the fifth metatarsal bone, and is covered by the flexor brevis minimi digiti and abductor minimi digiti. Fig. 175, 5.

Fig. 175.

Palmar muscles.

FLEXOR PARVUS MINIMI DIGITI.

Origin—from the hook-like process of the unciform bone, and from the annular ligament adjacent.

Insertion—by a rounded tendon into the inside of the base of the first phalanx of the little finger.

Action—to bend the little finger. Fig. 175, 14.

Fig. 175. Deep-seated palmar muscles. 1, pronator quadratus; 2, opponens pollicis; 3, its attachment to the annular ligament; 4, adductor pollicis, arising from the whole front of the second metacarpal bone, os trapezium and os magnum; 5, opponens minimi digiti; 6, its origin from the os unciforme; 7, os pisiforme; 8, 9, 10, 11, 12, 13, 14, interossei muscles; 8, abductor indicis; 9, adductor indicis; 10, abductor medii; 11, adductor medii; 12, adductor annularis; 13, abductor annularis; 14, flexor parvus minimi digiti.

3. MIDDLE PALMAR REGION.

INTEROSSEI.

The interosseous muscles are seven in number, three of which arise with single heads in the palm of the hand and are called the internal or palmar; four others are found on the back of the hand having double heads, and are called external, dorsal or bicipites. The reason why there are but three palmar interossei is, that the first muscle of the series, the *adductor pollicis*, is by common consent described separately. They may be collectively said to arise from the sides of the metacarpal bones, and to be inserted by slender tendons in common with those of the lumbricales, into the sides of the first phalanges, and into the tendinous membrane on the dorsum of those bones.

The special position of each of these muscles is contained in the following description:

INTEROSSEI INTERNI OR PALMAR INTEROSSEI.

1. ADDUCTOR INDICIS.

Origin—from the inner side of the metacarpal bone of the fore finger.

Insertion—into the inside of the tendon on the back of the fore finger.

Action—to draw the fore finger inwards, towards the others. Synonym—*posterior indicis.* Fig. 175, 9.

2. ABDUCTOR ANNULARIS.

Origin—from the outside of the metacarpal bone of the third or ring finger.

Insertion—into the outside of the tendon of the first phalanx of the ring finger.

Action—draws the ring finger towards the thumb. Synonym—*prior annularis.* Fig. 175, 13.

3. INTEROSSEUS AURICULARIS.

Origin—from the outside of the metacarpal bone of the little finger.

Insertion—into the radial side of the first phalanx of the same finger.

Action—to draw the little finger outwards. Fig. 175, 14.

Remarks.—These interossei are separated by a delicate aponeurosis from the extensor tendons on the back of the hand; and within they are covered by the muscles of the palmar region.

INTEROSSEI EXTERNI.—DORSAL INTEROSSEI.

1. PRIOR INDICIS.

Origin—from the radial side of the metacarpal bone of the fore finger.

Insertion—tendinous into the outside of the back of the fore finger.

Action—to draw the finger outwards towards the thumb. Synonym—*abductor indicis.* Fig. 175, 8.

2. ABDUCTOR MEDII.

Origin—from the corresponding sides of the metacarpal bones of the fore and middle fingers.

Insertion—into the outside of the tendon on the back of the middle finger.

Action—to draw the middle finger outwards. Synonym—*prior medii.* Fig. 175, 10.

3. ADDUCTOR MEDII.

Origin—from the corresponding sides of the metacarpal bones of the middle aud ring fingers.

Insertion—into the inside of the first phalanx of the middle finger.

Action—to draw the middle finger inwards. Synonym—*posterior medii.* Fig. 175, 11.

4. ADDUCTOR ANNULARIS.

Origin—from the corresponding sides of the metacarpal bones of the ring and little fingers.

Insertion—into the ulnar side of the first phalanx of the little finger.

Action—to draw the ring finger towards the little finger. Synonym—*posterior annularis.* Fig. 175, 13.

Remarks.—The palmar interossei are covered by the flexor tendons and muscles of the palmar region. Behind, each one is in relation with a dorsal muscle of the same class.

MUSCLES OF THE INFERIOR EXTREMITY.

MUSCLES OF THE PELVIS AND THIGH.

1. GLUTEAL REGION.

GLUTEUS MAXIMUS.

Origin—fleshy from the posterior margin of the crista of the ilium and its contiguous dorsum; from the side of the sacrum and os coccygis, and from the posterior sacro-sciatic ligaments over which the lower edge of the muscle is folded. The fibres are collected into fasciculi which pass forwards and a little downwards, so as to cover nearly the whole of the trochanter major. It is the largest muscle of the human body.

Insertion—by a broad, thick tendon into the upper third of the linea aspera at its outer margin, and by accessory fibres into the contiguous fascia femoris.

Action—to draw the thigh backwards, and to assist in maintaining the equilibrium of the body on the lower extremity, which rests on the ground while the other is put forwards, as in walking. Fig. 182, 2.

Remarks.—The gluteus maximus is covered by the fascia lata and the skin, and is readily separated on this surface, into several fasciculi. It covers the gluteus medius, pyriformis, gemelli, obturator internus, quadratus femoris, the great sciatic notch, the tuber ischii and the muscles that arise from it. It also overlies the trochanter major and adductor magnus, together with the gluteal, ischiatic and internal pudic vessels and nerves and the great sciatic nerve. This muscle is provided with several synovial bursæ; one between it and the great trochanter; a second over the tuberosity of the ischium and a third between the tendon of this muscle and the vastus externus.*

GLUTEUS MEDIUS.

Origin—fleshy from the anterior two-thirds of the crista of the ilium; from the dorsum of the bone between its semicircular ridge and crista, and from the fascia femoris that covers this muscle.

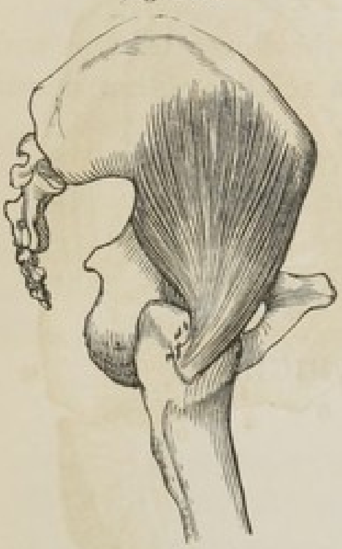
Insertion—by a broad, strong tendon into the upper surface of the trochanter major and into the contiguous part of the shaft of the femur.

Action—to draw the thigh backwards and outwards. Fig. 182, 1.

* Cruveilhier. Anatomy, p. 265.

Remarks.—The gluteus medius is covered by the gluteus maximus and tensor vaginæ femoris, and it covers the gluteus minimus.

Fig. 176.



Gluteus minimus.

GLUTEUS MINIMUS.

Origin—from the dorsum ilii between the semicircular ridge and the capsular ligament of the hip-joint; it lies under the gluteus medius and converges to a strong, flat tendon.

Insertion—into the upper and anterior part of the trochanter major.

Action—to assist the gluteus medius in drawing the thigh outwards and in rotating it inwards. Fig. 176.

Remarks.—This muscle is covered by the gluteus medius; it covers the hip-joint at its upper part and is in contact with the dorsum ilii.

2. PELVI-TROCHANTERIC REGION.

PYRIFORMIS.

Origin—fleshy and tendinous within the pelvis from the anterior face of the second, third and fourth pieces of the sacrum; and forming a conical belly, it goes out of the pelvis along with the sciatic nerve through the sacro-sciatic foramen, from which it receives a few fleshy fibres.

Insertion—by a rounded tendon into the upper part of the cavity at the inner side of the trochanter major.

Action—to rotate the limb outwards. Fig. 177, 4.

Remarks.—Within the pelvis the pyriformis is placed behind the sciatic plexus of nerves, the internal iliac vessels and the rectum. Outside of the pelvis it lies on the capsular ligament of the hip-joint, and is covered by the gluteus maximus. Above, it is separated from the gluteus medius by the gluteal vessels at their exit from the pelvis.

GEMINI OR GEMELLI.

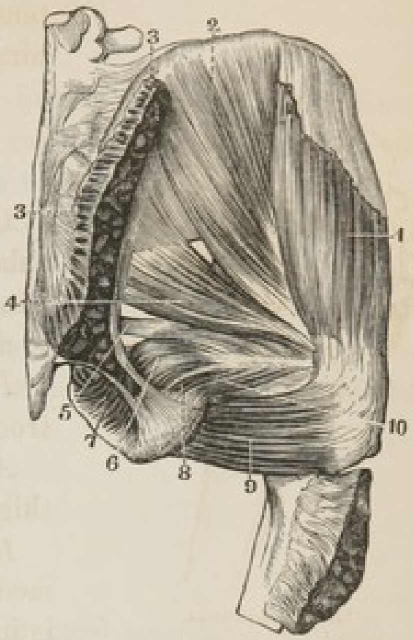
Origin—by two heads, one from the base of the spinous process of the ischium, the other from its tuberosity. These heads are united by a tendinous membrane and form a sheath for the tendon of the obturator internus, which is thus placed between the two muscles.

Insertion—fleshy into the cavity at the inside of the trochanter major: it is also adherent to the tendon of the obturator internus.

Action—to rotate the limb outwards. Fig. 177, 5, 8, 10.

Remarks.—The posterior surface is covered by the gluteus maximus; the anterior rests on the ischium and capsular ligament of the hip-joint. These muscles are called from their relative position, superior, Fig. 177, 5, and inferior gemellus, Fig. 177, 10, the latter being the larger of the two.

Fig. 177.



Pelvic muscles.

Fig. 177 represents several muscles of these parts. 1, 2, gluteus medius; 3, cut origin of gluteus maximus; 4, pyriformis; 5, 8, 10, gemelli; 6, 7, obturator internus; 9, quadratus femoris.

OBTURATOR INTERNUS.

Origin—by a semicircular fleshy margin from the edge of the thyroid foramen excepting where the vessels pass out. Its fibres converge and send off a round tendon that goes over the ischium, its spine and tuberosity, like a rope over a pulley.

Insertion—tendinous into the pit at the root of the great trochanter.

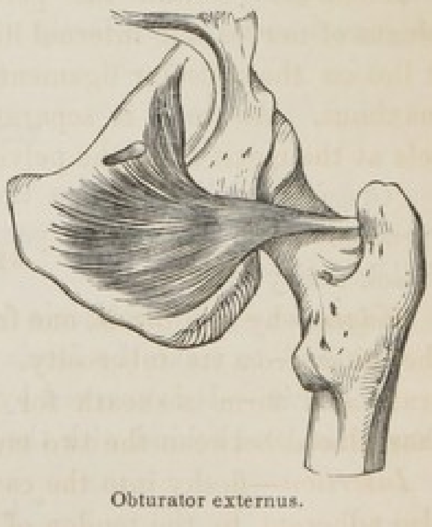
Action—to rotate the limb outwards. Fig. 177, 6, 7.

Remarks.—Within the pelvis it is covered by the obturator fascia and crossed by the internal pudic artery. It is covered by the gluteus maximus, and is in contact with the great sciatic nerve.

OBTURATOR EXTERNUS.

Origin—from the anterior circumference of the foramen thyroideum and from the whole surface of the thyroid ligament. The fibres converge and pass outwards over the capsular ligament of the hip-joint to which they adhere.

Fig. 178.



Obturator externus.

Insertion—by a round tendon into the cavity at the inner and back part of the trochanter major.

Action—to roll the thigh obliquely outwards. Fig. 178.

Remarks.—In front the obturator internus is covered by the pectineus and adductor brevis muscles, and crossed by the obturator vessels. Its tendon is in contact with the capsular ligament of the hip-joint. Its inner and posterior surface is in contact with the obturator foramen and the quadratus femoris.

QUADRATUS FEMORIS.

Origin—by tendinous and fleshy fibres from the outside of the tuberosity of the ischium, whence it passes transversely outwards.

Insertion—fleshy into the ridge between the two trochanters.

Action—to rotate the limb outwards. Fig. 177, 9.

Remarks.—Its internal insertions are nearly the same as those of the obturator internus. In front it covers the obturator externus and plays behind over the lesser trochanter, from which it is separated by a synovial capsule. This muscle is sometimes deficient.

3. ANTERIOR FEMORAL REGION.

SARTORIUS.

Origin—tendinous from the anterior superior spinous process of the ilium, and soon becoming fleshy, goes obliquely to the inside of the thigh and to the back of the internal condyle of the femur, being the longest muscle in the body.

Insertion—into the inside and lower part of the tubercle of the tibia.

Action—to bend the leg and draw it obliquely inwards across the other. The action of both muscles crosses the legs in the position common among tailors, whence the name of sartorius. Fig. 179, 6.

Remarks.—The sartorius lies directly beneath the skin and fascia of the thigh. In its oblique course it covers or crosses the psoas magnus and iliacus muscles, the rectus, vastus internus, adductor longus, gracilis and adductor magnus. The femoral artery passes along the internal margin of the sartorius. To be more explicit, the sartorius, adductor longus and femoral arch form a triangle with its base upward, and the artery represents a line drawn vertically from the base to the apex of the triangle. In the middle third of the thigh the artery is in relation, first with the inner border of the muscle, then with its posterior surface, and lastly with its outer margin.*

TENSOR VAGINÆ FEMORIS.

Origin—tendinous from the outer margin of the anterior superior spinous process of the ilium, and passing downwards and a little backwards forms a thick fleshy muscle.

Insertion—into the fascia femoris at the upper and outer side of the thigh.

Action—to make the fascia tense, and rotate the foot inwards. Fig. 179, 1.

Remarks.—It is covered by the fascia lata. It is in contact above with the sartorius, and behind with the gluteus medius.

* Cruveilhier, Anatomy, p. 272.

RECTUS.

Origin—fleshy from the anterior inferior spine of the ilium, and by a tendon from that bone above the acetabulum.

Insertion—tendinous into the upper margin of the patella, and by the ligamentum patellæ into the tubercle of the tibia.

Action—to extend the leg. This muscle has a median, longitudinal line of a tendinous nature which is best seen behind, and from which the fleshy fibres are given off like the plumage of a feather. Fig. 179, 3.

Remarks.—The rectus is covered by the fascia lata. It rests behind on the three associated muscles next to be described, and above, it is attached to the capsular ligament of the hip-joint. It lies between the vastus internus and vastus externus, and the tendons of all these muscles unite below.

CRURÆUS.

Origin—by fleshy fibres from the femur in front and laterally as far as the linea aspera, whence it passes down in connection with the vastus internus and externus, with the rectus in front, and joins its tendon to that of the latter muscle at the lower end of the bone.

Insertion—into the upper margin of the patella behind the tendon of the rectus.

Action—to extend the leg.

Remarks.—Its anterior surface is covered by the rectus; posteriorly it lies on the femur. Synonym—*cruralis.*

VASTUS EXTERNUS.

Origin—from the upper and outer part of the os femoris below the trochanter major, and thence from the outer margin of the linea aspera its whole length, and from half the angular line leading from it to the external condyle. It forms the principal muscular mass of the outside of the thigh.

Insertion—into the upper and external margin of the patella, and into the contiguous tendon of the rectus.

Action—to extend the leg. 179, 4.

Remarks.—It has the fascia lata in front, and the femur behind. Its extended margin is in contact with the short head of the biceps; internally it is blended with the cruræus.

VASTUS INTERNUS.

Origin—tendinous and fleshy from the front of the os femoris on a line with the trochanter minor, from the internal margin of the linea aspera its whole length, and from the angular line leading to the inner condyle; its fibres

Fig. 179.

Muscles of the thigh.

run forwards and downwards on the inside of the thigh.

Insertion—into the upper and inner edge of the patella, and into the contiguous tendon of the rectus muscle.

Action—to extend the leg. Fig. 179, 5.

Fig. 179. 1, tensor vaginæ femoris; 2, pectineus; 3, rectus femoris; 4, vastus externus; 5, vastus internus; 6, sartorius; 7, adductor longus.

Remarks.—The vastus internus is connected in front with the fascia lata sartorius and the femoral vessels. Behind, is the femur; the inner margin is in contact with the adductor magnus, adductor longus, pectineus and psoas muscles; externally it is connected with the cruræus. The three last muscles, the cruræus, vastus externus and vastus internus, are frequently described as one muscle under the name of *triceps femoris* and *triceps extensor cruris.* Other anatomists, and Soemmering among them, regard the rectus as also a part of the same muscle and gives to them collectively the designation of *quadriceps femoris.*

4. INTERNAL FEMORAL REGION.

PECTINEUS.

Origin—broad and fleshy from the upper concave margin of the os pubis between the linea ilio-pectinea and the ridge above the foramen thyroideum, whence it goes downwards and outwards at the inner side of the psoas magnus.

Insertion—by a short, flat tendon into the linea aspera, just below the trochanter minor.

Action—to draw the thigh upwards and inwards, and rotate it outwards. Fig. 179, 2.

Remarks.—It is bounded in front by the fascia lata and femoral vessels; behind, are the obturator vessels and nerves and obturator externus muscle. At its external margin is the psoas magnus; internally, the adductor longus. Synonym—*pectinalis.*

TRICEPS ADDUCTOR FEMORIS.

The triceps, as its name imports, consists of three parts which are in reality three distinct muscles, although to a certain extent connected together.

ADDUCTOR LONGUS VEL PRIMUS.

Origin—by a strong, round tendon from the os pubis near its symphysis, forming a fleshy belly that runs downwards and outwards.

Insertion—by a broad, thin tendon into the middle third of the linea aspera. Fig. 180, 8, 181, 3, and 179, 7.

Remarks.—The adductor longus is covered in front by the fascia lata and sartorius; behind it are the associated adductors. Its inner margin is in contact with the gracilis muscle, and it has the pectineus on its outside. It is separated from the sartorius by the femoral artery and vein.

ADDUCTOR BREVIS VEL SECUNDUS.

Origin—from the os pubis, below the adductor longus, and between the symphysis and the thyroid foramen.

Insertion—into the upper third of the linea aspera, at its inner margin. Fig. 180, 6, 7.

Remarks.—The adductor brevis is perforated by some branches of the arteria profunda. It has the pectineus and adductor longus in front, and the adductor magnus behind.

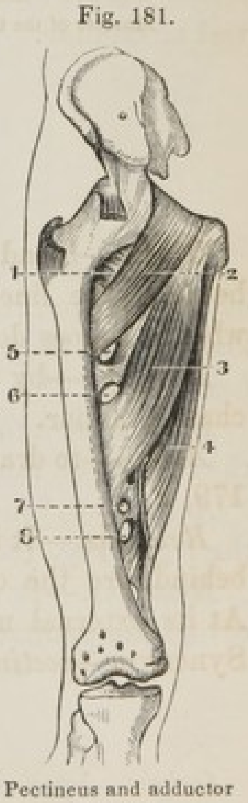
ADDUCTOR MAGNUS VEL TERTIUS.

Origin—fleshy from the body of the pubis below the adductor brevis, and from the ramus of the pubis and of the ischium to the tuberosity of the latter bone. From these sources the fibres run outwards and downwards, expanding into a large and powerful muscle.

Fig. 180.

Adductor muscles of the thigh.

Fig. 181.



Pectineus and adductor muscles.

Fig. 180. Adductor muscles, &c., of the thigh. 1, femur; 2, ilium; 3, pubis; 4, obturator externus; 5, superior fasciculus of the adductor magnus; 6, 7, adductor brevis; 8, adductor longus; 9, 10, adductor magnus; 11, foramen for the passage of the perforating arteries; 12, same for femoro-popliteal vessels.

Fig. 181. Another view of the adductor muscles with the pectineus. 1, upper part of adductor magnus; 2, pectineus; 3, adductor longus; 4, adductor magnus; 5, 6, foramina for the first and second perforating arteries; 7, 8, foramina for the femoro-popliteal vessels.

Insertion—fleshy, into the entire length of the linea aspera,

and terminating at the ridge leading to the internal condyle of the femur, to which latter it is also attached by a flattened, tendinous cord. Near this point the femoral artery passes between the tendon of the adductor magnus and the bone.

Action.—These three muscles have a common or united action, in drawing the thigh inwards and upwards. Fig. 180, 5, 9, 10, and 181, 1, 4.

Remarks.—This muscle is covered by the pectineus, adductor longus and adductor brevis; and it overlies the semi-tendinosus, biceps, semi-membranosus and gluteus maximus. It has the gracilis at its upper and inner margin, and the sartorius below. It is perforated by the femoral artery and vein in their course to the popliteal region. Fig. 181, 7, 8.

GRACILIS.

Origin—by a thin tendon from the os pubis near the symphysis, whence it takes a direct course on the inside of the thigh and terminates above the knee in a tendon that passes behind the joint.

Insertion—by a long, rounded tendon into the inner and lower part of the tubercle of the tibia, below the sartorius.

Action—to assist the sartorius in flexing the leg. It is also an adductor of the thigh.

Remarks.—It is covered by the fascia lata and crossed below by the sartorius. It crosses and partially covers the triceps adductor muscle; and also the internal lateral ligament of the knee-joint, from which it is separated by a synovial membrane.

5. POSTERIOR FEMORAL REGION.

SEMITENDINOSUS.

Origin—in common with the biceps from the posterior part of the tuberosity of the ischium, its fleshy fibres passing downwards to within four inches of the knee, where they terminate in a long, round tendon, which passes behind the head of the tibia and then becomes flat.

Insertion—into the inside of the tibia, just below its tubercle and beneath the tendon of the gracilis.

Action—to bend the leg, and to rotate the tibia inward during semi-flexion of the leg. Fig. 182, 4, 6.

Remarks.—It is covered by the gluteus maximus and fascia femoris, and covers the semimembranosus.

SEMIMEMBRANOSUS.

Origin—by a strong tendon from the upper and outer part of the tuberosity of the ischium, its fibres being sent off obliquely from its outer to its inner tendinous margin. The tendon below passes behind the condyles of the os femoris,

and is there connected by an aponeurotic membrane with the capsular ligament of the knee-joint.

Insertion—by a rounded tendon into the inner and back part of the head of the tibia.

Action—to flex the leg on the thigh. Fig. 182, 5.

Remarks.—The semimembranosus is covered by the gluteus maximus, semitendinosus and biceps; and it covers the quadratus femoris, and adductor magnus. Where it crosses the knee-joint a synovial bursa is interposed. It also covers the popliteal artery and vein; and the sciatic nerve is parallel with its external margin its whole extent. The semimembranosus, semitendinosus and gracilis, form the inner hamstring.

BICEPS FLEXOR CRURIS.

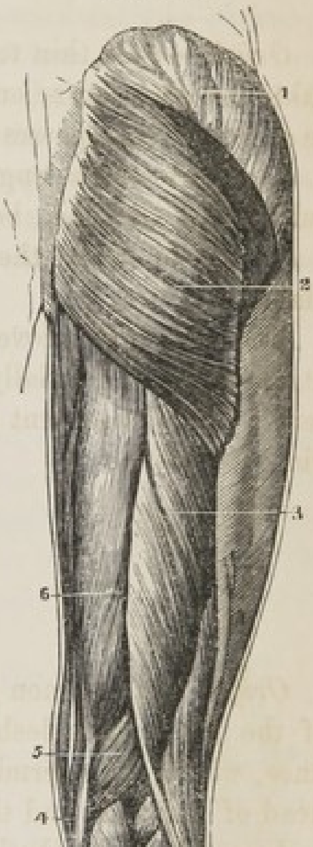
Origin—by two heads; the first, or long head, coming from the back part of the tuberosity of the ischium in common with the tendon of the semitendinosus; the second or short head arising, fleshy from the linea aspera below the gluteus maximus. These heads unite a little above the external condyle.

Insertion—tendinous in the upper and outer part of the head of the fibula.

Action—to bend the leg. Fig. 182, 3.

Fig. 182. Muscles of the back of the thigh; 1, gluteus medius; 2, gluteus maximus; 3, biceps flexor cruris; 4, tendon of semitendinosus; 5, semimembranosus; 6, semitendinosus.

Fig. 182.



Muscles of the back of the thigh.

Remarks.—The biceps is covered by the gluteus maximus and fascia lata; and a synovial bursa separates its tendon from the proximate part of the sartorius. It covers the semitendinosus, semimembranosus and vastus externus; and below it more or less conceals the popliteal artery and vein. The great sciatic nerve is at first seen behind the biceps, then in front, and lastly on the inner side of the muscle. The biceps constitutes the outer hamstring, and thus forms the external boundary of the popliteal region.

MUSCLES OF THE LEG.

1. ANTERIOR CRURAL REGION.

TIBIALIS ANTICUS.

Origin—tendinous from the head of the tibia between its tubercle and the fibula, and from the interosseous ligament more than half way down, sending

off a long, round tendon that passes under the annular ligament in front of the malleolus internus, and over the astragalus and naviculare.

Insertion—into the front of the internal cuneiform bone on the sole of the foot.

Action—to bend the foot and turn the sole obliquely inwards. Fig. 183, 6.

Remarks.—This muscle is covered by the fascia of the leg, from which it derives much of its origin. Behind it are the tibia and interosseous ligament; and below the ankle joint and tarsus. The tibia constitutes its inner boundary; on its outside it has the extensor longus digitorum and extensor proprius pollicis muscles, and the anterior tibial vessels.

EXTENSOR LONGUS DIGITORUM.

Origin—by tendinous and fleshy fibres from the upper and outer part of the head of the tibia, and from the head and anterior spine of the fibula nearly the whole length of that bone; also, from the fascia of the leg and the interosseous ligament. Having split into four tendons, these pass under the annular ligament and along the upper part of the foot.

Insertion—by flat tendons into the base of the first phalanx of each of the four lesser toes, and thence by a tendinous expansion into the base of the last phalanx.

Action—to extend the four lesser toes, and to flex the foot. Fig. 183, 7.

Remarks.—It is covered in front by the fascia cruris and integuments, and below by the annular ligament. It rests, behind, on the fibula, tibia and interosseous ligament. It has the peroneal muscles on its outside, and the tibialis anticus and extensor proprius pollicis within.

Fig. 183.

Fig. 183. Muscles of the leg and foot. 1, biceps flexor cruris; 2, vastus externus; 3, 3, gastrocnemius; 4, soleus; 5, tendo achillis; 6, tibialis anticus; 7, extensor longus digitorum pedis; 8, extensor proprius pollicis; 9, peroneus tertius; 10, peroneus longus; 11, peroneus brevis; 12, adductor minimi digiti; 13, extensor brevis digitorum; 14, interosseus dorsalis.

EXTENSOR PROPRIUS POLLICIS PEDIS.

Origin—by tendinous and fleshy fibres from the front of the fibula three or four inches below its head, and from that bone almost to the ankle. The fibres unite obliquely with the tendon, which passes through the annular ligament and over the astragalus and scaphoides.

Insertion—tendinous into the base of each phalanx of the great toe.

Action—to bend the great toe and bend the ankle joint. Fig. 183, 8.

Remarks.—This muscle is connected at its outer surface with the extensor digitorum communis; internally and above, with the tibialis anticus and anterior tibial vessels. It passes through a distinct groove of the annular ligament; it has the fascia of the leg in front, and behind, the interosseous ligament, the tibia and fibula and ankle joint.

2. PERONEAL REGION.

PERONEUS TERTIUS.

Origin—from the middle of the fibula in common with the extensor longus digitorum with which its fibres are inseparably blended. It runs down to the malleolus externus and forms a tendon that passes under the annular ligament.

Insertion—into the base of the metatarsal bone of the little toe.

Action—to assist in bending the foot. Fig. 183, 9.

Remarks.—Behind it are the fibula, interosseous ligament and peroneus brevis. It is covered on its outside by the fascia of the leg; and its inner margin is blended with the fibres of the extensor digitorum communis. It passes under the annular ligament with the last named muscle, where both are furnished with a synovial bursa.

PERONEUS LONGUS.

Origin—tendinous and fleshy from the head of the fibula in front, and fleshy from the outer margin of that bone to within three or four inches of the ankle; the fibres taking a penniform course, end in a long, round tendon that passes in a groove of the malleolus externus. From thence it runs to the sinuosity of the os calcis and in a groove of the os cuboides, until it finally reaches the middle of the sole.

Insertion—tendinous into the outside of the base of the metatarsal bone of the great toe and into the internal cuneiform bone.

Action—to extend the foot and incline the sole obliquely outwards. Fig. 183, 10, and Fig. 189, 7, 8.

Remarks.—It is curved externally by the fascia of the leg; its inner surface is in contact with the fibula and peroneus brevis. Behind and above it has the soleus, and the flexor longus pollicis below.

PERONEUS BREVIS.

Origin—from the outside of the fibula above its middle, and thence to the malleolus externus. The fibres run to an external tendon, which becomes round and passes behind the outer angle in the same groove of the malleolus that lodges the tendon of the peroneus longus. It then goes through the superficial fossa on the outer surface of the os calcis, having a sheath proper to itself.

Insertion—into the outer margin of the base of the metatarsal bone of the little toe.

Action—to assist the peroneus longus, in drawing the foot outwards and outer edge upwards. It also has some influence in extending the foot. Fig. 183, 11.

Remarks.—It is covered by the peroneus longus and common fascia, and it covers the fibula and external surface of the os calcis. It is also in contact with the extensor longus digitorum; peroneus tertius and flexor longus pollicis.

3. POSTERIOR CRURAL REGION.

Superficial Layer.

GASTROCNEMIUS EXTERNUS.

Origin—by two heads, one tendinous, from the back part of the internal condyle of the os femoris, and fleshy from the ridge leading to the linea aspera; the other head is derived broad and tendinous from the external condyle and the contiguous ridge. From this double origin a fleshy belly is formed a little below the joint, at which place the muscular fibres are connected with a posterior, medial tendon. About the middle of the tibia a broad, thin tendon is given off, which tapers as it descends and just above the ankle joins that of the gastrocnemius internus. Fig. 184, 1 to 9.

Remarks.—It is covered by the fascia of the leg; and it rests within on the popliteus, plantaris, and soleus muscles. Where its two heads pass over the condyles of the femur, synovial bursæ are interposed. Cruveilhier remarks that he has often found, in the upper part of the tendon of each head, a sesamoid bone that glides on the back of the condyle. Synonym—*gemelli suræ.*

GASTROCNEMIUS INTERNUS.

Origin—beneath the former muscle and also by two heads, one from the back part of the head of the fibula and contiguous body of that bone; the other from the back of the tibia below the popliteus, and about four inches of the internal angle of the tibia. The fibres of this muscle run obliquely downwards and inwards from each side, in a penniform manner, and are continued almost to the end of the tibia, when the tendon is united with that of the gastrocnemius externus to form the tendo-achillis.

Insertion—into the posterior and lower surface of the os calcis.

Action—to draw up the heel, and thereby extend the foot on the leg.

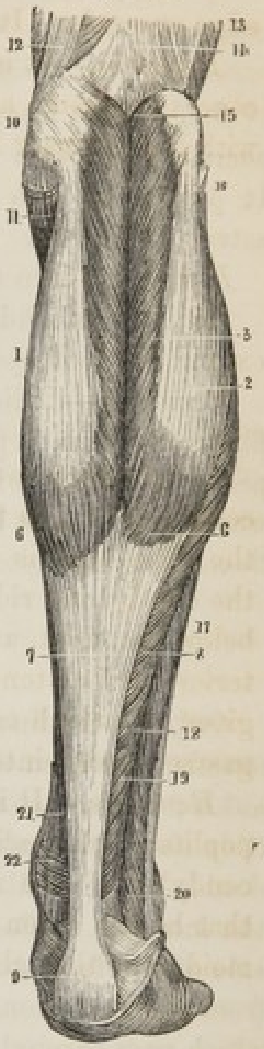
Remarks.—The soleus is covered by the gemellus and crossed by the plantaris muscles. In front of it are the tibia and fibrila, peroneus longus, flexor longus pollicis, tibialis posticus and flexor longus digitorum. It also conceals the posterior tibial and fibular vessels and nerves.

The *tendo achillis* is formed from the conjoined tendons of the two gastrocnemii and plantaris, and consequently is placed at the posterior and lower part of the leg. It is a long and remarkably robust structure, broader above than below, and lies directly beneath the fascia and integuments. Before its insertion

into the base of the os calcis, it plays over the posterior margin of that bone, forming a triangular facet which is provided with a synovial bursa. Synonym—*soleus.*

Fig. 184. Muscles of the back of the leg. 1, 2, the two bellies of the gastrocnemius muscle; 3, median raphæ into which its fibres are inserted; 6, 6, termination of the fibres in the common aponeurosis, 7, which unites with that of the soleus 8, to form, at 9, the tendo-achillis; 10, internal condyle of the femur; 11, tendon of the semimembranosus; 12, tendon of the adductor magnus; 13, inferior extremity of the vastus externus; 14, fascia covering the joint; 15, origin of the plantaris muscle; 17, tendon of the biceps; 18, peroneus brevis; 19, flexor longus pollicis; 20, peroneus longus; 21, tendon of flexor longus digitorum; 22, posterior annular ligament.

Fig. 184.



Muscles of the back of the leg.

PLANTARIS.

Origin—fleshy from the upper and posterior part of the external condyle of the femur, and from the capsular ligament of the knee-joint. A little below the latter it ends in a long, slender tendon, which passes down between the inner heads of the gastrocnemii muscles, and as low as the point of their junction; after which the tendon of the plantaris pursues its course on the inside of the tendo-achillis to its termination.

Insertion—into the inner side of the os calcis at its posterior part, and below the tendo-achillis.

Action—to assist in extending the foot; but though sometimes double it is occasionally deficient; and under the most favorable circumstances its agency must be extremely feeble. Fig. 184, 15.

Deep-seated Layer.

POPLITEUS.

Origin—by a round, delicate tendon from the external and under part of the outer condyle of the os femoris, and from the capsular ligament behind. Its fleshy fibres run inwards and downwards over the joint and are covered by an aponeurotic expansion.

Insertion—fleshy, into a ridge at the inner and upper end of the tibia a little below its head.

Action—to bend the leg and keep the capsular ligament tense. It also rotates the leg inward.

Remarks.—The popliteus is covered by an expansion from the semimembranosus muscle, and by the gastrocnemius and plantaris. It is also crossed by the popliteal vessels and the sciatic nerve.

FLEXOR LONGUS POLLICIS PEDIS.

Origin—by a tendinous and fleshy slip from the posterior face of the tibia, commencing three inches below its head and continuing almost to the ankle. It passes through a groove in the tibia behind, and in another groove of the astragalus.

Insertion—into the last joint of the great toe.

Action—to bend the second phalanx of the great toe upon the first, and to extend the foot upon the leg. Fig. 184, 19, and 189, 1 to 4.

Remarks.—It lies beneath the soleus and the tendo-achillis. It covers the fibula, the tibialis posticus and lower part of the interosseous ligament, and the peroneal artery is in contact with it. At the outside of the leg it is associated with the peroneus longus and peroneus brevis; and at its inner margin lies the flexor longus digitorum.

FLEXOR LONGUS DIGITORUM PEDIS.

Origin—tendinous and fleshy from the back of the tibia below the popliteus muscle, and from the inner edge of the bone by short fleshy fibres nearly to the ankle; it also arises by tendinous and fleshy fibres from the outer edge of the tibia above the ankle-joint, and the tibialis posticus is interposed between this double range of fibres. A tendon is now formed and runs in the groove behind the internal malleolus, and thence through the sinuosity of the os calcis to the sole of the foot about its middle. At this point it receives an accessory tendon from the flexor longus pollicis, and immediately after separates into four tendons which pass through the slits of the flexor brevis digitorum.

Insertion—into the base of the third phalanx of the four smaller toes.

Action—to bend the four smaller toes and to extend the foot. Fig. 189, 10, 11.

Remarks.—It is covered by the soleus, between which and the flexor longus pass the posterior tibial vessels and nerves. Its anterior margin lies upon the tibia and overlaps the tibialis posticus muscle. In the foot it is covered by the flexor brevis digitorum and adductor pollicis.

TIBIALIS POSTICUS.

Origin—from the upper end and front of the tibia, below the process that joins it to the fibula, whence it passes through the opening in the interosseous ligament and continues its origin from the back part of the fibula and tibia two-thirds of the way down, and from the interosseous ligament. The fibres run towards a middle tendon which becomes round, and passes in a groove of the internal malleolus.

Insertion—partly into the inner surface of the naviculare and partly into the under surface of the tarsal bones by separate slips, one of which is attached to the root of the metatarsal bone of the middle toe.

Action—to extend the foot and turn the toes inwards. Fig. 189, 12, 13.

Remarks.—It is covered by the flexor longus digitorum and flexor longus pollicis and soleus within; it rests on the interosseous ligament, the tibia and fibula.

MUSCLES OF THE FOOT.

1. DORSAL REGION.

EXTENSOR BREVIS DIGITORUM PEDIS.

Origin—fleshy and tendinous from the anterior and outer part of the os calcis: a fleshy belly is formed that soon after divides into four portions that give off corresponding tendons on the top of the foot, beneath those of the peroneus tertius.

Insertion—by its four slender tendons into the great toe and the three next toes, by joining with the tendons of the extensor longus which is expanded over them.

Action—to extend the toes. Fig. 188, 1, 2, 3.

Remarks.—It is crossed by the tendons of the extensor longus digitorum and extensor longus pollicis. The dorsal artery of the foot runs for a short distance along the inner margin of this muscle.

DORSAL INTEROSSEI.

The interosseous muscles are seven in number, four being in the dorsum of the foot and three on the sole: the latter series, called interni, arise by single heads; while the former, or externi, have a double origin. They have a common insertion by very slender tendons into the membranous expansion sent off from the extensor muscles of the toes. The four external interossei are the following:

1. ABDUCTOR INDICIS PEDIS.

Origin—from the opposite margins of the metatarsal bones of the great and the second toes, filling the space between them.

Insertion—into the inner side of the base of the first phalanx of the second toe.

Action—to draw the second or fore-toe inwards, and from the other toes. Fig. 185.

2. ADDUCTOR INDICIS PEDIS.

Origin—from the contiguous margins of the metatarsal bones of the first and second toes.

Insertion—into the outer side of the first phalanx of the second toe.

Action—to draw the second toe outwards. Fig. 185.

3. ABDUCTOR MEDII DIGITI PEDIS.

Fig. 185.

Dorsal interossei.

Origin—from the contiguous margins of the metatarsal bones of the third and fourth toes.

Insertion—into the outside of the base of the first phalanx of the third toe.

Action—to draw the third or middle toe outwards. Fig. 185.

4. ABDUCTOR QUARTI DIGITI PEDIS.

Origin—from the metatarsal bones of the fourth and fifth toes between their upper, contiguous margins.

Insertion—into the outside of the root of the first phalanx of the fourth toe.*

Action—to draw the fourth toe outwards. Fig. 185, 186.

Fig. 185. Dorsal interossei. 1, first metatarsal bone; 2, 2, interosseous muscles; 3, 3, 3, 3, their tendinous insertion into the first phalangeal bones.

2. PLANTAR REGION.

First Layer.

FLEXOR BREVIS DIGITORUM PEDIS.

Origin—by a narrow fleshy slip from the greater tuberosity of the os calcis, and from the upper surface of the aponeurosis plantaris, forming a thick belly which separates at the middle of the metatarsal bones, into four tendons. These tendons are split for the passage of the tendons of the flexor longus.

Insertion—into the sides of the second phalanges of the four smaller toes.

Action—to bend the second joint of the toes. Fig. 186, 6, 7.

Remarks.—Within, it is associated with the plantar fascia; externally with the flexor accessorius, the tendons of the flexor longus digitorum and the lumbricales. Synonym—*flexor perforatus.*

ABDUCTOR POLLICIS PEDIS.

Origin—tendinous and fleshy from the internal part of the greater tuberosity of the os calcis, and from the os naviculare and cuneiforme internum.

Insertion—tendinous into the inner sesamoid bone, and first phalanx of the great toe.

Action—to draw the great toe from the others, and to flex it. Fig. 186, 1, 2.

Remarks.—It is covered by the skin and fascia of the foot.

* It will be observed that the toes are here enumerated from one to five, beginning with the great toe.

ABDUCTOR MINIMI DIGITI PEDIS.

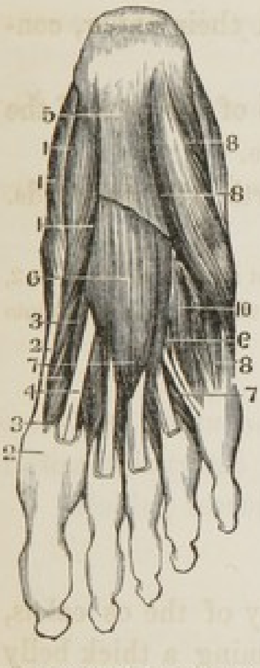
Origin—tendinous and fleshy from the external tubercle, the os calcis, and from the base of the metatarsal bone of the little toe at its outer margin.

Insertion—by a rounded tendon into the outside of the base of the first phalanx of the little toe.

Action—to draw the little toe outwards from the others. Fig. 186, 8, 8.

Remarks.—It is covered below by the plantar fascia; above, it is in contact with the flexor accessorius and flexor brevis minimi digiti.

Fig. 186.

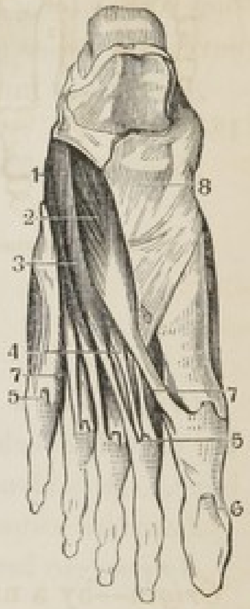


Plantar muscles of the foot.

Fig. 187.

Plantar muscles of the foot.

Fig. 188.



Dorsal muscles of the foot.

Fig. 186. Plantar muscles of the foot. 1, adductor pollicis; 2, 2, its tendon; 3, 3, flexor brevis pollicis; 4, tendon of flexor longus pollicis; 5, aponeurosis plantaris, divided; 6, 7, flexor brevis digitorum pedis; 7, lumbricales; 8, abductor minimi digiti; 9, flexor brevis minimi digiti; 10, interossei.

Fig. 187. Dissection of a second layer of the plantar muscles of the foot. 1, tendon of tibialis posticus; 2, tendon of flexor longus pollicis; 3, tendon of flexor longus digitorum; 4, point where it separates into four tendons; 5, points of insertion; 6, flexor accessorius; 7, calcaneo-cuboid ligament; 8, lumbricales pedis; 9, adductor pollicis; 10, flexor brevis pollicis; 11, tendon of peroneus longus; 12, flexor brevis minimi digiti; 13, interossei.

Fig. 188. Dorsal muscles of the foot. 1, 2, 3, extensor brevis digitorum pedis; 4, occasional supernumerary tendon; 5, tendons, cut off, of the extensor digitorum communis; 6, tendon, cut off, of the extensor proprius pollicis; 7, interossei muscles; 8, superior astragalo-scaphoid ligament.

Second Layer.

FLEXOR ACCESSORIUS.

Origin—fleshy at the inside of the sinuosity of the os calcis, and tendinous from the outer side of that bone in front of its tuberosities.

Insertion—into the tendon of the flexor longus digitorum before its subdivision.

Action—to flex the toes. Fig. 187, 6.

Remarks.—This muscle is also called *massa carnea Jacobi Sylvii.* It is associated below with the flexor longus digitorum, and above with the os calcis and the inferior calcaneo-cuboid ligaments.

LUMBRICALES PEDIS.

Origin—by four tendinous and fleshy slips from the tendon of the flexor longus digitorum pedis, just before its division.

Insertion—by four slender tendons into the inside of the first phalanx of the four lesser toes, and into the tendinous expansion sent off by the extensors to cover the upper part of the toes.

Action—to increase the flexion of the toes and to draw them inwards. Fig. 187, 8.

Remarks.—These muscles are covered below by the flexor brevis digitorum.

Third Layer.

FLEXOR BREVIS POLLICIS.

Origin—by a bifurcated head, one part coming from the under surface of the os calcis behind the cuboides, the other part from the external cuneiform bone. It is blended with the fibres of the abductor and adductor pollicis.

Insertion—into the two sesamoid bones of the great toe.

Action—to bend the great toe. Fig. 187, 10.

ADDUCTOR POLLICIS PEDIS.

Origin—by a thin tendon from the under part of the os calcis and cuboides, from the external cuneiform bone, and from the roots of the metatarsal bones of the second and third toes.

Insertion—into the external sesamoid bone, and into the first phalanx of the great toe.

Action—to draw the great toe towards the others. Fig. 187, 9.

FLEXOR BREVIS MINIMI DIGITI.

Origin—tendinous from the cuboid bone and the calcaneo-cuboid ligament and from the base of the metatarsal bone of the little toe.

Insertion—into the first phalanx of the little toe at its base, and into the head of the metatarsal bone of the same toe.

Action—to bend the little toe. Fig. 187, 12.

TRANSVERSALIS PEDIS.

Origin—tendinous from the capsular ligament of the first joint of the little toe, and of the toe next adjoining, forming a fleshy belly that runs between the metatarsal bones and the flexor muscles of the four smaller toes.

Insertion—into the metatarsal bone of the great toe and into the adjacent external sesamoid bone.

Action—to bring the heads of the metatarsal bones together.

Fig. 189.

Tendons of the sole of the foot.

Fig. 189. Tendons of the sole of the foot. 1, flexor longus proprius pollicis; 2, point where its tendon enters its sheath, under the arch of the os calcis; 3, 4, its course under the plantar arch to the great toe; 5, peroneus brevis; 6, insertion of its tendon into the fifth metatarsal bone; 7, tendon of the peroneous longus, passing under the outer ankle; 8, angle formed by the latter tendon on the facet of the os cuboides; 9, its attachment to the head of the first metatarsal bone; 10, flexor longus digitorum pedis; 11, division of its tendon into four slips for the four lesser toes; 12, tendon of the tibialis posticus; 13, its insertion into tuberosity of the os scaphoides.

Fourth Layer.

PLANTAR INTEROSSEI.

The internal interosseal muscles are the following:

1. ABDUCTOR MEDI DIGITI PEDIS.

Origin—from the inside of the metatarsal bone of the third or middle toe.

Insertion—into the inside of the root of the first phalanx of the middle toe.

Action—to draw the middle toe inwards, and from the other toes. Fig. 190.

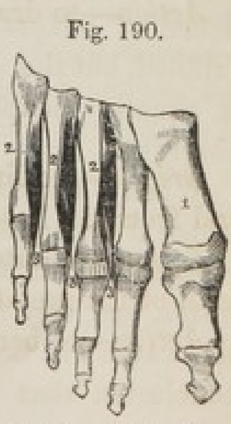
2. ADDUCTOR QUARTI DIGITI.

Origin—in the sole of the foot, from the inside of the metatarsal bone of the fourth toe.

Insertion—into the inside of the base of the first phalanx of the fourth toe.

Action—to draw the fourth toe inwards. Fig. 190.

Fig. 190.



Plantar interossei.

3. ADDUCTOR MINIMI DIGITI.

Origin—from the inner margin of the base of the metatarsal bone of the little toe.

Insertion—into the inside of the base of the first phalanx of the little toe.

Action.—to draw the little toe inwards. Fig. 190.

Fig. 190. Plantar interossei. 1, metatarsal bone of the great toe; 2, 2, 2, interosseous muscles; 3, 3, 3, their insertion into the first phalanx.

MUSCULAR ACTION.

THE power by which the various movements of the animal system are effected, is derived from the muscles. These possess a property peculiar to themselves, termed *muscular contractility* or *myotility*. All muscular tissues, during the life of the animal to which they belong, and even for some time after death, may be made to contract on the application of certain stimuli. If, for example, the motor (efferent) nervous trunks in a living animal be irritated by a pointed instrument or the application of an acid, contractions will be excited in the muscles to which such nerves are distributed. In cold-blooded animals the same results are found to take place for many hours after death. A galvanic shock will frequently excite contractions, long after the muscular fibre has ceased to be susceptible to every other kind of irritation. Perhaps, however, the most interesting and remarkable exhibition of contractility, is that which occurs in the organs of animal life under the influence of volition. How we have the power of exciting at will the muscles in different parts of the body, sometimes one or two at a time and sometimes a multitude together, according as it may best serve the purpose we desire to accomplish; or why indeed the muscular tissue, more than any other, should be endowed with this peculiar power of contraction—are questions which it would be as difficult to answer, in the present state of physiological science, as to point out the original cause of gravitation, or any other of those ultimate principles or laws, for the existence of which, the best and only reason we can render, is, that the Creator has seen fit to establish them as important parts in the great economy of nature. The physiologist may indeed perceive in the muscles, as in other parts of the body, the clearest evidence of adaptation as *instruments* to the particular office intended to be fulfilled, but the *ultimate power* by which these instruments are made to operate, is equally inexplicable by the profoundest philosopher and the unscientific observer.

When a muscle contracts, it increases in thickness, so that the actual space which it occupies is nearly the same, whether it be in a state of contraction or relaxation. If an arm be plunged into a deep and narrow vessel or tube of water, properly fitted for the purpose, and the muscles be forcibly contracted, the water will be seen to descend. But this experiment does not justify the conclusion that the muscles themselves, when contracted, occupy less space

than before; since in consequence of the violent contraction, the arterial blood would necessarily be in a great measure prevented from entering the arm, at the same time that the venous blood would be expelled; and this perhaps might fully account for whatever diminution is observed.

The general property of contractility is divided by physiologists into *irritability* and *tonicity*. By the former is meant that susceptibility of being excited to *motion* by different stimuli, which exists in the muscular fibre during life and immediately after death. The latter denotes that *fixed* and moderate contraction which the muscles of a living animal often exhibit when not excited by any particular stimulus, as well as that peculiar rigidity (the *rigor mortis*) which takes place after death.

Irritability.—The contractions resulting from irritability are always found to alternate with frequent relaxations. This is manifested in the beating of the heart, and is also shown by the fact that it is impossible to keep any of the muscles of the body constantly on the stretch for any considerable length of time. Indeed, during the state of intense contraction, the muscular fibres are continually undergoing partial and momentary relaxations, whence arises the impossibility we experience in holding, even for a minute, a heavy body *steadily* at arm's length, or, in fact, of supporting by the power of the muscles alone, a great weight in a state of *perfect immobility* for any length of time, whatever be the position of the limbs, or whatever muscles be called into action. There is reason to believe, moreover, that when a muscle is contracting, all its fasciculi are not on the stretch at once, but that there is a constant interchange in the state of the different parts, some relaxing while others are shortening.*

When a piece of muscle is viewed under the microscope, it often exhibits irregular waving lines, which has led some writers to suppose that in contraction, a muscular fibre always assumes a zigzag course, again becoming straight as elongation takes place; and that this crooking and straightening of the fibres is in fact the cause of the shortening and lengthening of the muscles. But this point is far from having been established. It does not appear that the zigzag course alluded to, is uniformly exhibited in the contraction of muscular fibres. Messrs. Todd and Bowman, who have evidently examined the subject with great care, consider this zigzag or wavy appearance to be produced by some external cause, either directly disturbing the natural course of the fibres, or else restraining their free contraction, and thus occasioning the irregularity in question.†

It has already been intimated that the muscles retain their irritability after the general death of the system, that is, after circulation has ceased without the power of renewal; and that this form of contractility continues longer in cold-blooded animals than in others. As a general rule, the duration of contractility in such cases is in inverse proportion to the amount of respiration. Thus the muscles of birds, whose respiration is highest, lose this peculiar susceptibility sooner than those of mammals, while the irritability of these again, is of shorter

* Todd and Bowman's Phys. Anat., pp. 182, 183. Carpenter's Elements of Physiology, § 232.

† Phys. Anat., p. 186.

duration than that of reptiles and fishes. Much also appears to depend on the *kind* of death to which the animal is subjected. When this results from any sudden and severe injury of one of the great nervous centres, for example, from the instantaneous destruction of the brain or the spinal cord, from a violent blow on the stomach, or from electricity, the whole vitality of the system seems to be destroyed at once, so that the muscles lose immediately or in a few moments all their susceptibility, and cannot afterwards be excited by any artificial means.*

The energy of muscular contraction appears to depend in a great measure on the supply of oxygenated (arterial) blood. When a ligature is applied to a large arterial trunk, there results not only a deficiency of sensibility in the part to which the artery is distributed, but also a partial or complete suspension of muscular power, until the collateral circulation is established.† We find that in birds and insects, whose respiration is most extensive in proportion to their size, the muscular power is more remarkable than in any other animals. In the mammalia it is somewhat inferior, and in reptiles and fishes it is comparatively feeble. Hence it appears that the duration of muscular irritability after death is inversely as the energy possessed by the animal when alive; or in other words, that the muscles of those animals which are accustomed to the largest supply of oxygenated blood during life, soonest lose their vitality when this supply is withheld, which must necessarily happen from the cessation of the circulation at death. In connection with this subject, it may be observed that those affections of the respiratory organs which occasion a deficient supply of oxygenated blood, are invariably attended by muscular debility.

Some physiologists have entertained the opinion that the power of muscular contractility is either derived from the nerves, or at least, in a great measure, dependent on them; and that all stimuli which excite the muscles to contraction, first operate on the nervous filaments which are distributed in the muscular tissue, and through these act upon the muscles themselves. To the nervous system, undoubtedly during life, is delegated the power of exciting, directing and restraining the action of the muscles, yet there appear to be sufficient reasons for believing that the property in question is no more dependent for its existence on the nervous system, than that the latter is dependent for its existence on the will, by which many of its operations are controlled. Not only is contractility sometimes seen in muscular fibres completely insulated from all other tissues,‡ (those, for example, exhibited under the microscope,) but the same general property is found to exist in plants, in which we are unable to discover the slightest traces of a nervous system. It would appear that muscular activity is directly dependent upon the stimulus and nutrition derived from the blood, in a far greater degree than upon nervous influence. The action of the heart may be kept up a long time after the destruction of the brain and spinal marrow, by taking care that the current of blood supplying that

* Horner's Anat. and Histol., vol. i. pp. 405–6, and Todd and Bowman's Phys. Anat., p. 189.

† Carpenter's Elements of Phys., § 583.

‡ Todd and Bowman's Phys. Anat., p. 174.

organ be uninterrupted. The debility and shriveling away of the muscles which sometimes ensue, when the nerves distributed to such parts have been divided or otherwise rendered incapable of conveying their appropriate stimulus, are rather to be attributed to the deficiency of nutrition, resulting from a want of exercise and healthy circulation in the muscles, than to any direct loss of vitality from the absence of nervous influence. This has recently been shown by the experiments of Dr. J. Reid. "The spinal nerves were cut across as they lie in the lower part of the spinal canal, in four frogs; and both posterior extremities were thus insulated from their nervous connections with the spinal cord. The muscles of one of the paralyzed limbs were daily exercised by a weak galvanic battery; while those of the other limb were allowed to remain quiescent. This was continued for two months; and at the end of that time, the muscles of the exercised limb retained their original size and firmness and contracted vigorously, while those of the quiescent limb had shrunk to at least one-half of their former bulk, and presented a marked contrast with those of the exercised limb. The muscles of the quiescent limb still retained their contractility even at the end of two months, but there can be but little doubt that from their imperfect nutrition and the progressing changes in their physical structure, this would in no long time have disappeared had circumstances permitted the prolongation of the experiment."*

From the late experiments of Professor Matteucci, of Pisa, it appears that both in the muscles of living animals, and of those recently killed, there exists an electrical current which is directed from the interior to the surface. The result is the same whatever particular muscle or animal be operated on, and even if the muscle be separated from the rest of the body. The indications of an electric current remain longest in those animals in which muscular contractility lasts longest. In fish and reptiles this phenomenon has been observed by Professor Matteucci to last several hours.†

From the power possessed by electricity of exciting the action of the muscles, long after all appearance of vitality has departed and they have ceased to respond to every other species of stimulation, from the analogy between the well-known velocity of the electric fluid and the rapidity with which the mandates of the will are communicated to the remotest parts of the body, and the various sensations are returned from these parts to the brain, and from the fact that several animals, for example the *torpedo* and the *gymnotus electricus*, possess the power of producing galvanic shocks, apparently by a mere effort of volition,—some writers have hastily adopted the theory that the various phenomena both of sensation and motion are caused by some modification of electricity. That such a theory is untenable, may be shown by the following facts:—1st. It is well known that the conducting power of a nerve is destroyed, not only by dividing the trunk (the ends cut being still allowed to remain in contact), but by putting a ligature around it; neither of which processes would materially diminish its power as a conductor of electricity. 2d. There is the strongest reason

* Carpenter's Elements of Physiology, § 589, *b*.

† Todd and Bowman's Physiological Anatomy, pp. 375-6-7.

to believe that the nervous influence does not pass from one set of nerve-fibres to another, but is restricted through its whole course to its own particular fibre or fasciculus of fibres: it is well known that electricity cannot be thus restricted. 3d. If a piece of nerve be cut out, and the two remaining parts be connected by a metallic conductor, electricity will pass quite as freely as before, but no nervous influence will be propagated from the portion above the section to that below. 4th. From the experiments of Prof. Matteucci, it appears that the conducting power of nerve is considerably inferior to that of muscle, and both according to Messrs. Todd and Bowman, are "*infinitely worse* conductors than copper." Hence if the nervous power were in reality electricity, so far from being limited to its own fasciculus of fibres, it would not be confined to the nerve at all, but in obedience to a well-known law, would leave its appropriate channel, the nerve, and pass into the surrounding muscle, this being the better conductor; and in case a metallic conductor were placed in contact with the part, it would pass from the muscle also, leaving both nerve and muscle destitute of nervous power, or, in other words, completely paralyzed. Lastly, although the presence of electricity in the nerves during their active state, would not necessarily argue the identity of electricity and the nervous power (any more than the presence of moisture would tend to establish the identity of water and the nervous power), yet the entire absence of all the well-known and certain indications of electricity in any of the nerves during their excitement, cannot but be regarded as a powerful argument against the identity in question. All attempts to prove the existence of an electric current in a nervous trunk that is actively engaged in conveying motor influence, have completely failed, though made with the greatest precaution. Thus Matteucci has lately experimented upon the very large crural nerve of a horse, which was caused by stimulating the roots to throw the muscles of the leg into violent contraction; nevertheless, although he used instruments of such delicacy as to be capable of detecting an infinitesimally small disturbance of the electric equilibrium, no such disturbance was apparent.*

There is a marked difference in the action of the *striated* and that of the *non-striated* muscular fibre (or as Todd and Bowman term them, the "striped" and the "unstriped" fibre). When a fasciculus of striated muscle is irritated, that particular part instantly contracts, but the rest of the muscle remains relaxed as before. The only means of exciting the entire muscle to contraction, appears to be through the motor nerves, by which it is supplied. If, however, a fibre of non-striated muscle—one for example on the parietes of the intestinal canal—be stimulated, it does not contract so immediately, but the contractions are gradually extended to the neighboring fasciculi, and perhaps subsequently to a considerable portion of the viscus. The final cause of the difference alluded to, is obvious. No useful purpose could be answered by the contraction of one of the muscles of animal life in case of a slight mechanical irritation; on the contrary, it is evident that it must often be attended with serious disadvantage, by interfering with the prerogative of the will and producing unsteadiness in our

* Carpenter's Elements of Physiology, § 297.

movements, on occasions when steadiness might be of vital importance. On the other hand, when the intestinal canal is stimulated by any irritating matter acting on its internal surface, a considerable portion of the entire organ is excited to contraction in order to remove the cause of irritation. The effect of all cathartic medicines is undoubtedly owing at least in part to the operation of this principle.

It appears to be a generally received opinion among physiologists, that muscular fibres are active only when in a state of contraction, and that on the contractile force subsiding they become entirely passive. According to Messrs. Todd and Bowman, a muscle, when once contracted, is of itself incapable of recovering its previous length, but must remain in the same state until elongated by the power of antagonistic muscles, or by some extraneous force.

Tonicity.—Messrs. Todd and Bowman consider the *tonicity* of muscular fibre as synonymous with its *passive contraction.** They appear to comprehend under one term, that permanent contraction which is dependent upon muscular vitality, and that firmness or tone of the muscles which is due to the "mere quality of their tissue;" under which expression we understand to be included simple elasticity and other mechanical properties. Dr. Carpenter has justly (as it appears to us) drawn a distinction between the purely vital and the mechanical attributes of muscle.

According to his definition, tonicity is that "form of contractility which produces a constant tendency to contraction (varying, however, as to its degree) in the muscular fibre; but which is so far different from simple elasticity, that it abates after death before decomposition has taken place." This species of contractility is exhibited in the retraction which takes place in the ends of a living muscle when it is cut across, as in amputation. The difference between the tonicity and irritability of muscle, is also manifested by the fact that the former survives the latter, and that it is not destroyed by treatment which occasions a complete departure of irritability. The *rigor mortis* may be regarded as the final manifestation of this property, coming on, as it does, after the irritability of the muscles has departed, but before any putrefactive change has taken place. This phenomenon is rarely absent, though it may be so slight and may last so short a time as to escape observation.†

Energy, Rapidity and Extent of Muscular Contraction.—The energy or force with which a muscle contracts is, *cæteris paribus*, in proportion to the number of its fibres; the extent of contraction is in proportion to their length. When the fibres run longitudinally or nearly so, it may be said that the strength of a muscle is in proportion to its thickness or diameter. Should they, however, run obliquely, as in the *semimembranosus*, the strength of the muscle (in other words the number of its fibres) is proportioned to its length; but the length of its fibres and consequently their extent of contraction, is as a general rule in proportion to its thickness. Muscular energy is greatly

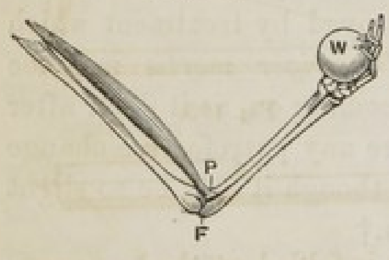
* Physiological Anatomy, p. 171.

† Carpenter's Elements of Physiology, §§ 193, 194, 195.

modified by the conditions under which it is called forth. It is not only dependent to a great extent on a proper supply of oxygenated (arterial) blood, but is also strikingly affected by the stimulus of the mind. Hence we find that persons of a comparatively feeble make, are sometimes, when under the influence of violent passion, more than a match for others of greatly superior muscular development. Sometimes, too, an energetic, determined *will* is sufficient to turn the scale of strength in favor of him who otherwise would be far inferior in physical energies. There can be but little doubt, however, that, as a general rule, mental stimulus has a much greater influence on the rapidity than on the mere force of muscular movements; and to this circumstance in all probability is chiefly due the extraordinary accession of strength which many persons appear to receive under the excitement of anger or insanity.

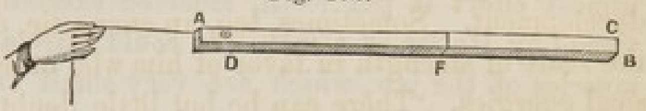
The power of a muscle may be regarded in two distinct lights, its *intrinsic* and its *effective* force. The intrinsic force of a muscle is the entire force which it is capable of directly exerting, under circumstances most favorable to its action. The effective force is that which it actually exerts under the mechanical disadvantages necessarily to be encountered in a structure, for the perfection of which, velocity, compactness, and a certain degree of beauty, are no less requisite than strength. The distinction attempted to be drawn may be rendered perfectly clear by the following illustration. The *biceps flexor cubiti* is a muscle which arises from the scapula, and passing down the humerus is inserted into the tubercle of the radius, about an inch and a half below the elbow-joint. On contraction it flexes the forearm. Suppose a weight placed in the hand be required to be raised by the action of this muscle. We have here in the arm, Fig. 191, a lever of the third kind (see Fig. 200, p. 266): the elbow-joint is the fulcrum, the part of the radius (F P) between the joint and the insertion of the biceps, is the power-arm, and the whole radius together with a part of the hand (F W), the weight-arm of the lever. Now, according to a law of mechanics, "as the power-arm (or distance from the fulcrum to the point where the power is applied), is to the weight-arm (the distance from the fulcrum to the weight), so is the weight to the power." Suppose the weight W to equal 20 lbs.: then as F P (an inch and a half) is to F W (about 15 inches), or as 1 to 10, so is 20 to 200. In this case the intrinsic force exerted by the biceps, is equal to 200 lbs., although the effective force is only equal to 20 lbs. If a weight of 50 lbs. be raised, the intrinsic power required in the biceps, would amount to 500 lbs. In giving these results, we have proceeded upon the supposition that the tendon of the biceps is inserted into the radius *at right angles*, but in fact this does not occur except at one particular point of flexion seen in Fig. 191. Now, in this and all similar cases, whenever the angle of insertion is greater or less than a right angle, the muscle labors under a mechanical disadvantage, and the greater the departure from a right angle the greater will be the loss resulting from such a disadvantageous application of

Fig. 191.



force. That this may be more readily understood, let us substitute for the arm two straight bars A B (Fig. 192) united by a hinge-joint F, which admits of being bent only in one direction; the utmost limit of motion in the opposite direction merely permitting the bars to be brought into the same line. In this example let A F represent the humerus, F the elbow-joint, F B the radius, and the cord A C the tendon of a muscle which contracts in the direction of C A.

Fig. 192.



Now, the bar A F being fixed by a spike at D, it is manifest that any force applied in the direction of C A (like a weight resting evenly on the top of a perpendicular beam or pillar), could not have the least effect in causing F B to incline from the straight line, which it now forms with A F. If, however, the joint be already slightly bent, as in Fig. 193, any force applied in the direction of C A, though principally expended on the joint itself, will have a tendency to incline the bar still further, and at every successive point of flexion, the loss of force will become less and less, till it entirely ceases when the cord C A meets the bar F B at right angles, (Fig. 194;) but immediately afterwards the loss again commences and arrives at its maximum, that is becomes infinite, when the bar F B is folded on F A (Fig. 195); for it is evident that in their present position, any traction on the cord, made in the direction of C A, can neither have the effect of pressing them together more firmly, nor of separating them, because all the force is exerted in a line precisely parallel to the bars themselves, and therefore would be expended on the joint F. From the above explanation, it will be seen that when the entire arm is straight or nearly so, or when the forearm is folded on the humerus as far as this is possible, the loss of muscular force must be very great. In fact when the arm is fully extended, the biceps muscle could not exert any effective power towards flexing it, were it not that, in consequence of the tendon passing near its insertion, over a considerable protuberance of the os humeri, the force is never applied in a line parallel to the direction of the arm, but always meets the radius at a considerable angle.—The angle of insertion being given, the loss of force resulting from any mechanical disadvantage of this kind, may be determined with mathematical precision; but for full information on this and similar questions, we must refer the reader to

Fig. 193.

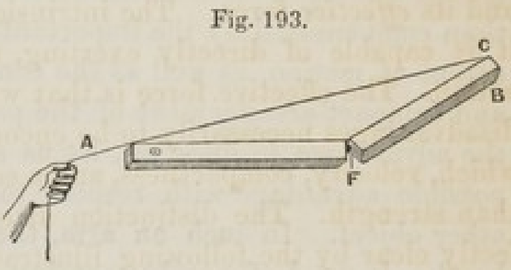


Fig. 194.

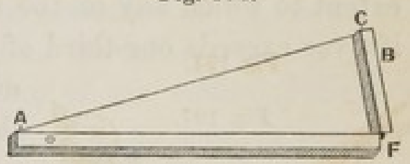


Fig. 195.

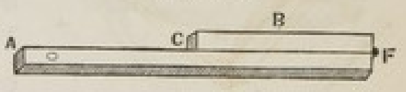
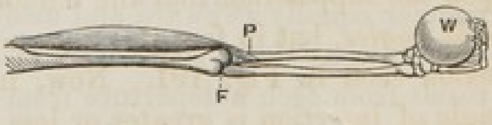


Fig. 196.

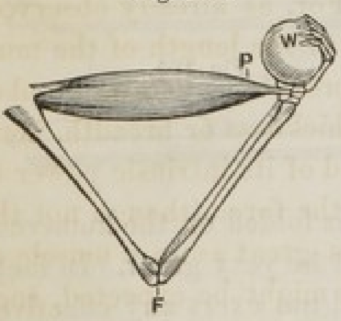


other works, as our narrow limits will not permit us to dwell longer on this part of our subject.*

From what has been said, it will be evident that the intrinsic force exerted by the biceps and other muscles of the arm, when in a robust person their utmost effort is put forth, must be exceedingly great. An instance is mentioned by Haller of a man who could raise a weight of 300 lbs. by the elevator muscles of the jaw, which are very small and feeble compared with many, in other parts of the body. And yet owing to the mechanical loss of power arising from the insertion of those muscles, the intrinsic force required would be about 900 lbs. When a man raises a weight of 200 lbs. by the flexor muscles of his arms, the intrinsic force exerted is probably not less than 2000 lbs.

The disadvantage incurred by the insertion of the biceps and many other muscles, so near the fulcrum and so far from the point of resistance, is more than compensated by the important advantages of superior velocity and greater extent of motion, as well as the convenience and beauty resulting from an even and compact arrangement of the parts. That we may more clearly appreciate the advantages in question, let us suppose an arm formed so as to afford every possible advantage with respect to muscular strength, without regard to any other object. In such an arm, the biceps must be inserted into the wrist or hand. Instead of merely covering, as it does now, the front of the humerus, it must be extended the length of the entire arm, thus materially interfering with the room allotted to the muscles properly belonging to the forearm. It would not answer to have it connected with the hand by a tendon as long as the radius, since this would not allow a sufficient extent of contraction. The utmost extent to which any of the straight muscles contract in the living body, rarely if ever exceeds one-third of the whole length of the muscle. Suppose it, however, to contract to one-half of its original length; this, in case the belly of the muscle extend to the wrist itself, would not permit the hand to be brought nearer the head of the humerus than is seen in Fig. 197; whereas by the arrangement actually existing, a contraction of about one-third of the length of the biceps is sufficient to move the forearm from its utmost extension, and fold it closely on the arm. As muscles in contracting gain in thickness what they lose in length, the biceps would assume the corpulent appearance here represented; and instead of lying close to the arm would be stretched across from the scapula to the wrist somewhat like the membrane of a bat's wing. Now suppose all the other muscles of the arm to be arranged in a manner equally awkward and unsightly, then cover the whole with integuments, and we may form some idea of the unwieldiness and deformity which would result from such a departure from the present structure of the muscular system. We have, however, omitted to mention one important disadvantage which would

Fig. 197.



* Those who desire a clear and complete exposition of this whole subject, may be referred to Dr. Dunglison's interesting and excellent work on Human Physiology, vol. i. p. 383, *et seq.*

arise from inserting the muscles so far from the joints, the diminution of velocity that such an arrangement must unavoidably cause. By the insertion of the biceps so near the fulcrum of the radius, when it contracts one inch, it moves the hand ten inches; by contracting two inches, it will move the hand twenty inches, and so on; but if it were inserted into the wrist, the motion of the hand would not sensibly exceed the motion of the muscle itself.

The force of a muscle is materially modified by the direction in which the fibres run and the manner of their insertion into the tendon. When the fibres run parallel to each other in the direction of the muscle's length, they are capable of exerting a greater force, and to a greater extent, than an equal number of fibres of the same length arranged in any other manner whatever. Let us suppose, for the sake of illustration, a *bipenniform* muscle with the fibres inserted precisely at right angles into the tendon which runs lengthwise through it. It is manifest in this case, that the fibres on the two sides of the tendon, acting, as they must do, directly against each other, could exert no force whatever in the direction of the length of the muscle; since this could only be rendered *narrower* but not *shorter* by the contraction of its fibres. The same general remark would be true of a *penniform* or a *semipenniform* muscle, (as it is sometimes termed.) If, again, we suppose the fibres to be a very little inclined, the principal part of the force would indeed be lost, but as the fibres on one side do not operate directly against those on the other side, the muscle would be shortened as well as made narrower by contraction; and consequently some little force would be exerted in the direction of the muscle's length. When, however, the inclination of the fibres is considerable (as is invariably the case with the penniform and bipenniform muscles of the body), the force exerted by the muscle is sometimes very great. In such cases, the loss of power necessarily incurred by the indirect insertion of the muscular fibres, is compensated by the greater number of the fibres. For, as already observed, the number of fibres in such a muscle is in proportion to the length of the muscle. In the semimembranosus, for example, there are probably a greater number of fibres than in any other muscle of three times its thickness or breadth, composed of longitudinal fasciculi; and if we allow one-third of its intrinsic power to be lost by the unfavorable insertion of its fibres, still the force (though not the *extent*) of its contraction, would be more than twice as great as in a muscle of the same size, composed of longitudinal fasciculi. As might be expected, such muscles are found in situations where force rather than extent of contraction is required, and where a very short and thick muscle would materially impair the convenient shape and graceful proportions of the limb.

The rapidity or velocity of muscular contraction is quite distinct from its force. Indeed we find that large animals which excel in force, are generally inferior to small ones, in rapidity of muscular motion. Some idea may be formed of the velocity with which muscles sometimes contract, when it is considered that many persons can utter fifteen hundred letters in a minute; and as the relaxation of the muscles requires at least as much time as their contraction, a single contraction must be accomplished in the 3,000th part of a minute, or the

50th part of a second. There is indeed reason to believe, that in the wing-muscles of some insects while flying, more than 1,000 contractions take place in a single second.

As already intimated, the extent of contraction of the straight muscles in the living body, is rarely if ever more than one-third of their length when relaxed—in other words the muscles when contracted are reduced to about two-thirds of their ordinary length—but we are not hence to conclude that this is the utmost possible limit of their contraction. Todd and Bowman assert* that a muscle removed from the body will sometimes contract to one-third of its original length, an extent twice as great, as that mentioned above, as the usual limit of the contraction of *straight* muscles in the living body. It seems probable, however, that several of the *circular* muscles, such for example as the sphincter ani, are often contracted even to less than one-third of the extent which their fibres assume, when in their utmost relaxation.

It appears from experiment, that the contractile power of a muscle is greatest, when after perfect relaxation it first begins to contract, and that the farther it contracts, the feebler it becomes. It is therefore not improbable, that in the body, the attachments of the muscles are so arranged in relation to the osseous frame, that they shall never be brought too near to their ultimate limit of contraction, lest their action should become feeble and wavering, and incompatible with a steady and vigorous motion of the limbs in walking or running, or with a firm posture in standing.

Mechanical Contrivances in the Human Body.—In the structure of the human body, we find a multitude of contrivances similar to those employed in the mechanic arts.

In the first place there are the three kinds of levers.†

A lever of the first kind (Fig. 198) is one in which the fulcrum is between the power and weight or resistance. A lever of the second kind (Fig. 199) is one in which the weight is between the power and the fulcrum. In the third kind of lever (Fig. 200) the power is applied between the fulcrum and the weight. Fig. 201 represents an irregular mass of stone which is intended to show that a straight rod or bar with a weight of different substance from itself, is not essential to the character of a lever. In an ordinary lever of the first kind, it is obvious that the weight of the bar between the fulcrum and the power, co-operates with the power, and should in fact be considered a part of the

Fig. 198.

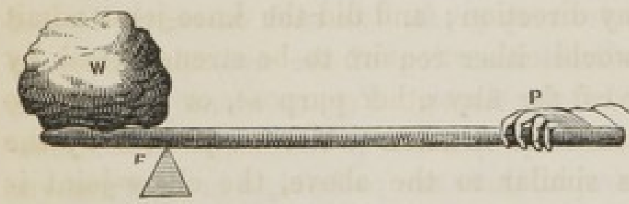


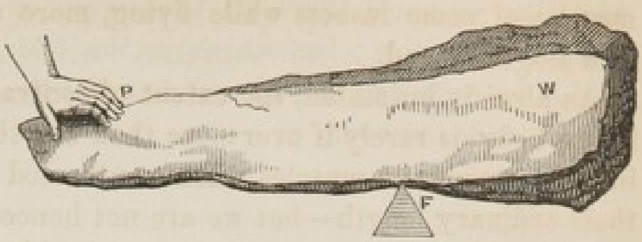
Fig. 199.

Fig. 200.

* Physiological Anat., p. 181.

† A lever is an inflexible rod or bar resting on or turning round a point called its *fulcrum* (*i. e.*, "prop" or "support"). Though a lever is usually defined to be a rod or bar, it is evident that an irregular mass of wood or stone (Fig. 201) resting on or turning round a point, might as truly—though not so neatly or clearly—exhibit the principle of this mechanical power, as anything of a more regular shape.

Fig. 201.



power; so the weight of the bar between the fulcrum and the resistance, is to be regarded as a part of the resistance. In the example before us, the whole mass of stone may be considered as the bar of the lever, the weight of that portion between the hand and the fulcrum forming a part of the power, and the weight of the opposite end beyond the fulcrum, constituting the entire resistance.

The balancing of the head upon the vertebral column affords an example of the first kind of lever: the muscles inserted into the occiput constitute the power, the atlas is the fulcrum, and the weight of the fore part of the head, the resistance to be overcome. In the foot, we have a lever of the second kind: in this instance, the gastrocnemius and soleus muscles terminating in the tendo-achillis, form the power, the weight of the leg and superincumbent body constitute the resistance, and the phalanges of the toes the fulcrum. We find, however, that in the action of a very large majority of the muscles of the body, the third kind of lever is employed: we have already given an instance of it in speaking of the flexion of the forearm by the biceps muscle. Almost any of the flexors or extensors of the different limbs, might be cited as illustrating the same form of mechanical power.

In the elbow and knee, are exhibited examples of a hinge joint. This species of articulation is employed in cases where a motion forwards or backwards is required, but where a motion from side to side would be useless or inconvenient. In the knee, no important advantage could be derived from the power of lateral flexion, since by means of the ball and socket joint at the hip, the whole leg can readily be swung in any direction; and did the knee-joint admit of being flexed from side to side, it would either require to be strengthened by several very strong muscles not needed for any other purpose, or it would be impossible to stand with anything like the firmness which we possess by the existing arrangement. For reasons similar to the above, the elbow-joint is capable of being flexed only in one direction, all other necessary motion in the arm being furnished by the ball and socket joint of the shoulder. Here, as well as in the knee, we see an exemplification of the rule which prevails in every part of the mechanism of the body—never to employ more means than are simply sufficient to accomplish the purpose in view. Undoubtedly the elbow might have been formed to admit of a much greater variety of flexions, but this (at least in the present structure of our frame) must have been necessarily attended with some inconveniences, while it would be difficult to show any real advantage resulting from it.

In the joint connecting the head with the neck, two different mechanical principles are combined. We have already noticed the lever which is worked whenever we nod the head, or move it backwards or forwards. The other arrangement by which we are enabled to turn the head round from side to side, is precisely like that of a horizontal wheel turning on a vertical pivot. This pivot or axis is formed by the odontoid process of the second vertebra, turning

in an opening or socket formed in the atlas for this particular purpose. Hence whenever we move the head backwards or forwards, the joint is between the head and the atlas; but whenever the head is turned round horizontally, the joint is between the second vertebra and the atlas, the latter in this case always turning with the head.

MECHANISM OF LOCOMOTION.*

It is proposed in the subsequent portion of the present article, to consider a few of the leading points connected with the mechanism of locomotion in man. The subject may at first sight appear to present but little difficulty; but it will be found, in reality, to be one of great complexity, involving not only the most accurate anatomical knowledge of the parts concerned, and of the relation of these parts to each other, but also requiring for its full elucidation the nicest application of different mathematical principles. It would perhaps be impossible to cite any example of mechanism, whether in the works of art or of nature, which displays in so striking a degree, the combination of a multiplicity of contrivances in the production of a perfect, harmonious and apparently simple result, as that exhibited in human locomotion. A large share of the ingenuity of man in all ages, appears to have been directed towards the construction of machines that might either relieve him from the necessity of self-exertion in traveling, or assist him in the conveyance from place to place, of those burdens which, among uncultivated nations, are carried by the unaided muscular force of men or animals. Yet, although he has succeeded in subjecting to his will forces immeasurably superior to any power of muscle, and though he has outstripped in speed all animals, excepting only the swiftest of the inhabitants of the air, he has never been able to construct a machine, which—as regards the facility of traveling on every variety of ground, whether ascending or descending, rough or smooth, hard or soft, unbroken or intersected by ditches or ravines; or the power of changing its course in any direction and under all circumstances, of stopping suddenly without violence and turning round in the narrowest space—is worthy to be named in comparison with the locomotive mechanism of the human frame.

The parts of the body which play a direct and important part in the process of locomotion, are, the upper extremities, the vertebral column, together with the muscles by which it is inclined forwards or backwards, the pelvis, and the lower extremities. When the body is erect, the vertebral column is not straight and perpendicular, but resembles an undulating line, having two curvatures backwards and as many forwards. This arrangement is of great importance in all the movements of the body, both by giving ease and elasticity to the motions

* Most of the views respecting the mechanism of locomotion contained in this article, are derived from Weber's treatise on that subject, as given in the *Encyclopédie Anatomique*, tome ii.

of the trunk, and by preventing the effects of any jar or concussion received in the lower extremities, which, but for this provision, would be in danger of inflicting the most serious injuries on the delicate texture of the brain. That we may more clearly understand the importance of the curvature in question, let us take a slender and perfectly straight rod of steel:—now if this be struck in the direction of its length, the whole force of the blow will be transmitted to the opposite extremity; but if the rod be bent like the spinal column, as represented in Fig. 44, page 77, the violence of a blow applied to one end, will be greatly mitigated before it reaches the other. Another feature in the structure of the vertebral column, which contributes greatly to its elasticity and flexibility, consists in the character and arrangement of the intervertebral cartilages. These are cartilaginous disks, very elastic, which are placed between the bodies of the different vertebræ.

The pelvis (of which the five immovable vertebræ of the sacrum form a part) is joined to the superincumbent column in such a manner as to increase still more the curvature of the spine.* It rests on the femoral bones, which, however, do not support it on vertical shafts, but are bent near their upper extremities, so as still further to contribute to the important object of mitigating the effect on the brain, which might arise from any violent concussion of the lower extremities; and at the same time widens, so to speak, the base on which the body rests. In a similar manner the tripod of a telescope is made to stand firmly, by causing the legs to incline so that the feet may be separated a considerable distance from each other. The widening of the base alluded to, takes place only laterally, where only, indeed, it is needed; for the length of the feet, as well as the facility with which one can recover his equilibrium, by changing the point of support from the back to the forward part of the foot, and *vice versâ*, obviates the necessity of extending the base in either of those directions.

When a man who has been standing still, begins to walk, he first inclines the trunk and head forwards, and immediately advances a foot in order to preserve the centre of gravity, and as he still leans his body in the same direction, the other foot is advanced, and thus he proceeds by continually losing and recovering his equilibrium. One of the most remarkable features in the mechanism of locomotion, is the economy of muscular power herein exhibited. In easy and graceful walking, the motion of the limbs forwards is owing directly, not to muscular force, but to the force of gravity, and takes place on the same principle as oscillation in a pendulum. When the body leans forward, the leg which is behind assists in propelling it (in the same manner as a boat is urged along by poles), but when the body is so far advanced that the limb is fully extended, and no longer capable of communicating any propelling force, the foot, by the contraction of the muscles of the leg, is raised from the ground, and immediately swings or rather *oscillates* forwards, passing the other foot, which is then behind the centre of gravity, and in its turn becomes the propeller of the body. It

* It appears that many anatomists have erred in not giving, in their representations, a sufficient inclination to the pelvis, nor enough curvature to the spine.—(See *Encyclopédie Anatomique*, tome ii. pp. 289 and 312.)

may be observed, that as the foot behind becomes extended to its utmost limit, nearly the whole of it is raised from the ground, so that a comparatively slight addition of muscular power suffices to elevate the leg enough to permit it to oscillate. Hence we may perceive that the same force of muscle which was employed in propelling the body, now assists in carrying forward the propeller itself; for, as it has been intimated, all the power requisite to carry the lower extremities forward, in walking, is a contraction of the muscles which shall elevate and shorten the leg sufficiently to allow it to swing forwards by the force of gravity. It is well known that the greater the length of a pendulum, the less frequent are its vibrations; on the same principle the taller a person is, the greater is the time occupied in a single step. When a pendulum is oscillating, it falls or swings by the force of gravity from its highest point on one side till it reaches the lowest part of its course (at which time, be it observed, the rod is precisely perpendicular), after which, it rises on the opposite side by the momentum which it has acquired in descending, till this momentum is overcome by gravity, when it again descends by swinging in the opposite direction. The time required for it to fall to its lowest point, is just the same as that required for it to swing upward to its highest point; each occupying exactly one-half of the time of an entire oscillation. The reader need scarcely be reminded, that the time occupied by a single oscillation of a pendulum of any given length, is the same whether it pass through a large or a small space. For, if it move through a large space, as it then describes a larger arc of a circle, its fall at the commencement of its descent is, so to speak, steeper than when it moves through a small arc. Hence its descent is more rapid, and as the momentum thus acquired is much greater, its ascent is consequently more rapid.

When a person walks with slow and dignified steps, the limb is allowed to swing considerably beyond the point where it is perpendicular; whence the step requires almost the time of a full oscillation. The space, moreover, during which both feet touch the ground, which in rapid walking is scarcely appreciable, contributes also much to the slowness of the movement. On the other hand, when one walks rapidly, the limb which is swung forwards is set upon the ground almost at the moment when it becomes perpendicular, so that the step occupies only about half the time required for an entire oscillation. The step, however, is not necessarily shortened by this process, for as the foot is lifted much higher in the air, the oscillations extend through a much greater distance.

Any one may satisfy himself that the difference in the length of the steps of the same individual, is produced in the manner above described, by observing his own movements in walking. He will find it impossible to take steps much quicker than usual, except by setting his foot on the ground when the oscillation is but half completed; and if he walk in a free and easy manner, he will find that all his steps (counting from the time that the foot is swinging in the air), occupy about the same time as a pendulum, of the same length as his limbs, moving through an equal extent of space.

In walking, while the whole body is supported on one limb, the other being

stretched out behind and suspended in the air, has a tendency to destroy the equilibrium of the whole, and, were it not for a provision as perfect as it is simple, we should be obliged, in order to preserve our equilibrium, to bend the trunk in the opposite direction, which would render our motions ungraceful and laborious. The provision alluded to is this: at the moment when the leg is extended the farthest behind, the arm on the same side is advanced so as to balance it. As the leg draws near the centre of gravity, the arm does the same. When the leg swings forwards so as to endanger the equilibrium from another direction, the arm swings backwards in order to counteract such disturbing force. While this is going on, the arm on the opposite side performs the important office of balancing the suspended leg laterally. It will perhaps be asked, how a single arm on one side can balance both a leg and an arm on the other. It may be replied, that the arms, as they swing forwards, usually draw nearer to the median line of the course in which the body moves, so that when in this position, but little counter-weight is required to balance them laterally. It should also be observed that though the leg is much heavier than the arm, the latter is placed farther from the median line of the body, and hence is like a small weight on the long arm of a lever, balancing a much larger one on the short arm.

Many of the principles involved in running and walking, are the same; they differ, however, in some essential particulars. In walking, at the end of every step, a short time elapses, during which both feet touch the ground: in running, but one foot touches the ground at a time: in walking, the body is urged forwards by the propelling force of the limbs as they alternately rest on the ground: in running, it is thrown forwards by a succession of springs or leaps, executed by the feet alternately.

APONEUROLOGY.

This section of anatomy embraces those fibrous membranes which are found in various localities, sometimes serving for the investment and protection of muscles, in other instances for their insertion, and in some cases again answering to both these functions. These membranes, which are also termed *fasciæ*, resemble tendons flattened out: they are of extremely variable thickness, being generally composed of a series of laminæ piled one on the other, and much increased in strength in parts which are subject to mechanical stimulus or to diseased action. It is from the operation of these causes, together with unnecessary refinements in dissection, that the fascia have been so differently seen and described by different authors, to the manifest embarrassment of the learner. Our aim on the present occasion will be to present these structures in accordance with their simple and obvious characters.

The human fabric presents everywhere beneath the skin a thin superficial envelope, the *fascia superficialis*, also termed the *cellulo-fibrous fascia*, which is the medium of connection between the skin externally and the subjacent parts. It is interspersed with adipose tissue, and perforated throughout by the blood-vessels and nerves in their passage to and from the general integument. Dr. Erasmus Wilson observes that this fascia is separable by careful dissection into two layers, between which are found not only the superficial cutaneous vessels just mentioned, but also the saphenous veins, the radial and ulnar veins, and the superficial lymphatics, together with some muscles—the platysma myoides, orbicularis palpebrarum, sphincter ani,* &c. In some places this fascia assumes a much stronger texture, in those instances, for example, in which its duplicatures form the sheaths of the great vessels; but it is often so attenuated as to resemble common areolar tissue.

The true *aponeuroses* are essentially fibrous, being composed in part of parallel filaments which are again crossed by others in various directions. The exterior surface is white, opaque and pearly, and loosely attached to the integuments and other contiguous parts by means of loose areolar tissue; but the internal surface is firmly blended with the proximate tissues, with which it appears to be continuous. The aponeuroses not only invest the limbs and other parts

* Human Anatomy, p. 284.

forming a common envelope, but send prolongations inwards which form a great number of compartments, each of which forms the sheath of a muscle, a blood-vessel or a nerve. For the purpose of greater strength, these tendinous membranes are firmly attached to particular and prominent parts of the skeleton; and in some instances muscles are inserted directly into it, in order to preserve the requisite tension and in some measure also to assist in locomotion.

The aponeuroses present many foramina, arches, and canals for the transit of vessels and nerves, by which means the latter are protected from undue compression and other source of injury; and the fibrous rings and channels by which the tendons are kept in their relative position to the bones, are also true aponeurotic structures.

This tissue, wherever it exists, is devoid of sensibility in its healthy state: no nerves have been distinctly traced into it nor does its vessels convey red blood. It opposes the strongest resistance to mechanical force, and like the ligaments and tendons, is wholly inextensible.

The aponeuroses are usually divided into four topographical series: 1, those of the head and neck; 2, those of the trunk; 3, those of the upper extremities; and 4, those of the lower extremities.

CRANIAL APONEUROSES.

1. The OCCIPITO-FRONTAL, or *epicranial aponeurosis*, is the fibrous expansion connecting the anterior and posterior bellies of the occipito-frontalis muscle. It is attached to the skin above by areolar tissue, which often contains a large deposit of adipose matter; but it is much more loosely connected with the periosteum beneath, whence the freedom with which it is moved from side to side by the fingers. Between these last named surfaces no fat exists. Besides connecting the several parts of the occipito-frontalis muscle, this aponeurosis gives attachment, at its lateral margin, to the superior and anterior auricular muscles.

2. The TEMPORAL APONEUROSIS or fascia covers the temporal muscle, and affords, by its internal surface, part of the origin of that muscle. It is attached above to the temporal ridge its whole length, from whence it descends, becoming stronger and stronger until it reaches the zygoma: here it separates into two laminæ, one of which is attached to the outer, the other to the inner margin of the arch. The interspace is occupied by fat and gives transit to the orbital branch of the temporal artery.

3. The PAROTID FASCIA gives a very strong envelope to the parotid gland, and sends off septa from within that separate the lobules from each other. It is thickest externally, and is continuous below with the cervical fascia.

The buccinator and masseter muscles are also covered by their appropriate aponeuroses; the latter fascia is continuous with the cervical fascia; but that of the buccinator muscle is regarded as an expansion of the fibrous sheath of the duct of Steno.*

* Cruveilhier. Anatomy, p. 229.

CERVICAL FASCIA.

This is divisible into two parts, the superficial and deep-seated.

1. The superficial layer, FASCIA SUPERFICIALIS COLLI, is a thin layer between the skin and muscles, and is a continuation of the common superficial envelope. In its ascent from the abdominal parietes, it is attached to the sternum and clavicle; it then covers the neck, is again attached above to the base of the lower jaw, whence it spreads upon the face, being firmly connected above to the zygoma, mastoid process and annular process of the meatus of the ear. It passes behind the platysma myoides muscle, and forms the anterior layer of the sheath of the sterno-mastoid. It lies in front of the submaxillary and parotid glands, the lobules of which are enclosed by prolongations of this fascia; it also sends off processes that enter the muscular interstices and finally become continuous with the fascia profunda. The latter fact led Dr. Godman to describe the sheath of the great vessels as formed by processes of the fascia superficialis.*

2. The DEEP CERVICAL FASCIA, fascia profunda colli, may be said to commence behind at the ligamentum nuchæ, whence it goes forwards beneath the trapezius muscle until it reaches the sterno-mastoid, which it covers posteriorly; so that a distinct sheath is thus formed for it by the superficial fascia in front, as above mentioned, and the fascia profunda behind. The latter also forms sheaths for the several other muscles of the neck and also for the vessels and nerves, and is attached in front to the larynx. It is further connected with the inferior margin of the thyroid gland, whence it passes downwards, investing in its course the sterno-hyoid and sterno-thyroid muscles. Below it is inserted into the upper margin of the sternum and the contiguous parts of the clavicle and first rib on each side, thus forming, as Dr. Horner observes, a resisting membrane from the larynx to the thorax.

If this fascia be traced upwards from the preceding connections, it will be seen to be fixed to the base of the lower jaw; and it is continuous, more deeply, with the stylo-maxillary ligament, which passes, as heretofore shown, from the styloid process to the angle of the jaw.

The fascia profunda sends processes internally, which form separate envelopes for the common carotid artery, the internal jugular vein, the pneumogastric nerve, the great sympathetic and the cervical ganglia, at the same time that it affords a common sheath for the artery, vein and par vagum, which sheath isolates them from all surrounding parts.

There is no difficulty whatever in tracing the deep-seated and superficial fascia through all their connections; the only question arises, where does the one end and the other commence? The lines of demarkation, owing to continuity of structure, are so arbitrary, that the most practical division would refer all the subcutaneous portion of the membrane to the fascia superficialis; all that lies deeper than this to the fascia profunda. A simple rule of this kind

* Godman. Anatomical Investigations, p. 31.

might have prevented the ingenious Dr. Godman from describing the whole sheath of the sterno-mastoid muscle, and the pericardium itself, as mere prolongations of the superficial fascia.*

THORACIC FASCIÆ.

1. The THORACIC FASCIA, properly so called, occupies the superior outlet of the chest, being attached to the internal margin of the first rib and the proximate surface of the sternum. The esophagus lies between it and the vertebral column behind; and in front it separates in order to permit the upward elongation of the thymus gland. This fascia is also perforated by the great vessels; and it divides at this point into two laminæ, one of which ascends and becomes continuous with the sheath of the nerves and vessels in the neck, and consequently with the fascia profunda; while the other or descending portion, passes down upon the trachea to its bifurcation, surrounds the vessels arising from the arch of the aorta, and subsequently becomes blended with the fibrous layer of the pericardium.†

2. INTERCOSTAL APONEUROSES.—These are three in number: one covers the intercostal muscle externally; a second forms a similar tunic within the thorax; and a third fibrous membrane separates the internal and external intercostals from each other.

ABDOMINAL FASCIÆ.

1. The LINEA ALBA is a tendinous cord, extended in the median line of the abdomen, from the sternum to the symphysis pubis. That part of it below the umbilicus is a mere line, and the supra-umbilical portion is about the fourth of an inch in breadth; whence it happens that umbilical hernia always occurs above the navel. The linea alba is covered by the skin in front, and most firmly at the umbilicus; but below, the suspensory ligament of the penis is interposed between the linea alba and the integuments. Behind, it is covered by the peritoneum, but is separated from the latter for some distance by the remains of the urachus. The linea alba is formed by the intersection of the anterior abdominal aponeuroses. "One remarkable circumstance is, that the intersecting fibres do not stop at the median line, but pass from one side to the other; so that the tendinous fibres of the right side become the tendinous fibres of the internal oblique of the left; and again, that the intersection occurs not only from side to side, but also from before backward."‡ This structure is wholly inelastic and composed of white fibrous tissue. Fig. 159, 28.

2. FASCIA TRANSVERSALIS.—The peritoneum has everywhere interposed between it and the abdominal parietes, a fibrous membrane called the *subperitoneal aponeurosis*, for the most part very delicate, and even in places indistinct; and the fascia transversalis is that thickened portion of it which is interposed

* Loco citat., pp. 21, 33.

† Dr Erasmus Wilson. Anatomy, p. 286.

‡ Cruveilhier. Anatomy, p. 301.

between the peritoneum and transversalis muscle. It is connected to the internal or reflected margin of Poupart's ligament, and to the crista of the pubes behind the common tendon of the internal oblique and transversalis muscles. It is more strongly developed along the anterior third of the crural arch* as far as the symphysis pubis, and is further continuous, by its internal margin, with the external border of the rectus muscle. From these points the fascia transversalis passes upwards between the abdominal muscles and peritoneum, and meets the fascia of the opposite side in the linea alba; after which it becomes so attenuated that in the region of the umbilicus it is merged in the delicate subperitoneal aponeurosis. M. Cruveilhier justly observes, that the only part of this structure deserving special notice, is embraced between the outer border of the rectus muscle and the internal abdominal ring.

The *internal ring* is an imperfectly defined opening in the fascia transversalis, midway between the symphysis pubis and the anterior superior spinous process of the ilium, and about half an inch above the lower margin of Poupart's ligament. It is at this ring that the spermatic cord enters the abdominal canal in its course to the testicle; and the cord is here surrounded, within the canal, by a funnel-shaped prolongation of the fascia known as the *fascia propria.*

The epigastric artery runs on the posterior face of the fascia transversalis; it takes its course at the inner side of the internal ring, and thence obliquely upwards to the external margin of the rectus muscle; making a distance between this point and its origin from the external iliac artery of two or three inches.

3. The FASCIA ILIACA, or lumbo-iliac aponeurosis, constitutes the tendinous sheaths of the psoas and iliacus internus muscles, within the pelvis. It arises above from the whole inner margin of the crista of the ilium, and is attached to the sides of the lumbar vertebræ and the ligamentum arcuatum, being arched in these last-named localities for the transit of the lumbar vessels and those nerves which connect the lumbar plexus with the lumbar ganglia of the sympathetic. Below, it becomes continuous with the pelvic aponeurosis; and in front "it adheres to the edge of the crural arch from the anterior superior spinous process almost to the pubes, and is continued under it into the sartorial portion of the fascia femoris. It makes a line of adhesion from the anterior superior spinous process of the ilium to the femoral vessels, with the fascia transversalis abdominis. The external iliac vessels are upon this fascia, between it and the peritoneum; and below them, the fascia iliaca goes over that part of the pubes which gives origin to the pectineus muscle and is continuous with the pectineal fascia."† Below Poupart's ligament the fascia iliaca forms a sheath for the psoas magnus and iliacus internus muscles as far as their insertion; and immediately beneath and behind that ligament, the fascia forms the posterior part of the sheath for the femoral vessels.

Fascia pelvica.—This is rather a series of fasciæ grouped under the collective

* The word *crural arch* is here used synonymously with Poupart's ligament.

† Horner. Anatomy and Histology, i. p. 447.

name of *pelvic aponeuroses*, of which the recto-vesical and obturator fasciæ constitute the principal parts.

4. The RECTO-VESICAL FASCIA, or superior pelvic aponeurosis, lies within the pelvis beneath the peritoneum, which should be separated with the handle of a knife in order to bring the aponeurotic membrane fully into view. It will then be observed to form *a complete floor for the pelvis.* It is given off from the tendinous lining of the pelvis on each side of the symphysis pubis, in fasciculi or columns which pass backwards to be attached to the neck of the bladder, forming the *anterior vesical ligaments.* Another portion arises from the entire circumference of the brim of the pelvis, and converges inwardly upon the side of the prostate gland, bladder and rectum, in the male; and of the bladder, vagina and rectum, in the female.

Behind, it is very thin, passes in front of the sciatic plexus and is lost upon the sacrum. Its upper surface is concave and connected to the peritoneum by loose areolar tissue: its lower surface is convex, covered by the levator ani and in relation with the pyriformis and obturator internus muscles.

This aponeurosis is perforated by many openings. "In the male it is pierced by the prostate and the bladder, on the sides of which it is prolonged; and reflected on the rectum, whence the name of *recto-vesical aponeurosis.* In the female it is also perforated for the vagina; and in front it has some openings for the vesical and prostatic vessels."*

5. The OBTURATOR FASCIA, called also the *lateral pelvic aponeurosis*, lines the pelvis within and covers the obturator internus muscle. It commences at the upper part of the obturator foramen, and at the brim of the pelvis in connection with the recto-vesical fascia, which last it separates from in order to cover the obturator internus: it unites below with the reflected portion of the sacro-sciatic ligament, and is prolonged upon that portion of the anterior surface of the gluteus maximus which projects beyond the ligament, and also upon the coccygæus muscle.†

THE PERINEAL FASCIÆ.

Anatomists have variously described the perineal fasciæ; but the simplest and most practical mode of studying it is to regard it as composed of two laminæ, one of which is superficial, the other deep-seated.

1. The SUPERFICIAL PERINEAL FASCIA is a delicate aponeurotic membrane spread in a triangular shape over the perineal region beneath the integuments and the dartos. It is attached on each side to the rami of the pubis and ischium; its posterior margin is irregularly transverse, extending between the tuberosities of the ischial bones and backwards to the anus: in front it is continuous with the dartos; and it covers the erector penis, accelerator urinæ and transversus perinei muscles.

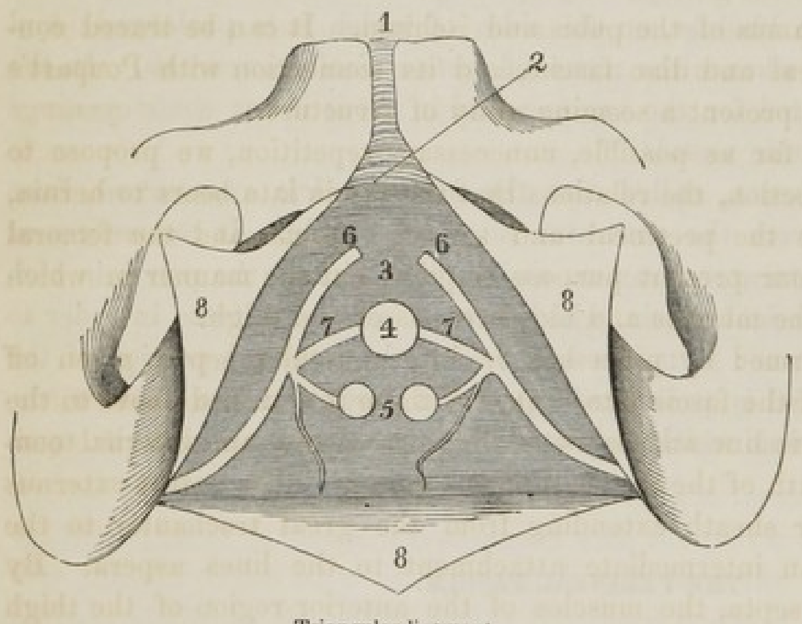
* Cruveilhier, *ut suprà.* I have followed this eminent anatomist in describing these fasciæ, because his dissections correspond in their details with my own.

† Idem.

2. The DEEP-SEATED PERINEAL FASCIA, called also the triangular ligament and the ligament of Camper, is brought into view by removing the preceding layer together with the subjacent muscles: the triangular ligament will then be seen to form a membranous septum between the perineum in front and the pelvis behind. It may be regarded as a downward prolongation of the subpubic ligament: it is attached at the sides to the descending ramus of the os pubis and the ascending ramus of the ischium, above the attachment of the erector penis muscle. Its outer surface is in relation with the erector penis and accelerator urinæ muscles, and it gives off, in the median line, a fibrous septum which passes between these muscles and affords them points of attachment.

Its ligamentous character becomes indistinct below, where it is prolonged backwards to the rectum and joins the anal fascia. It is perforated in a subcentral manner for the passage of the membranous part of the urethra; beneath which, within the substance of the fascia, are Cowper's glands. In the female the vagina forms an opening in the triangular ligament; which, we may add, may be separated into two laminæ, which are sometimes described as distinct fasciæ.

Fig. 202.



Triangular ligament.

Fig. 202. View of the deep perineal fascia. 1, symphysis pubis; 2, subpubic ligament; 3, triangular ligament, or deep perineal fascia; 4, perforation for the urethra; 5, two prominences of the anterior layer of the fascia, marking the position of the included Cowper's glands; 6, pudic arteries; 7, arteries of the bulb; 8, 8, 8, the superficial perineal fascia dissected off in three angular flaps.

FASCIÆ OF THE LOWER EXTREMITY.

The fasciæ of the thigh are two in number, one of which is called the superficial fascia, the other the fascia lata.

1. The SUPERFICIAL FASCIA, as will be understood from what has been already stated, is a continuation of the external fascial envelope of the body. This membrane, which is loosely connected to the abdominal muscles, becomes more firmly attached as it passes over Poupart's ligament. Having reached the thigh over the whole of that ligament, it separates into two layers, between which are embraced the superficial vessels and nerves of these parts, together

with the lymphatic glands of the groin and a quantity of adipose matter. It can be readily traced to the symphysis pubis and thence to the end of the penis; but becomes more and more attenuated as it descends the thigh.

Following the fascia superficialis from the crest of the ilium and backwards to the spine, we find it to cover the whole of the gluteal muscles, where it is strengthened by large additions of areolar tissue, in which latter membrane it is almost insensibly merged on the back of the thigh. This fascia, even its healthy and most delicate state, may be separated in many places into two or more laminæ which become multiplied and thickened in a certain diseased conditions, and sometimes cause much embarrassment to the surgeon.

2. The FASCIA LATA, or femoral aponeurosis, is a strong fibrous membrane that envelopes the thigh and furnishes sheaths to its muscles and subordinate parts. It may be said to arise from Poupart's ligament, from the crista of the ilium its whole length, and behind from the sacrum and os coccygis. At the two last named points its origin is somewhat indistinct; but as it descends upon the gluteus magnus muscle it becomes more strongly developed,—*fascia glutea*,—and is yet thicker over the gluteus medius. It has also firm attachments to the tuber ischii and to the ramus of the pubis and ischium. It can be traced continuously into the perineal and iliac fasciæ, and its connection with Poupart's ligament is so firm as to present a seeming unity of structure.

In order to avoid, as far as possible, unnecessary repetition, we propose to defer to the following section, the relations that the fascia lata bears to hernia, among which parts are the pectineal and sartorial fasciæ and the femoral ring. It may answer our present purpose to point out the manner in which sheaths are formed for the muscles and blood-vessels of the thigh.

These sheaths are formed by processes, or inter-muscular septa, given off from the internal face of the fascia lata. One of these is attached above to the anterior inter-trochanteric line and below to the linea aspera and internal condyle. It forms the sheath of the vastus internus muscle. The vastus externus is enclosed in a similar sheath extending from the great trochanter to the external condyle with an intermediate attachment to the linea aspera. By means of these fascial septa, the muscles of the anterior region of the thigh are separated from those of the posterior and internal regions; but independently of these coverings each group of the muscles of the thigh has its separate sheath. Thus the biceps, semi-tendinosus and semi-membranosus have a common sheath behind; the sartorius, tensor vaginæ femoris, rectus and gracilis, adductor magnus and adductor brevis, have each a separate sheath; there is a common one for the pectineus and adductor longus; and on the upper and outer side of the thigh, the psoas magnus and iliacus internus are enclosed in the same facial tunic, which is continuous with the fascia iliaca.*

The sheath of the femoral vessels (artery and vein) is derived also from the fascia lata; it is a downward, funnel-shaped prolongation of the fascia, con-

* Cruveilhier. Anatomy, p. 409.

tinuous above with the femoral ring and presenting its smaller end at that point where the vena saphena opens into the femoral vein. This part of the sheath is called the crural canal; it is prolonged below from processes derived from the sartorial and pectineal fasciæ, and still lower down from the fibrous envelope of the rectus internus.

The fascia lata terminates below by connecting itself with the ligaments and tendons at the knee-joint; but a continuous structure can thence be traced over the joint to the leg, where it becomes the crural fascia. In this intermediate course the fascia is thin in front of the patella and its ligament, from which it is separated by a synovial bursa; on the inside it is connected with the sartorial sheath; and on the outside it is firmly attached to the fascial prolongation of the tensor vaginæ femoris.

ANATOMY OF HERNIA.

Many facts connected with this subject have already been introduced when treating of the muscles, and some others are adverted to in the preceding account of the fasciæ; but although it may involve some repetition, we think there will be an advantage in now reviewing and extending these considerations; and for this purpose the subject will be considered under two heads,—Inguinal and Femoral Hernia.

INGUINAL HERNIA.

The abdomen, groin and thigh are covered, in common with the rest of the body, by the fascia superficialis abdominis, which has been already described. It is intimately connected with the fascia lata of the thigh, where it is readily separable into several layers. Towards the groin it increases greatly in thickness and encloses between its laminæ the lymphatic glands of that region: it is in turn traversed by some small blood-vessels, and among others by the *arteria ad cutem abdominis*, which, winding over Poupart's ligament, runs upwards nearly in a line with the epigastric artery, and is frequently divided in the operation for Inguinal Hernia. The external layers of the fascia superficialis pass downwards over the crural region, while the deeper-seated ones are attached to Poupart's ligament.

Turning off the superficial fascia, we expose the beautiful glossy surface of the external oblique muscle, of which the tendinous insertions are of much importance in inguinal hernia. Its fibres run obliquely downwards, and just before they reach the pubis, split and diverge so as to form a passage for the spermatic cord in the male, and the round ligament in the female. This is the *external abdominal ring*.

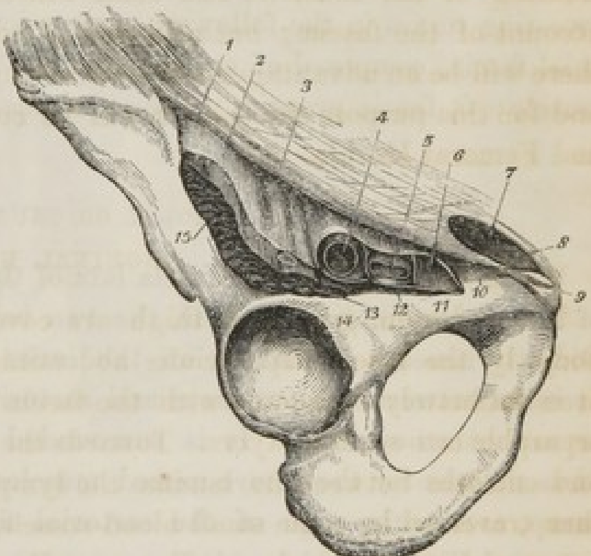
Notwithstanding its name, this is a triangular aperture having its base on the os pubis, and its apex, which is rounded, at the split in the tendon above.

Its sides are called *columns:* the internal or upper column is formed by that part of the tendon inserted into the symphysis pubis, which insertion is strengthened by the fibres passing from one side to the other in decussating lines: the external or lower column is derived from the inferior margin of the tendon of the external oblique muscle, or in other words from Poupart's ligament.

POUPART'S LIGAMENT.—This ligament, called also the femoral arch and ligament of Fallopius, is therefore merely the tendon of the external oblique extended between the anterior superior spinous process and the symphysis pubis. It presents a convexity in the downward direction and separates the abdominal from the femoral region. That portion of it contiguous to the iliac spinous process has little resemblance to ligamentous structure; it is, on the contrary, an aponeurotic membrane formed by the junction of the fascia lata of the thigh and the superficial fascia with the tendon of the external oblique. But as it approaches the pubis, its margin becomes more free and is reflected or turned inward in the manner of a cord.

This reflected margin is continuous with the iliac fascia, and, near the pubis, with the fascia transversalis; but its most important feature is that short portion which is inserted into the crista of the pubis to form *Gimbernat's ligament.* This ligament is about an inch in length and of a triangular shape. Its outer margin is free and concave and overhangs the crural canal, whence it often becomes the seat of stricture in femoral hernia.

Fig. 203.



Poupart's ligament and some associated parts. From Cruveilhier.

Fig. 203. 1, Poupart's ligament; 2, fascia iliaca; 3, points to the crural nerve; 4, femoral artery; 5, femoral vein; 6, crural or femoral canal; 7, external abdominal ring; 8, internal or upper column of the ring; 9, external or lower column; 10, Gimbernat's ligament; 11, os pubis; 12, portion of fascia transversalis, which, in union with the fascia iliaca, forms the sheath of the femoral vessels; 13, 15, psoas and iliacus muscles.

INGUINAL CANAL.—Turning aside the tendon of the external oblique, we expose the *inguinal canal*, or passage for the spermatic cord. It is from an inch and three-fourths to two inches in length, and runs obliquely downwards, forwards and inwards. Its anterior wall is formed by the lower margin of the external oblique; its base by the reflection forming Poupart's ligament; its roof is derived from the lower margins of the internal oblique and transversalis muscles: these muscles are much blended together, and connected with the upper half of the internal surface of Poupart's ligament, and are free and fleshy as far as the rectus muscle, where their tendon begins, and they thus form an arch over the

inguinal canal. The posterior parietes of the canal are formed by the fascia transversalis which here becomes of considerable strength and thickness.

The *spermatic cord* is now brought into view covered with a layer of muscular fibres from the *cremaster*, a structure already described (p. 210). We may here recapitulate that its two fasciculi in their descent enclose the cord and terminate in looped digitations on the testis. Fig. 159, 26, and Fig. 204, 8, 9.

The INTERNAL ABDOMINAL RING is that opening in the fascia transversalis through which the spermatic cord passes out of the abdomen into the inguinal canal, in its course to the testicle. We may repeat that it is midway between the anterior superior spinous process of the ilium and the symphysis pubis. As the femoral vessels receive an investment from the fascia transversalis, so also the cord is supposed to receive an infundibular investment as far as the testicle; and this is the *fascia propria.*

In *inguinal hernia* the knuckle of intestine forces the internal ring, (generally on the upper surface of the cord,) and passes along the abdominal canal beneath the arched border of the transversalis and internal oblique muscles: having reached the anterior termination of the canal, it emerges from the external ring, the orifice of which is closed by some loose areolar tissue called the *intercolumnar fascia.* The ruptured intestine will therefore have six investing tunics in the following succession: 1, the integument; 2, the superficial fascia, composed of several layers; 3, intercolumnar fascia; 4, cremaster muscle; 5, fascia propria; 6, the peritoneal sac.

FEMORAL OR CRURAL HERNIA.

We have stated that the fascia lata of the thigh is continuous with the tendon of the external oblique muscle, the two being conjoined at Poupart's ligament. Directly beneath the latter, on the inner side of the thigh, is a large oval depression between the pectineus and sartorius muscles: this is the *fossa ovalis*, or saphenous opening. It is surrounded by processes of the fascia lata which form sheaths for the above-named muscles, and is bounded externally by the sharp, crescentic edge of the sartorial fascia, or aponeurotic envelope of the sartorius muscle.

On the inner side the fossa ovalis has no corresponding margin, but is a depression in the pectineus muscle; its floor is formed by the pectineal fascia, a sheath derived from the fascia lata, which runs upwards to become continuous with the fascia iliaca. The femoral vessels lie in front of and upon the pectineal fascia.

At the inferior margin of the fossa ovalis the fasciæ in question become continuous in the following manner:—the lower horn of the crescent of the sartorial fascia curves upwards and joins the pectineal; thus also forming a lunated edge below, over which the vena saphena major turns and dips to join the femoral vein.

Above, the sartorial fascia is attached to Poupart's ligament; and its cres-

centic edge, overhanging the femoral vessels, passes inwards to be inserted into the crista of the pubis continuous with Gimbernat's ligament. This margin forms a second arched border over the femoral vessels; and having been shown by Mr. Hey to be a common seat of stricture in femoral hernia, has received the name of *Hey's ligament*.

The continuity of these portions of the femoral and abdominal aponeuroses, shows the importance of *position* in the employment of the taxis; for by rotating the thigh inwards and carrying it across the opposite limb, the greatest degree of relaxation is obtained.

Fig. 204.

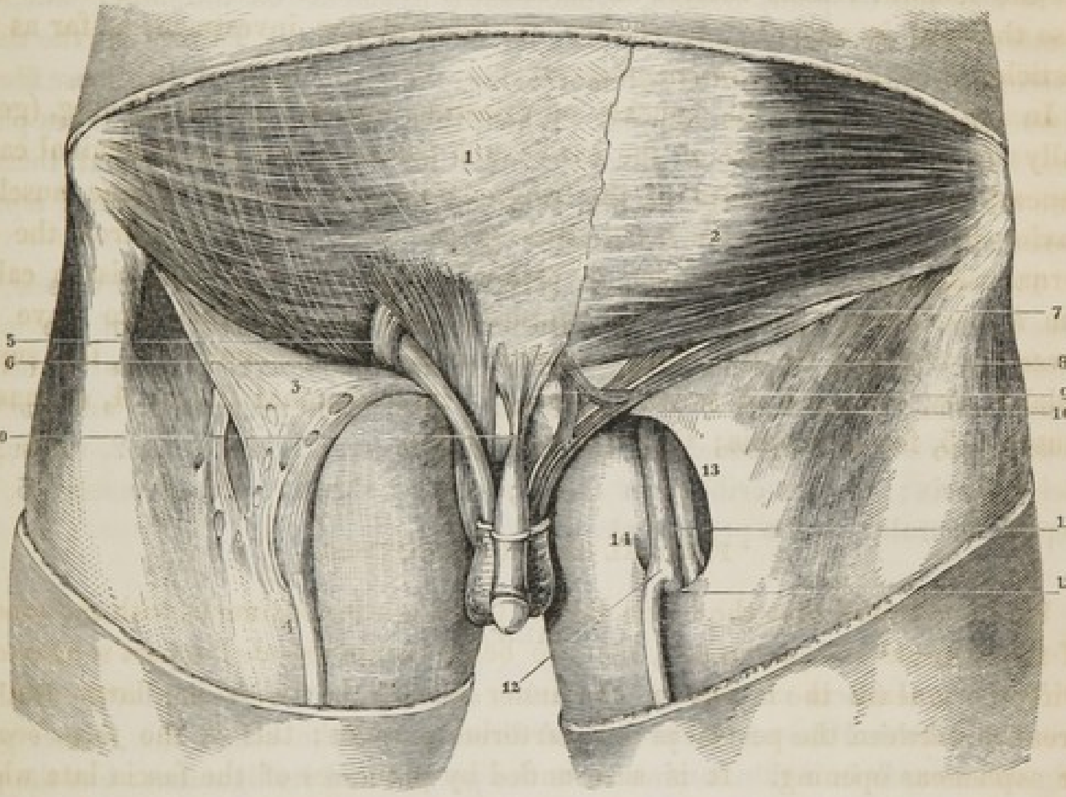


Fig. 204.* Dissection of some of the parts concerned in femoral and inguinal hernia. 1, tendon of the external oblique muscle; 2, tendon of the internal oblique, the first named muscle being dissected off; 3, cribriform fascia; 4, vena saphena; 5, external abdominal ring and spermatic cord; 6, Poupart's ligament; 7, abdominal canal laid open; 8, cremaster muscle, covering the cord from Poupart's ligament; 9, additional slips to the cremaster, arising from the spine of the pubis; 10, suspensory ligament of the penis; 11, femoral vessels; 12, point at which the saphenous vein joins the femoral; 13, sartorial fascia; 14, pectineal fascia; 15, lower horn of the crescent formed by the sartorial fascia; 16, upper horn of the crescent, the extreme point of which is inserted into the spine of the pubis, forming *Hey's ligament*.

The opening of the fossa ovalis is filled by loose fibrous layers of the fascia superficialis, perforated by many foramina for the transmission of the superficial lymphatics to the parts beneath. This is the *cribriform fascia*. It also encloses many lymphatic glands and thus fills up the inequalities of this region of the thigh.

At Poupart's ligament the fascia transversalis and fascia iliaca become con-

* Modified from a drawing in Bonamy and Beau by my friend Dr. William Gambel, to whom I am also indebted for various important suggestions in preparing this section.

tinuous; and the femoral vessels, in their passage from the abdomen close to the os pubis and under the ligament, receive from these fasciæ a compressed funnel-shaped envelope that descends with them on the thigh: this is the *crural canal* or *sheath of the femoral vessels.* The fascia iliaca forms its posterior, the fascia transversalis its anterior parietes; and it has an apparent termination at the lower border of the fossa ovalis.

At the point where the femoral vessels emerge from the abdomen, the mouth of the sheath is wide and loose, and a space is left between them and the os pubis: this is the *femoral ring;* and through this aperture the intestine protrudes in hernia.

It has the os pubis behind, Gimbernat's ligament on the inner side, the femoral vein exteriorly and Poupart's ligament in front. To prevent the ready descent of the intestine into the femoral ring, the latter is filled with loose fibrous tissue enclosing lymphatic glands. When, therefore, the protrusion takes place, this fibrous lamina is forced before the intestine along the crural canal, forming one of the coverings of the hernial sac, and has received the name of *septum crurale.*

The crural canal, therefore, is merely the sheath of the femoral vessels, derived from the fasciæ lining the anterior and posterior parietes of the lower abdomen. When, therefore, the hernial tumor reaches the termination of the crural canal, in the fossa ovalis, its further descent is prevented; and the distended sac is found to consist of the following layers: 1, the skin; 2, the superficial fascia; 3, the cribriform fascia; 4, the sheath of the vessels; 5, the septum crurale; 6, the peritoneal sac.

CRURAL FASCIA.

The crural fascia may be said to arise above from the fascia lata. Both in front and behind the one is prolonged directly into the other, the former passing downwards in a thin lamina from the patella and its ligament: but the posterior portion is much thickened by accessory layers from the tendons of the biceps on the outside and from the sartorius, gracilis and semitendinosus within. These tendons also give lateral strength to the fascia cruralis and are closely united with it. It is attached below to the annular ligament of the ankle and the associated ligamentous sheath.

The external surface is separated from the skin by the superficial vessels and nerves, and it gives a sheath to the saphenous vein and nerve. The internal surface covers all the muscles of the leg, but does not adhere to them excepting above and in front, where it gives attachment to the tibialis anticus and extensor communis digitorum muscles.* A process of this fascia separates the extensor digitorum communis from the peroneus longus, and another is interposed between the peroneus and soleus muscles. Another layer separates the tibialis posticus from the flexor longus digitorum, and also from the flexor longus pollicis.

* Cruveilhier, *ut suprà.*

The crural fascia does not cover the internal surface of the tibia except at its lower part, just above the malleolar process on each side; but it is strongly attached to the outer margin of the anterior angle of the tibia its whole length.

ANNULAR LIGAMENTS OF THE ANKLE.

The annular ligaments of the ankle joint are closely connected with the crural fascia for which they serve as an attachment, at the same time that they confine in their proper places the several tendons that pass over the joint.

The *anterior annular ligament*, ligamentum transversum,—is about an inch and a half broad and runs in front of the ankle joint. It is attached externally to the outer face of the os calcis, just below the malleolus externus, whence it passes forwards in fasciculi interspersed with fat until it reaches the front of the joint. Here it separates into two bands, one of which is inserted into the internal malleolus, while the other and lower one is attached to the os scaphoides and is gradually merged in the plantar fascia.

The *internal annular ligament* is an aponeurotic membrane extending in a radiated manner from the malleolus above to the side of the os calcis below. It can be traced upwards into the crural fascia, and inferiorly into the fascia of the foot. It forms sheaths for the tendons of the flexor muscles and for the blood-vessels of the foot.

The *external annular ligament* extends from the corresponding malleolus to the side of the os calcis. It is blended with the external lateral ligament, and affords sheaths for the tendons of the peroneus brevis and peroneus longus muscles.

FASCIÆ OF THE FOOT.

The *dorsal fascia* of the foot is a thin prolongation of the lower margin of the annular ligament, which extends from the front of the ankle-joint to the anterior ends of the metatarsal bones. It thus covers the whole dorsum of the foot, being attached at various points to the latter and finally merging on each side into the plantar fascia. It covers the extensor brevis muscle and the extensor tendons of the toes.

Aponeurosis plantaris.—This is a dense fibrous membrane lying between the skin and muscles of the sole of the foot. It arises from the tubercles of the os calcis, from which points it expands towards the toes, dividing into three slips. One of these is for the outside of the foot, the *external aponeurosis* being attached to the base of the fifth metatarsal bone; another goes to the inside, the *internal aponeurosis*, and is connected with the metatarsal bone of the great toe. The middle portion, however, is differently arranged; it passes forwards, diverging until it covers the anterior margin of the metatarsal bones from side to side, and there bifurcates so as to furnish an attachment to each side of the lower end of each metatarsal bone.

This aponeurosis is thick and continuous posteriorly, but becomes thinner as it advances. It gives origin to the muscles of the sole, and sends off prolongations that form sheaths for all the plantar muscles and their tendons. The tendons of the flexor muscles of the toes pass between the bifurcated ends of the middle division of the aponeurosis in order to reach the phalanges; and the lumbricales and interosseous muscles, and the plantar vessels and nerves, take the same course. The aponeurosis plantaris finally becomes continuous with the fascial sheath of each toe.

APONEUROSES OF THE UPPER EXTREMITIES.

These consist of several around the shoulder; the brachial and cubital aponeuroses; the dorsal and annular ligaments of the wrist and hand; the aponeurosis palmaris and the digital sheaths.

APONEUROSES OF THE SHOULDER.

These are three in number. One, called the *infra-spinous fascia*, is a strong fibrous membrane that covers the infra-spinatus muscle and forms its sheath. It is attached to the whole margin of the fossa of that name, and is externally continuous with the deltoid and brachial fasciæ.

The *supra-spinous fascia* in like manner covers the supra-spinatus muscle, being connected to the margin of the corresponding fossa. The *deltoid fascia* is prolonged from the external portion of the infra-spinous membrane; it embraces the infra-spinatus muscle and then terminates below in the common brachial aponeurosis.

THE BRACHIAL FASCIA.

From its points of continuity with the infra-spinous fascia, the brachial aponeurosis extends downwards, being connected on the inner side with the tendons of the pectoralis major and latissimus dorsi muscles. It is attached above to the clavicle, acromion and spine of the scapula. It embraces all the muscles of the arm in a general envelope, and terminates at the elbow in the cubital fascia. It lies immediately beneath the skin; and many blood-vessels and nerves are exterior to it, or subcutaneous.

From the inner face of this fascia processes are given off which form sheaths for the several muscles of the arm, and also for the deep nerves and blood-vessels. All these subordinate sheaths are found to belong to two greater ones, viz.: an *anterior sheath*, which embraces the biceps, the brachialis anticus and the coraco-brachialis muscles, the upper portion of the supinator longus and the extensor carpi radialis longior; and a *posterior sheath* which contains the several divisions of the triceps.*

* Cruveilhier, p. 416.

THE CUBITAL FASCIA.

The fascia of the forearm forms a common sheath for all the muscles of this region. It is much thicker on the back than on the front of the arm; many of the large superficial nerves and blood-vessels lie on its inside, and others perforate it by appropriate foramina. It terminates below in the annular ligament of the wrist.

The cubital fascia forms two great sheaths independently of its many subordinate ones; viz.: an *anterior sheath*, which separates the deep-seated from the superficial layer of flexor muscles; and a *posterior sheath* which performs the same function for the back of the forearm. Cruveilhier observes that the radial artery has a special sheath throughout its whole extent; while the ulnar artery and nerves have a proper sheath only in the lower part of the forearm.

FASCIAL LIGAMENTS OF THE WRIST AND HAND.

The *anterior annular ligament* is a broad, firm fibrous band extended across the palmar surface of the wrist, so as to confine and direct the flexor tendons that pass beneath it. It is attached at the inner side of the carpus to the unciform, cuneiform and pisiform bones; and on the outer or radial side, to the trapezium and scaphoides. Above, it blends with the cubital fascia; below, with the aponeurosis palmaris. It gives origin to several small muscles of the hand, and furnishes the sheaths in which they are enclosed. The *aponeurosis palmaris* comes from the anterior margin of the annular ligament and from the tendon of the palmaris longus: it then expands over the palm of the hand, above the muscles and beneath the skin, until it reaches the anterior ends of the four metacarpal bones. Here it separates into four slips, each of which bifurcates and thus affords a double attachment to the corresponding metacarpal bone. The blood-vessels and nerves, as in the foot, pass between the primary openings formed in the membrane; but the flexor tendons reach the fingers through the angle of bifurcation. The aponeurosis then becomes continuous with the several digital sheaths and tendinous thecæ which cover the fingers, and confine the tendons of the flexor muscles.*

* For many admirable illustrations of the aponeuroses, and especially of the fascial sheaths, see the great work of Bourgery and Jacob.

SPLANCHNOLOGY.

Under this head are included descriptions of the visceral organs, whether within the great cavities or exterior to them. This designation is arbitrarily used, like many others in anatomy; for it strictly embraces the brain, spinal marrow, the heart and several of the sensory organs, which, however, are by general consent distributed into other groups.

The viscera to be considered in this section are the digestive apparatus, the lungs and their appendages, genital and urinary organs, and some subordinate structures.

ORGANS OF DIGESTION.

These organs embrace the mouth, the tongue, the salivary glands, the whole alimentary canal from the pharynx to the terminal portion of the rectum, the liver, spleen and pancreas. The teeth are by some anatomists also included in this series of organs, but we have already described them in another section.

THE MOUTH.

The mouth is an irregular and variable cavity, of which the anterior and lateral parietes are formed by the lips and cheeks and their several bony connections. The roof of the mouth is formed by the palate processes of the upper maxillary and palate bones: the floor of the cavity is derived from the tongue and some small muscles; and it is bounded behind by an imperfect septum called the soft palate. All these parts, excepting the teeth, are covered by mucous membrane, exterior to which are the proper parietes of the mouth, formed in great measure by the many small muscles that enter into the construction of the face and fauces. The posterior opening of the mouth is called the *isthmus of the fauces;* it is narrow, but very dilatable, and is the medium of communication between the mouth and the pharynx.

The Lips.—These organs, which form the anterior parietes of the mouth, are composed of two convex parts that meet at the *commissure* or angle on each

side. They are composed of the double muscle (orbicularis oris) of the skin and epidermis, with glands, some fatty matter and a connecting medium of areolar tissue. The muscle has been already described (p. 182). The cutis vera differs in no respect from that on other parts; but the epidermis assumes a thin, transparent character and is called the *epithelium*. The glands, which are very small, lie beneath the cutis and secrete a fluid that moistens the inside of the lips, but the external surface is destitute of this arrangement. The lips are extremely vascular and abundantly supplied with nerves. Their arteries, called the labial, are branches of the facial; and their nerves are derived from the fifth and seventh pairs.

The uses of the lips are various. They have a very important agency in modifying the voice, and they are the means by which the several functions of sucking, blowing and drinking are performed. They also enter more or less into the expression of the mental emotions or passions, and they concentrate the breath in performances on wind instruments.

The GUMS.—These are composed of a red, dense mucous membrane, remarkable for its firmness and insensibility. They adhere strongly to the periosteum, and surround the neck of the tooth above the alveolus; this is called the reflected portion of the gum, which is subsequently involuted upon itself so as to line the tooth-socket and thus constitute its proper periosteum. The substance called *tartar* was formerly supposed to be elaborated by a peculiar glandular structure, but is now regarded as a mere deposit from the salivary secretion. It is a healthy product within certain limits, but occasionally shows itself in remarkable profusion. In infancy the gums perform the functions of the teeth; and when in old age the alveoli become absorbed, the gums again subserve the purpose of mastication. Their connection with the process of dentition has been already noticed.

The HARD PALATE constitutes the arched roof of the mouth. It is marked from front to back by a median line which terminates before at the incisive foramen, and is bounded on each side by a corrugation of the gum. This structure is composed of dense mucous membrane covered by a delicate epithelium; it is in some parts of a lighter red color than the dental gum, and like the latter is very vascular, but possesses little sensibility. It contains numerous mucous glands precisely analogous in structure to those of the cheeks and lips. The hard palate, observes Cruveilhier, serves as a fulcrum for the tongue in the act of tasting, in mastication and deglutition, and in the articulation of sounds.

The MUCOUS MEMBRANE.—This forms the lining of the mouth throughout. It is a prolongation of the skin, and covered, like all similar membranes, with an epithelium in place of the epidermis. It passes from the alveolar margin of the lower jaw to the tongue, under which, in the median line, it forms the frænum linguæ. From thence it is extended to the tongue, invests it, and is then reflected from its base in such way as to form the three glosso-epiglottideal folds. At this point it is continuous with the mucous membrane of the larynx and pharynx: in the upper jaw it is extended from the alveolar margin to the arched roof of the mouth, which it covers and thence invests the velum palati,

the arches and uvula, and is blended in the fauces and pharynx with the inferior layer from the floor of the mouth. It is also continued upon the cheeks in the manner already described. The structure of this membrane is very much modified in its different localities: it is dense and insensible on the gums and palate; thin and delicate on the under surface of the tongue and on the cheeks; thick and charged with papillæ on the surface of the tongue. It is everywhere full of follicles or crypts, which pour out their mucosity in aid of the secretions of the proper salivary glands.*

The CHEEKS form a large part of the parietes of the mouth and sides of the face. Besides the malar bone and lower jaw which form the bases of attachment, they are made up of the skin and several muscles, together with a quantity of adipose matter and muciparous glands. The skin needs no remark excepting that it is peculiarly vascular. The subjacent muscular structure consists of the masseter and buccinator at the sides, of the orbicularis palpebrarum above and partially of the two zygomatic muscles. The arteries of the cheeks are derived chiefly from the facial branch of the external carotid, and from the infra-orbital and dental branches of the internal maxillary.

The SOFT PALATE, or *velum pendulum palati*, forms a partial septum between the mouth in front and the pharynx behind, and is a continuation of the partition between the nose and mouth. It is attached to the posterior margin of the bony palate and to the pterygoid processes of the sphenoid bone, in such manner that it hangs freely in the mouth and performs the office of a valve between the latter cavity and the posterior nares. When the mouth is open the velum is distinctly seen forming the arched boundary in the direction of the fauces, and having in its centre a depending process called the *uvula*. From the uvula, on each side, a double arch begins, which widens and diverges as it extends outwardly until it reaches the floor of the mouth. At the latter point a triangular space is left between these arches, which are called, in front, the anterior lateral half arches; behind, the posterior lateral half arches; and the space between them at their base is the *amygdaloid fossa*, for the lodgment of the tonsil gland. These arches are also called the pillars or columns of the velum palati.

The UVULA, in its healthy state, is less than half an inch in length. It contains a double muscle, the azygos uvulæ (p. 189), which extends from its base to its apex and acts in contracting this body. The uvula contains, besides muscular fibres, some loose areolar tissue that gives it a spongy texture.

All parts of the velum palati are covered by the common mucous membrane; within which the half arches are essentially composed of several delicate muscles already described, but which may be briefly recurred to on the present occasion. The *levator palati* has its fixed extremity at the apex of the petrous portion of the temporal bone and the proximate cartilage of the Eustachian tube. Its movable end is inserted into the posterior margin of the soft palate, so that the latter is drawn up when the muscle contracts. The

* Cruveilhier. Anatomy, p. 343.

circumflexus, or *tensor palati*, is attached to the fossa navicularis of the sphenoid bone as a fixed point, and is inserted into the velum near its middle; its action consists in extending and expanding the soft palate. The *palato-glossus* is composed of a few fibres placed within the anterior half arch one on each side. They arise from the base of the uvula and extend to the side of the tongue; and by contracting depress the soft palate, elevate the base of the tongue, and thus narrow the isthmus of the fauces. The *palato-pharyngeus* is placed within the posterior half arch. It extends from the soft palate at the base of the uvula whence it diverges to the pharynx, and in contracting draws the velum downwards. (See p. 189.)

THE TONSILS.

The tonsils, or *amygdalæ*, are two glandular bodies that occupy the triangular fossa between the lateral half arches at the base of the tongue. Each of these bodies is an aggregation of glandular follicles which secrete mucus and open by numerous ducts on the surface. The orifices are so large as to be in many instances distinctly visible to the eye, and give the gland a cribriform appearance. The arteries of the tonsils are derived from the labial, inferior laryngeal and lingual branches of the external carotid. The internal carotid is sometimes in close proximity to it, although it sends it no branches. It possesses but little sensibility and obtains its few nervous filaments from the lingual and glossso-pharyngeal trunks. In front of the tonsil is the palato-glossus muscle; behind it, the palato-pharyngeus; and its outer surface is bounded by the stylo-glossus.

THE SALIVARY GLANDS.

The mouth is abundantly lubricated by a mucous secretion derived from many different sources. The mucous membrane is everywhere perforated by foramina leading to glandular follicles; and beside these there are several large conglomerate glands which pour their fluids into the mouth, some by single and some by several ducts.

The PAROTID GLAND.—This is the largest of the series and the most complicated in its relations. Parts of it are placed directly beneath the integuments, but other portions are very deeply seated. Its anterior surface extends from the zygomatic arch to the level of the mastoid process and base of the lower jaw, filling the cavity called the parotid region. More circumstantially speaking, it is bounded in front by the posterior edge of the ramus of the lower jaw; behind by the mastoid process and meatus externus of the ear; above by the zygoma; below by the angle of the lower jaw, and internally by the styloid process and the muscles attached to it. Its external surface is subcutaneous and is called its base. Its anterior surface is grooved for the posterior edge of the ramus of the lower jaw. In front it is covered by the skin and partly by the platysma myoides muscle and cervical fascia; and it extends inwards so as to occupy the hollow space between the ramus of the jaw and the mastoid process.

A portion that extends between the duct and the zygoma is called the *socia parotidis*, but is sometimes deficient. Another portion fills the posterior part of the glenoid cavity; another passes behind and between the styloid muscles, and a third, covered by the ramus of the lower jaw, rests against the pterygoideus internus.

The excretory canal of the parotid is the *duct of Steno.* It is given off from the anterior margin of the gland above its middle, and running across the masseter muscle and through the fat of the cheek to the buccinator, perforates the latter and opens into the mouth between the second and third molar teeth of the upper jaw. The orifice is smaller than the duct and has in some degree the effect of a valve. The duct itself is about the tenth of an inch in diameter. It is composed of two coats; an external fibrous one, and an internal or lining mucous coat which is continuous with the membrane of the mouth. Its course across the cheek is proximately indicated by a line drawn from the lobe of the ear to the ala of the nose.

The parotid gland is invested by a dense, white fibrous tunic that sends processes between its lobes and lobuli to the smallest subdivision.

The most important relations of the parotid gland are with the blood-vessels. It is traversed in a nearly vertical direction on its inner side by the external carotid artery; but this vessel sometimes makes only a groove in the gland. It is also penetrated in various directions by the temporal, transverse facial and anterior auricular arteries, and by the temporal vein.

The parotid gland is also largely supplied with nerves: the portio dura, after being for a short distance covered by the parotid, enters its substance and there forms the plexus called *pes anserinus.*

The SUBMAXILLARY GLAND.—This structure, which is of a rounded form, lies directly within the angle of the lower jaw; its outer boundary being formed by the bone, and having on its inner surface the digastric muscle and the ninth pair of nerves. It rests on the mylo-hyoid muscle and is separated from the parotid gland by the stylo-maxillary membrane; or this membrane may be said to connect them together.

Its structure is like that of the parotid gland. It is invested by a fibrous membrane of delicate structure that dips between its lobules and at the same time connects them together. It is highly vascular, deriving its arteries from the facial and lingual branches of the external carotid. Its nerves come from the inferior dental. The excretory duct, *ductus Whartoni*, is of considerable length: it passes between the mylo-hyoideus and genio-glossus muscles along the inner margin of the sublingual gland, and getting under the tongue, terminates by an orifice at the side of the frænum linguæ. In its course from the gland it is sometimes observed to be surrounded by small, rounded bodies, which are of the same nature as the gland itself. This duct, although larger than that of the parotid, is as thin as a vein and very susceptible of dilatation.

The SUBLINGUAL GLAND is an aggregation of lobules lying, as its name imports, beneath the tongue and consequently upon the mylo-hyoid muscle, and contiguous to the duct of the submaxillary gland. It is of a flattened oval shape, lies

directly beneath the mucous membrane of the mouth and touches its fellow of the opposite side. It derives its blood from the submental and sublingual arteries, and its nerves from the lingual branch. The ducts of this gland are variable in number: six or eight run from the upper part of the gland and terminate on the side of the frænum, and as many more open separately on the mucous membrane above the gland. Several others open into the duct of Wharton which runs by the side of the gland; but these generally unite in a single canal called the duct of Rivinus. Dr. Pancoast has repeatedly succeeded in distending this passage by injecting mercury into the duct of Wharton.

The function of the salivary glands consists in secreting the saliva; a clear, colorless and somewhat mucous fluid, which is generally alkaline to the taste and sometimes acid. There are always mixed with it some epithelial cells from the cavity of the mouth, of the tesselated kind, round or elliptical, with a nucleus of darker tint. Another kind of cells is found in the saliva, a little larger than the former and without a nucleus, and these cells appear to be the only solid constituents of the salivary fluid. Its great bulk, that is to say ninety-nine parts in the hundred, consists of water alone, as observed in the analysis of Berzelius:

Water - - - - - - - - -	992·9
Mucus and epithelium - - - - -	1.4
Ptyalin - - - - - - - - -	2·9
Ozmazome and lactates - - - - -	0·9
Chloride of sodium - - - - - -	1.7
Soda - - - - - - - - -	0·2
	1000·0

Ptyalin or salivin is a peculiar substance, soluble in water and insoluble in alcohol, but which is not precipitated from its state of solution by the reagents which ordinarily throw down the animal principles from their solutions.*

THE TONGUE.

The tongue is a flattened oval structure that forms in part the floor of the mouth, and is endowed with the function of taste. Its basal attachment is at the os hyoides; its anterior margin, called its apex, is free, and the space between these points is the body of the tongue. The margin is rounded and unconnected with surrounding parts; but the under surface is in contact with several muscles which are continued into its substance: the internal structure of the tongue is chiefly composed of these muscular fibres together with areolar and adipose tissue, all which are enclosed in the common mucous membrane.

The muscles that act upon the tongue and which are termed *extrinsic*, have been described in the chapter on Myology. They are the stylo-glossus, hyo-glossus, genio-hyo-glossus and lingualis: the latter forms an intermediate link between the extrinsic and the intrinsic muscles, since it arises at the root of the tongue and extends to its apex, adhering its entire length to the side of this

* Wagner. Elements of Physiology, p. 332.

organ; but the proper intrinsic fibres are arranged in three series in the following manner:

The *superficialis linguæ* covers the upper surface of the tongue immediately beneath the papillary structure. Its fibres commence at the greater papillæ by a broad and indefinite base, and run forward converging towards the apex of the tongue: it is not very distinct to the unassisted eye, but is thicker before than behind, and is best studied by analogy in the ox. Dr. Horner has described an elliptical plate of fibres beneath the superficial lingual muscle which he calls *ovalis linguæ*, and which begins and ends in the middle septum of the tongue.*

The *transversales linguæ*, or transverse lingual muscles, are dispersed throughout the tongue which they cross from side to side beneath the superficialis linguæ.

The *verticales linguæ* are placed at right angles to the last. They run vertically from the under surface of the superficial lingual, to the basal surface of the tongue.

The mucous membrane that covers the upper surface of the tongue is composed of three distinct parts, an epithelial covering, a peculiar papillary structure and beneath this again the cutis vera. The epithelium covers the entire surface, from which it can be detached entire by maceration; but its inner layer, or *rete mucosum*, although perfectly distinct and capable of being detached in a separate layer, is destitute of coloring matter. The furred or coated condition of the tongue as seen in many diseases, is nothing more than a morbid redundancy of the epithelial envelope.†

The papillary structure of the tongue is obvious to the unassisted eye, and embraces three modifications of size and form known by the names of *papillæ maximæ* or *capitatæ; mediæ* or *fungiformes;* and *villosæ* or *filliformes.*

The *papillæ maximæ* are eight or nine in number on the posterior surface of the tongue, arranged in the form of a triangle of which the apex presents backward. Each of these bodies is conical with the base or larger end turned upwards and surrounded by a circular depression or follicle. The central papilla, or that which is placed at the apex of the angle, is larger than the others, and has a corresponding fossa which has received the name of *foramen cæcum.* When examined by the microscope this cavity, as well as its papilla, presents numerous subordinate papillæ so distributed over its surface as to give it a tesselated appearance. The papillæ maximæ are of the most simple structure of this class of bodies and resemble those of the external skin. The arteries, on getting beneath the papillæ, send upwards a series of twigs, each of which terminates in one or two capillary loops from which a small vein returns the blood to the subjacent venous plexus.‡ The precise distribution of the nerves in this class of papillæ has not been ascertained.

The *papillæ fungiformes* are scattered everywhere over the surface of the tongue, but chiefly on its sides and apex, and like the larger bodies just described are broader at the summit than at the base, and their surface is studded with lesser

* See his edition of Wistar's Anatomy, i. p. 434. † Todd and Bowman. Physiology, i. p. 435.
‡ Horner. Anatomy and Histology, i. p. 545.

papillæ. They possess the same vascular arrangement as the former, and their ultimate nervous fibrils are arranged in a loop-like form.

The *papillæ villosæ* or *filliformes* are of a whitish color, of a conical or angular shape and extremely numerous, being visible on almost every part of the surface of the tongue. Their epithelial covering, which from its denseness gives them their whitish color, is furnished with elongated, pointed processes immersed in the mucus of the mouth, and movable in any direction, though they generally incline backwards: they are now regarded, at least in part, as soft, condensed hairs which preserve the same proportions for a considerable part of their length.*

The arteries of the tongue are the lingual, the palatine and the inferior pharyngeal. The veins form two sets, one of which is superficial and in a measure independent of the arteries, and another set which is deep-seated and accompanies those vessels. The nerves are very large and come from the hypoglossal, the lingual branch of the fifth pair and the glosso-pharyngeal.

TASTE.

This function is regarded as a modification of touch, and both require absolute contact. Taste is chiefly effected by substances in a state of solution either before or after their application to the tongue. The latter organ must be in a healthy state to respond to this function; for if the mucous membrane be inflamed or abraded, for example, taste is deficient and is replaced by painful sensations.

It is not determined which of the nerves of the tongue subserves the function of taste. The lingual branch of the fifth pair supplies the front and dorsal surface and the papillæ at the apex. The glosso-pharyngeal is chiefly distributed to the posterior part of the tongue and the contiguous fauces; but it sends a branch forward to the inferior surface of the tip, which branch anastomoses with the lingual nerve. Dr. Carpenter is disposed to regard the latter as the medium of the sense of taste as well as of touch, in those parts of the tongue to which it is especially distributed; and the glosso-pharyngeal as possessing the same function in the parts supplied by it. This mutual function can alone explain the admitted fact that the whole dorsum of the tongue, its base, sides and apex, the arches of the palate, the tonsils and even the uvula, all possess the sense of taste, though in extremely varied degrees.

THE PHARYNX.

The pharynx is an elongated pouch interposed between the fauces above and the esophagus below, being thus continuous with both. Its length in the undistended state is about four inches; its breadth is much greater at its upper than at its lower end and its structure is essentially muscular.

The position of the pharynx is as follows: it is attached behind to the long

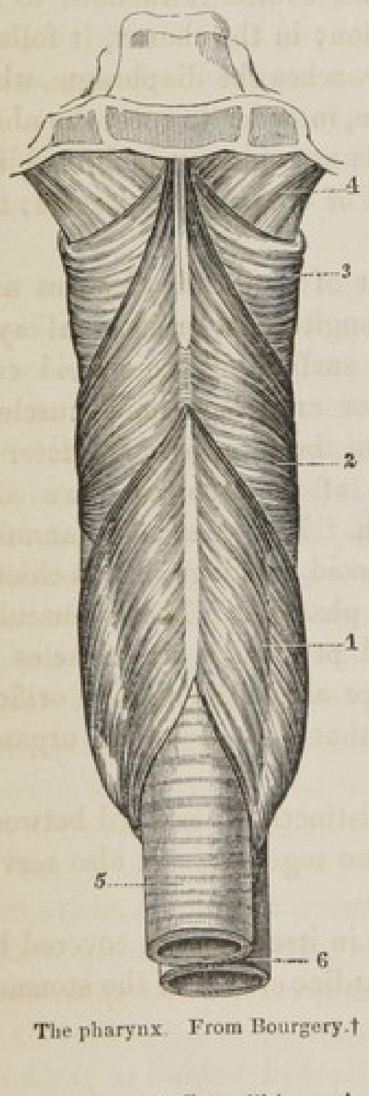
* Todd and Bowman. Physiology, i. p. 440.

† Idem. p. 441.

muscles of the neck and the anterior recti muscles, which alone are interposed between it and the vertebral column. Laterally it is in relation with the internal pterygoid muscle; and between the two are the internal carotid artery, internal jugular vein, and the pneumogastric, glosso-pharyngeal, hypoglossal and spinal accessory nerves, all of which are surrounded by loose areolar tissue. Lower down, the pharynx is contiguous to the external carotid artery and its branches and to many lymphatic glands.* It is attached above to the cuneiform process of the occiput and to the point of the petrous portion of the temporal bone; and in front to the pterygoid processes of the sphenoid bone, to the upper and lower maxillæ, to the cornua of the os hyoides and the side of the thyroid and cricoid cartilages. Below, it terminates in the esophagus opposite the fifth cervical vertebra.

The pharynx communicates with the nose by two apertures called the *posterior nares;* and with the mouth through the arch of the soft palate or isthmus of the fauces. It opens into the larynx through the glottis; and on each side it communicates by a large oval foramen with the Eustachian tube.

Fig. 205.



The pharynx. From Bourgery.†

The pharynx is intrinsically composed of three muscles already described, viz., the constrictor superior, constrictor medius and constrictor inferior. Fig. 205. The extrinsic muscles are the stylo-pharyngeus and palato-pharyngeus.

This structure is lined by a continuation of the mucous membrane of the mouth, which is attached to the muscular structure by loose areolar tissue. It is replete with muciparous glands and follicles, and covered by a very delicate epithelial tunic.

The pharynx is chiefly supplied with blood by the inferior pharyngeal, a branch of the internal carotid; and also from the superior pharyngeal branch of the internal maxillary. Its veins enter the internal jugular and superior thyroid. The nerves, which are numerous, come from the pharyngeal, a branch of the pneumogastric, and from the glosso-pharyngeal; the former being principally distributed to the muscular layer, the latter to the mucous membrane.

Fig. 205. Posterior view of the three pharyngeal muscles. 1, constrictor pharyngis inferior; 2, constrictor medius; 3, constrictor superior; 4, cephalo-pharyngeal aponeurosis; 5, trachea; 6, esophagus.

* Cruveilhier. Anatomy, p. 345.

† This cut was unavoidably omitted from its proper place in Myology.

The use of the pharynx is principally that of deglutition; but it also serves for the passage of the air on its way to the larynx, and it also is an important agent in the modulations of the voice.

ESOPHAGUS.

Where the pharynx ends the esophagus begins; that is to say, opposite the fifth cervical vertebra. From this point it continues in a nearly vertical direction to the cardiac orifice of the stomach. In this course it is mostly in contact behind with the vertebral column, from which it is separated above by the longus colli muscle; lower down by the thoracic duct; and towards its termination, by the aorta. In front, the *cervical portion* of the esophical portion of the esophagus is in contact with the membranous trachea; the *thoracic portion* is in the posterior mediastinum, behind the arch of the aorta and the heart, being separated from the latter by the pericardium. On reaching the diaphragm, the esophagus penetrates it through the *foramen esophageum*, and after extending about an inch, which is called its *abdominal portion*, it enters the stomach at a point nearly opposite to the tenth dorsal vertebra. In this course it inclines to the lower part of the neck while yet in the cervical region; in the thorax, it follows the middle line of the vertebral column until it approaches the diaphragm, when it curves a little to the left side, in front of the aorta, in order to enter the abdomen. Its length is about ten inches; its diameter is not quite an inch, and it is larger below than above. The esophagus is formed of three distinct coats; the muscular, cellular and mucous.

The *muscular coat* is twofold; an external layer of longitudinal fibres and internal one of annular or transverse fibres. The longitudinal or external layer arises, according to Cruveilhier, from the posterior surface of the cricoid cartilage, in the median line between the two posterior crico-arytenoid muscles; and two other fasciculi arise, one on each side, from the inferior constrictor of the pharynx.* These fibres run the whole length of the tube, and are continuous with the longitudinal fibres of the stomach. The internal or annular coat has an attachment above to the base of the cricoid cartilage, but is chiefly a prolongation of the inferior constrictor of the pharynx. These muscular layers are connected by delicate cellular tissue, and pertain to the muscles of animal life; yet it is remarkable that a short distance above the cardiac orifice, there are always blended with those fibres, others that belong to the organic class, as represented in Fig. 212.

The second, or cellular coat of the esophagus, is distinctly interposed between the muscular and mucous layers, and connects the two together. It also serves as a medium for the transmission of blood-vessels.

The internal, or mucous coat, is remarkably thick in itself, and is covered by a distinct epithelium, and which terminates at the cardiac orifice of the stomach in a fringed border.†

* Horner. Special Anatomy and Histology, i. p. 562.

† Cruveilhier. Anatomy, p. 352.

The glands of the esophagus are embedded in the submucous tissue. They have a long excretory duct that passes obliquely through the esophageal tunics and opens on the internal surface.

The *arteries* of the esophagus come from the inferior thyroid, the aorta and the intercostals; and in the abdomen, from the coronary artery of the stomach and the phrenic. The *nerves* are chiefly derived from the two pneumogastric trunks, which surround the esophagus in a series of loops, and are joined by some branches from the thoracic ganglia of the sympathetic.

The use of the esophagus is proverbial; when aliments are received into it, it contracts from above downward, and propels them into the stomach.

THE ABDOMEN.

This large cavity is bounded above by the diaphragm, which overhangs it like a dome; its floor is constituted by the levator ani muscle on each side. Its anterior and lateral parietes are formed by the abdominal muscles and ossa innominata; and behind it is closed by the spine, the quadratus lumborum of the two sides, and the pelvis. There are several foramina in the abdomen; three in the diaphragm, as already described, for the aorta, esophagus and vena cava; four below and in front for the transit of the spermatic cord and femoral vessels; one at the basis for the termination of the intestine; and a number of others of less magnitude for the obturator, sciatic, pudic and gluteal vessels.*

Thus constituted, the abdominal cavity contains the stomach and intestines, the liver, spleen, pancreas, mesentery and omentum; the kidneys with their capsules, the ureters and bladder; the vesiculæ seminales in the male, and the uterus, Fallopian tubes and vagina in the female.

The abdomen is by common consent divided into a number of regions, marked out by lines drawn on the surface of the body. Anatomists differ as to the points of departure for these lines; but the following seem most conducive to practical purposes. The first line is drawn from the under margin of the ribs, and continued round the body; the second is drawn parallel to the preceding one over the crista of the ilium on each side. These are decussated by two vertical lines, which Mr. Quain has judiciously suggested to be drawn from the cartilage of the eighth rib on each side down to the centre of Poupart's ligament, which answers to the top of the acetabulum. We consider these points more available than either the anterior superior or the anterior inferior spinous process, so frequently adopted in anatomical works, because the latter boundaries divide the regions with too great inequality.

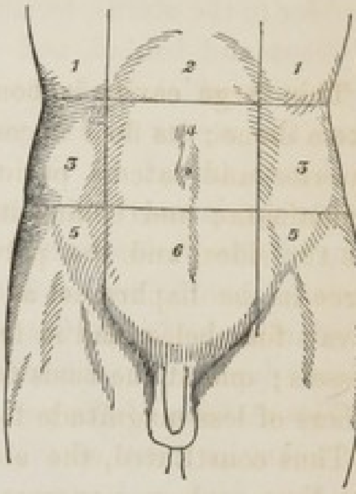
We thus obtain nine regions, three of which are above, three below and three intermediate. Of those above the central one, Fig. 206, 2, is the *epigastric region*. It contains the greater part of the stomach, the pancreas, the left lobe of the liver and the left extremity of the right lobe; and is traversed vertically by the aorta, vena azygos and thoracic duct.

* Quain. Anatomy, p. 663.

On each side of the epigastric are the two *hypochondriac regions:* the *right hypochondriac* contains the great lobe of the liver, part of the duodenum and of the ascending colon. The *left hypochondriac region* gives lodgment to the greater end of the stomach, the spleen, and the extremity of the pancreas.

The three central regions are the umbilical in the middle and the lumbar on each side. The *umbilical region*, Fig. 206, 4, contains part of the omentum and mesentery, the arch of the colon and portions of the small intestine. The *right lumbar region* accommodates the kidney, ascending colon and part of the jejunum; and the *left lumbar region* contains the corresponding viscera of the left side.

Fig. 206.



Regions of the abdomen.

The three inferior regions are the hypogastric in the centre, and the iliac region on each side. The *hypogastric region*, Fig. 206, 6, contains the lower part of the small intestine, the rectum, the bladder in the male and the bladder and uterus in the female. The right iliac region or fossa includes the ileo-cæcal valve, the cæcum and the ureter; and the left iliac region contains the sigmoid flexure of the colon and the ureter.

Fig. 206. The abdominal regions. 1, 1, hypochondriac regions; 2, epigastric region; 3, 3, lumbar regions; 4, umbilical region; 5, 5, iliac regions; 6, hypogastric region.

THE PERITONEUM.

The peritoneum is a delicate serous membrane that first covers the abdominal viscera, and is then so reflected from them as to form a perfect sac that lines the abdomen itself. Its internal surface is therefore free, smooth and glossy, and moistened by a serous halitus. Its external surface, on the contrary, is attached to the visceral and other parts that are covered by it, the medium of connection being the common areolar tissue. As a sac, the peritoneum cannot be said to have any commencing point; but in order to follow and comprehend its various and complicated reflections it is necessary to imagine one, and from thence tracing the membrane through its ramifications, to return to that point. This plan can only be satisfactorily accomplished by means of a diagram, as seen in Fig. 207, which represents a vertical and lateral section of the body with the viscera *in sitû*, and the peritoneum, marked by a line, embracing the viscera and reflected from one to the other. The membrane is generally described as consisting of two portions—abdominal and visceral.

The *abdominal peritoneum* covers the parietes of the abdomen excepting only

at those dorsal surfaces from whence the membrane is reflected on itself to embrace some one of the proximate organs. It thus lines the whole posterior face of the abdominal muscles (being separated from them by the fascia transversalis) and forms the suspensory ligament of the liver and some other analogous structures. On reaching the symphysis pubis it descends into the lesser pelvis, embracing some of the viscera entirely, others only partially.

Thus it covers the fundus, the sides and the posterior surface of the bladder, but to a variable extent according to the repletion or vacancy of that organ. In its reflections from the bladder to the rectum, the peritoneum forms in the male two duplications, one on each side (called the lateral ligaments of the bladder) with an intervening pouch or sac. In the female the reflection is from the bladder to the uterus, forming the *vesico-uterine fossa*, and then covers the uterus in front and behind, and is prolonged at the sides so as to form the broad ligaments which embrace the ovaries and Fallopian tubes. It is reflected from the uterus to the posterior surface of the vagina, so as to cover it, and is thence traced to the rectum, which below, it only covers in front, but higher up, invests completely. From the fundus of the bladder three plications of the peritoneum are formed which extend to the umbilicus; the middle one encloses the cord called the *urachus*, which in some instances appears to be tubular in the fœtus, but has no ascertained function in the human body. The lateral duplications contain the remains of the fœtal umbilical arteries.

This division of the peritoneum next ascends on the posterior parietes of the abdomen, in front of the quadrati lumborum muscles, the ureters, the aorta, the vena cava and azygos and hemiazygos veins, and the thoracic duct; the kidneys being behind and untouched by it. After giving off the visceral reflections (next to be noticed), it covers the inferior surface of the diaphragm, whence it passes, behind, upon the liver, stomach and spleen, and before, upon the anterior parietes of the abdomen.*

The *visceral peritoneum* consists of two large and several small inversions, given off from the dorsal portion of the abdominal division. The *upper large reflection* embraces between its laminæ the liver, stomach, spleen and arch of the colon, partially covers the duodenum and has the pancreas behind it. It also constitutes the *omenta*, hereafter to be described, the coronary ligament of the liver and some subordinate parts. The *lower large reflection* includes within its folds the jejunum and ileum and forms the mesentery; while the smaller reflections embrace the cæcum, ascending and descending colon and the rectum, forming at the same time their media of attachment (mesocolon, mesorectum) to the abdominal parietes.

The duodenum receives only a partial peritoneal coat and the liver is also deficient of it where it comes in contact with the diaphragm. The pancreas, kidneys and renal capsules are behind the peritoneum, and consequently receive no tunic from it. Where the liver comes in contact with the diaphragm the perito-

* Von Behr. Handbook of Anatomy, § 453.

neum is wanting, but it is reflected between the contiguous surface in such manner as to form the coronary and lateral ligaments; while another broad prolongation extending from the umbilical fissure of the liver to the umbilicus, encloses the cord-like remains of the umbilical vein and forms the proper suspensory ligament of the liver.

In a sac that has neither beginning nor end, the starting point for tracing its course and involutions is altogether optional; and the student is advised to follow his own fancy in this respect in connection with the annexed diagram, first, however, making himself in some measure acquainted with those processes of peritoneum called *omenta.*

Fig. 207. Reflections of the peritoneum. 1, liver; 2, stomach; 3, small intestine; 4, arch of the colon; 5, duodenum; 6, pancreas; 7, rectum; 8, uterus; 9, vagina; 10, bladder; 11, peritoneum reflected a little further back, from the diaphragm to the liver, which last it covers above in front and below and forms the anterior lamina of the lesser omentum, 12; it then covers the anterior face of the stomach, and forms at 13 and 14 the anterior layer of the omentum majus; at 15 it is reflected upwards to form at 16 the posterior layer of that omentum; at 17 it embraces the colon on its posterior surface and forms the posterior lamina of the mesocolon at 18; it then passes in front of the duodenum, 5, and descends to embrace the small intestine, 3, whence it is reflected upwards so as to give the posterior lamina to the mesentery, 19: it next passes down the posterior parietes of the abdomen, covers the rectum, 7, in front,—the uterus 8, the bladder 10, and thence ascends to constitute the abdominal peritoneum, 20 and 21,—lines the diaphragm and terminates above in the coronary ligament of the liver at 22. If we now trace the peritoneum from the posterior margin of that ligament, 22, we find it coating the posterior face of the stomach, 1, and then separating from that organ to form the posterior lamina of the lesser omentum at 23; it next covers the posterior face of the stomach, 24, and is thence reflected downwards to constitute the posterior layer of the anterior fold of the greater omentum, 25, 26; after which it turns upwards and forms at 27 the anterior layer of the posterior fold of the greater omentum; it then invests the front surface of the colon, 4, and forms at 28 the anterior face of the mesocolon: it thence passes upwards in front of the pancreas, 6, and terminates where we began, at the posterior margin of the coronary ligament of the liver.

Fig. 207.

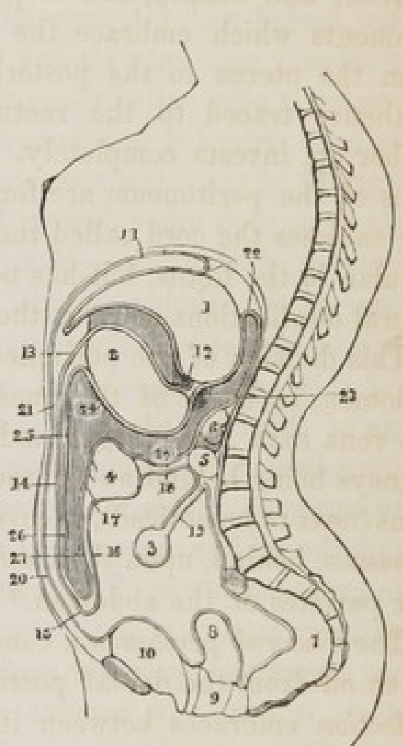


Diagram of the reflections of the peritoneum, and of the abdominal viscera as seen in a lateral section. From Cruveilhier.

The omenta.—The omenta are duplicatures of the peritoneum which are either elongated between certain viscera of the abdomen, or serve the purpose of suspending such parts in their proper position.

The *lesser omentum* or omentum hepatico-gastricum, is interposed between the transverse fissure of the liver above, and the lesser curvature of the stomach

below. Fig. 207, 12, 23. Its right margin is free and embraces between its laminæ the hepatic artery and nerves, the vena portarum, the ductus communis choledochus and some lymphatic vessels. These parts are connected together by a loose mass of areolar tissue called the capsule of Glisson. The lesser omentum after reaching the stomach, sends a layer in front of it and another behind, and the union of these again at the greater curvature below, constitutes the origin of the great omentum.

The *omentum majus*, or gastro-colicum, after commencing at the lower margin of the stomach, passes downwards to the pelvis, and then turning on itself, ascends to meet the transverse colon, which it embraces between its folds. It is then attached to the parietes of the abdomen, where it is called the *mesocolon.* Since the omentum in its descent is a double membrane, and is subsequently folded on itself, it must of necessity consist of four laminæ of peritoneum. It is often loaded with fat, especially in corpulent persons, but is scarcely seen in early infancy and only attains its full development in adult age. The omentum majus is also called the *epiploon.* Its uses are not distinctly understood. It has been regarded as a reservoir of fat, as a covering to increase or preserve the warmth of the intestines, and as a medium for facilitating the motion of the bowels upon each other during their vermicular action. Fig. 207.

Foramen of Winslow.—Near the right margin of the lesser omentum, and at the base of the lobulus spigelii, is seen the foramen of Winslow, an opening of an inch in diameter leading directly into the sac of the great omentum. The use of this arrangement was imperfectly understood until explained by Dr. Hodge of this city, who has shown that it is the avenue by which the internal or lining lamina of the omentum majus is introduced, so as to make the parietes of the omentum double throughout;* or, in the words of Cruveilhier, through this opening the peritoneum enters the pouch formed between the two external layers of the great omentum. The peritoneum is first applied to the posterior surface of the anterior lamina of the lesser omentum, and hence forms its posterior layer: it then covers the posterior surface of the stomach, from the greater curvature of which it comes in contact with the great omentum, passes down with it and constitutes it a double membrane. When this twofold structure has reached the point where the anterior layer of the great omentum is reflected, the layer we are now describing is itself reflected in the same manner, and becomes applied to the anterior surface of the posterior fold of the great omentum. Continuing to ascend, it reaches the convex border of the transverse colon, covers the upper surface of that intestine, and farther back, is applied to that layer of the great omentum which, as we have seen, covers the lower or posterior surface of the colon, thus forming the upper or anterior of the two laminæ of the transverse mesocolon.

Some subordinate prolongations of the peritoneum remain to be mentioned. The *appendices epiploicæ* are small peritoneal sacs attached to the large intestine

* Horner's Anatomy and Histology, ii. p. 23.

and filled with fat. Fig. 219, *m*. The *omentum colicum* is a process of the great omentum on the right side, that runs for a short distance along the upper part of the transverse colon. The *mesocolon* attaches the transverse colon to the proximate parietes of the abdomen; the *mesorectum* serves the same purpose for the rectum; and the *gastro-splenic omentum* connects the spleen to the stomach and invests the blood-vessels that pass between these viscera. The *gastro-phrenic ligament* is a duplicature of the peritoneum that connects the diaphragm with the esophagus and lesser curve of the stomach; and the *mesentery*, (Fig. 217,) a more remarkable duplication, will be described with the small intestine.

THE STOMACH.

The stomach or ventriculus, the great dilatation of the alimentary canal, lies in the left hypochondriac and epigastric regions, nearly filling the former and extending across the latter. It is of a conoidal shape, the base being on the left side, from which it extends obliquely downward to the right side so that its apex or duodenal termination is at or near the gall-bladder. It is sustained in its position by its connection with the esophagus above and by its peritoneal attachments and relation to the duodenum below. The size of the stomach is very different in different individuals and variable according to its emptiness or repletion. Its medium capacity may be assumed at a quart; but every one accustomed to post-mortem examinations must have often seen it of far greater size, and especially in great drinkers.

The stomach has two curvatures; the lesser one corresponds to the upper margin and occupies the space between the esophagus on the left side to the pylorus on the right: it is to this surface that the hepatico-gastric omentum is attached, forming a suspensory ligament for the stomach. The greater curvature includes the whole inferior convex margin, or in other words, the space between the pylorus and esophagus below. It gives off the anterior double layer of the great omentum.

The stomach has also a greater and a lesser extremity. The greater end is on the left side within the hypochondrium: it comprises the cul-de-sac to the left of the esophagus, and is in contact with the spleen, to which it is connected by the gastro-splenic omentum. It is also in direct relation with the diaphragm above, and behind with the pancreas and left kidney. It need scarcely be repeated, however, that these relations are constantly varied by the contents of the stomach. The right or lesser extremity of this viscus is the part of it that is prolonged from the cardiac orifice to the pylorus, forming the conoidal body of the stomach and at least two-thirds of its whole length.

The two surfaces of the stomach are called anterior and posterior. The *anterior or upper surface* in the undistended state faces the abdominal parietes; but when inflated in the dead body it turns upwards in the direction of the diaphragm. The posterior surface, on the contrary, presents towards the spine.

The stomach has also two orifices, the *cardia* and the *pylorus*. The esophageal or cardiac orifice is the termination of the esophagus into the greater end of the stomach. Dr. Horner remarks in reference to this opening, that it is marked by a circular rounded pad, elevated two lines or more all around, so as to form a perfect ring from eight to twelve lines broad at its base. He adds that this pad appears to be composed of white, elastic cellular substance, interposed between the lining membrane of the cardiac orifice and the adjoining coat.* With every deference to this distinguished anatomist, I have not been able to detect this structure, which was insisted on by the older anatomists, but which has been relinquished by most recent observers. Its occasional existence may be regarded as an accidental conformation,—a local hypertrophy of one of the coats, a condition to which both the fibrous and muscular tunics are particularly liable.

The *pyloric orifice* indicates the termination of the stomach and the commencement of the duodenum. It is marked by an annular thickening of the parts and may be regarded in some respects as a sphincter, in others as an imperfect valve between the proximate cavities. Its structure will be described with the mucous coat.

The stomach is constituted of four coats or tunics, each of which is readily separated from the others in the succession of a peritoneal, a muscular, a fibrous and a mucous layer.

The *peritoneal coat* has been already described. It is only necessary here to repeat, that it forms a complete investment excepting at the two curvatures, where it is more loosely attached and presents open spaces of a triangular shape. The obvious use of these spaces is to allow of the greater distension of the stomach in a state of repletion. This is manifest to observation by inflating this organ; but Cruveilhier is of the opinion that when it is inordinately dilated, the two anterior layers of the great omentum yield to the emergency and embrace the stomach.

The *muscular coat* consists of three layers more or less complete, of which the external one is longitudinal. It is seen distinctly beneath the serous coat, its fibres being continuous with those of the esophagus from which they expand in their course from the cardiac to the pyloric orifice. The fibres of this tunic can also be traced into the greater extremity of the stomach and along its greater curvature. The *second layer* is annular. The rings of muscular fibre commence at the cardiac orifice and extend to the pylorus, increasing in number the further they are removed from the cardia. These rings are not continuous around the whole organ, but are constantly interrupted for the obvious purpose of admitting dilatation. At the pylorus the fibres are thickened to form the basis of the pyloric valve. It will be observed that these circular fibres decussate the exterior layer at right angles, thus affording a great power of contraction. The *third*, or *inner muscular layer*, is composed of fibres that run

* Special Anatomy and Histology, ii. p. 32.

obliquely in respect to the others, and are chiefly seen in several planes; one of these embraces the greater end of the stomach, runs outward and downward from the cardiac orifice to the greater curvature and diverges upon the anterior and posterior surfaces; another plane, commencing at the right of the cardiac orifice, is chiefly spread over the anterior and posterior surface of the greater end of the stomach. These fibres decussate both of the longitudinal and the circular series, and consequently augment the power of contraction.

The *nervous*, or, more correctly speaking, the *fibrous coat*, is a distinct layer of white, dense, closely woven fibres interposed between the mucous and muscular coats. Its use is to connect those coats together and at the same time to furnish a medium for the transit of the blood-vessels of the stomach. It is of nearly uniform thickness throughout.

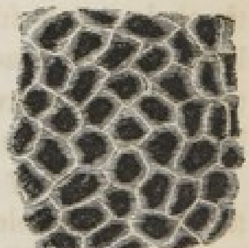
The *mucous coat* is that which lines the stomach within; one surface being attached to the fibrous coat, the other free. When this internal surface is examined by the unassisted eye, it has a soft, velvety appearance and is thrown into longitudinal folds. The folds or rugæ are temporary, existing only in the undistended state of the organ, but becoming more and more marked in long-continued abstinence from food. This fact I had occasion to verify in the case of a lady who died of inanition, in whom the stomach was extremely contracted and the rugæ developed in proportion.

The mucous membrane consists of three layers, the epithelial or free surface, the basement-membrane and the proper mucous structure which forms the connection with the fibrous coat.

The *epithelium* of these organs is a continuation of the epidermic layer of the skin; it commences at the lips and retains the tesselated form as far as the cardiac orifice of the stomach, where it merges into the cylindrical epithelium, a modification it retains to the anal extremity of the digestive canal. These epithelial structures will be fully considered in the chapter on secretion.

The lining membrane of the stomach, when carefully deprived of its mucus by washing, has a pitted appearance not unlike a honeycomb. The septa between these depressions are ridges formed of condensed areolar tissue, which in common with the other parts of this structure, possesses a great vascularity. If a moderate magnifying power be directed to one of these gastric pits or *favuli*,* its whole concave surface presents a multitude of minute orifices which lead to corresponding pouch-like follicles.

Fig. 208.



Gastric favuli.

Fig. 208. Inner surface of the stomach from which the mucus has been washed in order to show the favuli.

The follicles themselves are simple inflections of the mucous membrane: they run in straight or slightly curved lines, and discharge

* *Favulus*, the diminutive of *favus*, a honeycomb. I employ this word as a specific designation. The term *stomach-cell*, used even by Drs. Todd and Bowman, cannot be entertained with the present physiological value of the word *cell*.

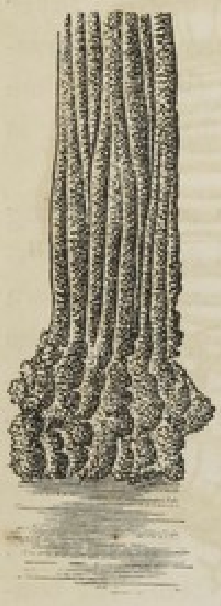
their secretion, which is the gastric juice, into their associated favuli. They are dilated at their origin, so that the basis of every series of follicles has a swelled and convoluted appearance.

Fig. 209.

Gastric follicles.

Fig. 209 represents a fasciculus of gastric follicles magnified three times their natural diameter; and Fig. 210 shows another series much more highly magnified.*

Fig. 210.



Gastric follicles, highly magnified. After Wagner.

The follicles are lined to the bottom with columnar epithelium,—the true secretory apparatus,†—and they are most numerous at the pyloric end of the stomach. The vicinity of both orifices also embraces within the mucous membrane some small but distinct glandular bodies supposed to belong to the same class with the glands of Brunner; and like the latter their function appears to consist in the secretion of simple mucus, which is poured into the stomach by a set of appropriate follicles.

Fig. 211.

Fig. 211. Horizontal section of a single gastric favulus or pit made a short distance within its orifice. 1, basement membrane; 2, columnar epithelium; 3, fibrous matrix surrounding and supporting the basement membrane; 4, small blood-vessel. All but the centre of the cavity is occupied by a transparent mucous secretion. From Todd and Bowman.

At the point where the stomach terminates in the duodenum, the mucous membrane is partially folded or reflected across the orifice so as to form a septum with a central, rounded perforation that will freely admit the little finger. It is called the *valve of the pylorus*. The circular fibres of the muscular coat are considerably thickened around the external margin of the valve, and are regarded by some anatomists as a separate muscle.

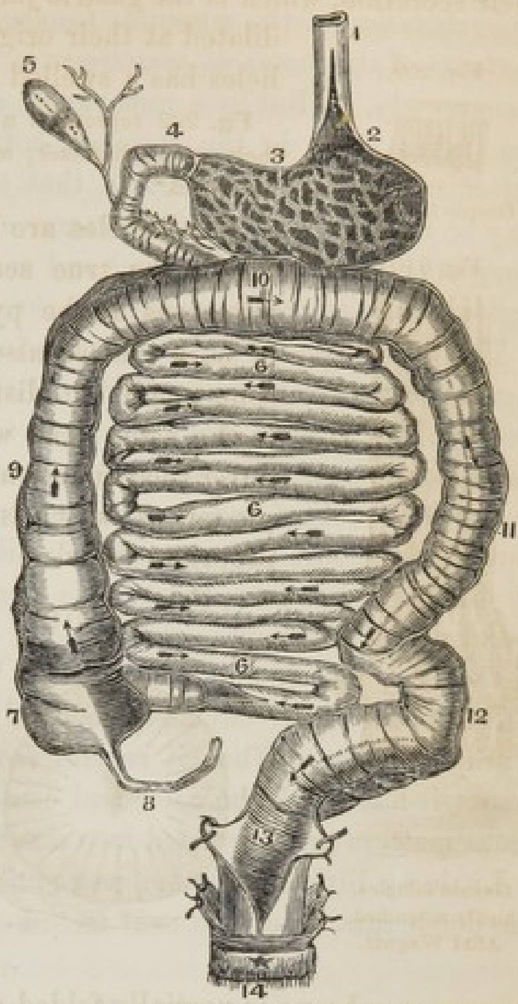
The *arteries* of the stomach come directly or indirectly from the cæliac branch of the aorta. Thus the lesser curvature is supplied by the coronary artery and the pyloric branch of the hepatic. The greater curvature has the right and left gastro-epiploic arteries; and to the left extremity of the stomach are distributed the vasa brevia, some five or six in number, which are themselves branches of the splenic.

The *nerves* of the stomach are derived from the pneumogastric and from the semilunar ganglions of the sympathetic. The former surrounds the cardiac orifice as a plexus, and is the medium of communication between the stomach, the esophagus and pharynx, the larynx, lungs and heart.

The veins of the stomach terminate in the vena portarum; and the lymphatics, which are very numerous, are readily traced to the associated glands on the greater and lesser curvatures.

* Wagner. Icones Physiologicæ, tab. xvi. fig. 1. † See *Secretion*.

Fig. 212.



Digestive tube. After Cloquet.

Fig. 212 represents the digestive tube from the esophagus to the anus. 1, esophagus, which is laid open at 2, to show its termination in the cardiac orifice of the stomach; 3, interior of the stomach with its rugæ; 4, duodenum, commencing at the pylorus; 5, gall-bladder with the cystic duct, which last passes downwards to open into the duodenum; 6, 6, 6, small intestine, terminating in the cæcum, 7; 8, appendicula vermiformis; 9, right ascending colon; 10, transverse arch of the colon; 11, left descending colon; 12, sigmoid flexure; 13, rectum; 14, anus.

FUNCTION OF THE STOMACH.

This is limited, in man, to the reduction of food to a certain consistence called *chyme*, and this is effected by the remarkably solvent power of the gastric juice,—a clear, yellowish fluid, generally mixed with a little mucus, without smell, slightly saline and antiputrescent. Its analysis yields water, a free acid, a few organic particles and the salts common to the animal fluids. The free acid in man is the hydrochloric; the organic constituents are ptyalin, ozmazome and a peculiar matter which, in combination with the free acid, forms the proper digesting principle called *pepsin*. It acts in so small a quantity that even the $\frac{1}{60,000}$th part added to acidulated water endows the fluid with digestive properties.*

When food is received into the stomach, it is not only subjected to the action of the gastric juice, but also to the mechanical action of the muscular coats of the stomach, by which the aliments are thoroughly triturated and blended together until every portion of them has been brought into direct contact with

* Wagner. Elements of Physiology, p. 334.

the parietes of the stomach. This motion is effected by an alternate shortening and relaxation of the muscular fasciculi, "producing a kind of revolution in the contents of the stomach, sometimes in the direction of its length, and sometimes transversely." But by a remarkable adaptation of parts, an hour-glass contraction takes place in the stomach before digestion is fully completed; and the object of this arrangement is, that the undissolved or non-chymified portion may be retained in the left or larger end of the stomach until the chyme-state is complete: meanwhile the fluid and more elaborated part passes into the pyloric region of the stomach and thence through the valve into the duodenum.

The time requisite for the conversion of aliments into chyme is varied according to the nature of the ingesta. Dr. Beaumont made several hundred observations on this subject, from which it appears that rice becomes chymified in a single hour; some fish, as salmon-trout, in an hour and a half; liver and tapioca in two hours; beef and mutton in three hours; veal in four hours; and roasted pork, in five hours and a quarter. Different periods would of course be required by different stomachs, for what is digestible with one would be unmanageable with another; and again the capacity for digestion will vary with circumstances in the same individual.*

Fully elaborated chyme is semifluid, homogeneous and slightly acid, and of a grayish color. When it results from the digestion of highly nutritious aliments it has much the color and consistence of cream; but watery and farinaceous matters are converted into a substance resembling gruel.

Little by little the chyme passes the pyloric valve and is thus received into the duodenum, where its next metamorphosis is into chyle.

THE INTESTINES.

The intestines constitute a tube that extends from the pyloric end of the stomach to the anal termination of the rectum. Their average length is about thirty feet, but varies in different individuals. Their diameter is also very unequal, being in some parts an inch, in other places three inches. The whole tube is divided into two principal portions, the small and the great intestine; the first section lies between the pylorus and the ileo-cæcal valve; the second extends from that valve to the anus.

The four coats of the stomach are extended, with slight exceptions and some variations of arrangement, to the whole intestinal canal. The *peritoneal coat* is the same in both. The *muscular coat* is formed of two laminæ of which the external is longitudinal: its fibres are thin, pale and much scattered. The internal muscular coat is composed of annular fibres which do not, however, pass continuously round the bowel, but are invariably interrupted at some part of their course. The *cellular coat* is like that of the stomach; but the *internal* or *mucous coat* is in several respects different.

* Beaumont. On Digestion, p. 269.

The *mucous coat* of the intestine is remarkable for the arrangement called *valvulæ conniventes*. These consist of plications or folds of the mucous membrane, two or three lines broad in the centre, but running gradually to a point at each end. They do not surround the intestine, but represent from a half to three-fourths of its circumference. Their use appears to be to increase the mucous surface of the bowels which is thought to be at least doubled by them.

THE SMALL INTESTINE.

This portion of the intestine is again subdivided into three parts, the duodenum, jejunum and ileum, which present, however, a continuity of structure without any precise lines of demarkation; and they form, collectively, five-sixths of the whole alimentary canal.

THE DUODENUM.

The *duodenum* is so named on account of its length, which is equivalent to the breadth of twelve fingers or about ten inches. It is the largest portion of the small intestine and at the same time much the shortest. It commences at the pylorus, ascends to the under surface of the liver, and thence descending in front of the right kidney, passes obliquely across the abdomen to the left side of the second lumbar vertebra where it opens into the jejunum. Where the duodenum is in relation with the liver, it is attached to the latter at the gall-bladder by a duplicature of peritoneum by which it is movably suspended, and from which it also receives an investing tunic. That portion of the intestine which is continued from this point, that is to say, its descending and transverse portion, is embraced between the lamina of the mesocolon, but has no proper peritoneal covering; but the termination on the left side is again surrounded by the peritoneum. The transverse duodenum is contiguous, on the right side, to the ascending colon, and on the left to the pancreas with which it is closely connected; in its intermediate course it is in front of the pancreas, the crura of the diaphragm, the aorta and vena cava.

The mucous membrane of the duodenum contains the first appearance of the *valvulæ conniventes*, which commence an inch or two from the pylorus, few in number and small at first, but gradually increasing in size towards the jejunum. The villi are of course developed in the same proportion and become vastly numerous at the terminus of the duodenum.

The villi.—When the mucous membrane of the small intestine is cleansed and examined by a good light, its whole internal surface has a furred or velvety appearance, owing to a multitude of fungiform or foliaceous prolongations of its structure from the twentieth to the tenth of a line in length. Their number is estimated at 4000 to the square inch. Under the microscope, each villus is

seen to consist of a plexus of blood-vessels and a lacteal tube, the former being very numerous and especially on the surface of the villus, which is a complete vascular network. Hence it is inferred, and experiment sustains the supposition, that they perform an important part in the function of absorption. But the most interesting feature of the villus is the absorbent itself which is here called a *lacteal*. This tube appears to originate in the dilated apex of the villus by anastomosing loops which converge to form a single trunk: the latter pursues a curved direction to the base of the villus, where it opens into larger tubes formed by the confluence of innumerable other villi. How does the lacteal of the villus communicate with the cavity of the intestine? It was formerly supposed that it opened by one or by several orifices on the mucous surface; but all the more recent observations prove that no such orifices exist, and that the origin of the lacteals is either by cæcal canals, or by an anastomotic plexus as above stated, or by both modes conjointly. Fig. 213 represents a villus with its lacteal plexus, taken from the jejunum of a young man who was hanged soon after taking a full meal of farinaceous food.

Fig. 213.

Villus with its lacteals.

Since the lacteal is not provided with an orifice on the intestinal mucous membrane, we can only explain its power of absorbing the chyle on the principle of *endosmosis*.* From the observations of Mr. Goodsir, quoted by Dr. Carpenter, it appears that the lacteal loops are embedded in a mass of cells which are the real agents in the selection of the materials to be conveyed into the lacteals; and which after becoming distended with the nutritive fluid, transfer it to the lacteals either by bursting or by deliquescence.

A cluster of these *absorbent cells* may be seen at the apex of every villus, in the midst of which the origin of the lacteal is lost. These cells are relaxed during the intervals of digestion and appear as a mere aggregation of granular germs, and they are then also covered by the proper epithelial cells of the mucous membrane. But when stimulated by the presence of food, the epithelium becomes detached in order that the former may come into more direct relation with the absorbent cells, which now become erect and turgid from distension with a milky fluid: this fluid is identical with that of the lacteals;

* *Endosmosis and exosmosis.*—"When two fluids differing in density are separated by a thin animal or vegetable membrane, there is a tendency to mutual admixture through the pores of the membrane; but the less dense fluid will transude with much greater facility than the more dense, and consequently there will be a considerable increase on the side of the denser fluid; whilst very little of this, in comparison, will have passed towards the less dense. When one of the fluids is contained in a sac or cavity, the flow of the other towards it is called *endosmose* or flow-inwards; whilst the contrary current is called *exosmose*, or flow-outwards.

"Thus if the cæcum of a fowl, filled with syrup or gum-water, be tied to the end of a tube and immersed in pure water, the latter will penetrate the cæcum by endosmose, and will so increase the volume of its contents as to cause the fluid to rise to a considerable height in the attached tube. On the other hand, a small proportion of the gum or syrup will find its way into the surrounding fluid by exosmose. But if the cæcum were filled with water, and immersed in a solution of gum-water or sugar, it would soon be nearly emptied—the exosmose being much stronger than the endosmose."—*Carpenter. Elements of Physiology*, § 491.

whence the function of the absorbent cells appears to be, in the first place, to draw their materials, not from the blood, as the secreting cells do, but from the nutritious matter of digestion; and in the second place, to burst or liquefy and by this means discharge their contents near the proximate lacteal, by which they are at once imbibed.

It is thus that "the cells grow rapidly, select, absorb, and prepare the nutritious matter for making it a part of themselves; and when their work is accomplished, they deliver it to the lacteals" in the manner we have mentioned. They begin and end as cells without undergoing any transformation, being continually destroyed and as constantly reproduced.

The accompanying diagrams from Dr. Carpenter represent the comparative condition of the mucous membrane, its villi and its secreting follicles during the time when absorption is going on and also during the intervals of that process.

Fig. 214.

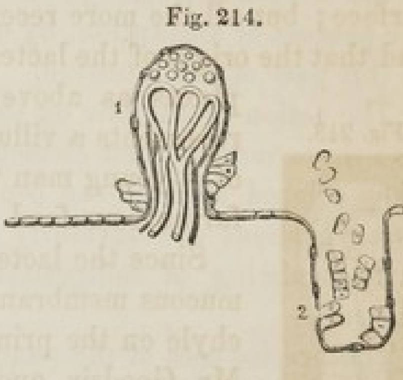


Fig. 215.

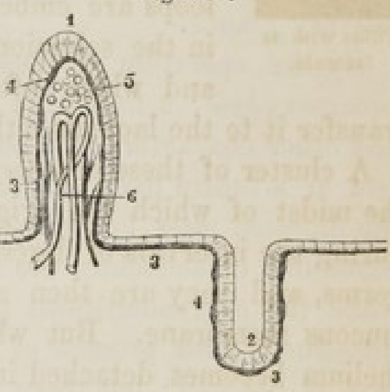


Fig. 214 represents the mucous surface during the process of digestion and the absorption of chyle. 1, one of the villi turgid and erect, its protective epithelium being cast off from its free extremity; its lacteals, absorbent-cells and blood-vessels being all in a state of distension and activity. At 2, is shown a mucous follicle in the act of casting off its secreting epithelial cells; a process which takes place during digestion not only in these follicles, but in the villi and from the free surface of the membrane.

Fig. 215 is another diagram, which represents the mucous membrane of the jejunum during the absence of absorption. 1, protective epithelium of the villus; 2, secreting epithelium of the follicle; 3, 3, primary or basement membrane with germinal spots or nuclei 4, 4; 5, germs of absorbent cells; 6, lacteals; the blood-vessels of the villus are seen at its base.*

But the lacteals are not, as we shall hereafter see, the sole agents of chylous absorption; for the blood-vessels of the mucous membrane of the alimentary canal, and especially those of the villi, also perform an important collateral function.

The *glands of Brunner* are situated in the submucous tissue of this intestine. Their size is that of a hempseed, flattened or oval, yet each one contains several hundred follicles collected around a series of excretory ducts, which empty their contents into the duodenum in the same manner that those of the sublingual gland open into the mouth. Their secretion is supposed to be analogous to that of the pancreas, or in other words like that of the salivary fluid.

The *glands* or *crypts of Lieberkühn*, or gastro-enteritic follicles, are multitudinous depressions in the mucous membrane giving it a cribriform appearance. They lie between the bases of the villi in the small intestine and are also very numerous throughout the mucous membrane of the alimentary canal. Dr.

* Carpenter. Elements of Physiology, §§ 241, 242.

Horner has shown that this cribriform structure is owing to a peculiar arrangement of the veins, in which the arteries have little or no part.*

About four inches from the pylorus is a small orifice marked by a slight thickening of the mucous membrane. This is the common opening of the hepatic and pancreatic ducts; although, in some instances, each makes a separate perforation.

FUNCTION OF THE DUODENUM.

The food which has become *chyme* in the stomach is transformed into *chyle* in the duodenum, through the agency of the biliary and pancreatic fluids; and the process of absorption, by means of the villi, is commenced, as we have seen, in this part of the intestine.

The action of the bile on the chyme is threefold, for it separates the latter into three very distinct elements;—a reddish brown sediment at the bottom—a whey-colored fluid in the centre and a creamy pellicle at the top. The two latter portions are obviously destined for alimentation; but the sedimentary part, consisting of indigestible food and some bile, is of an excrementitious nature.

The precise uses of the pancreatic secretion are not yet determined; but they are probably little more than of a solvent character, like the mucus of the salivary glands.

By the operation of these fluids, aided by the principle of vitality, chyme becomes *chyle;* a fluid of a milky color and consistence, of which the physical and other characters will be considered with the description of the lacteal system in a future part of this work. It is sufficient here to observe, that after the digested mass has passed that part of the duodenum marked by the ductus communis choledochus, the chyle begins to be absorbed into the lacteal tubes, while the excrementitious portion passes onwards to the lower portions of the intestine. This process of absorption will be understood from what has been said of the villi; but there appears to be another mode by which aliments are received into the circulatory system.

This is supposed to take place from direct absorption by the veins both in the stomach and intestinal tube. This function, however, is probably limited to nutritive substances in a state of *perfect solution*, such as gum, sugar, pectine, gelatin, and soluble albumen and water, which last is chiefly received into the system through this medium.

The proofs of venous absorption are mainly as follow:—"It appears from the experiments of Tiedemann and Gmelin, that when various substances were mingled with the food, which, by their color, odor or chemical properties might be easily detected—such as gamboge, madder, rhubarb, camphor, musk, assafetida and saline compounds—they were seldom found in the chyle, though many of them were detected in the blood and in the urine. The coloring matter

* Anatomy and Histology, ii. 52.

appeared to be seldom absorbed at all; the odorous substances were generally detected in the venous blood and in the urine, but not in the chyle; whilst of the saline substances, many were found in the blood and urine, and very few in the chyle."*

In the stomach, moreover, which contains no lacteals, experiment has shown that fluid substances are absorbed from its walls when they have been prevented from passing the pylorus.

THE JEJUNUM AND ILEUM.

The *jejunum*, so called on account of its usually vacant condition, forms the upper two-fifths of the small intestine. It commences where the duodenum ends, on the left side of the second lumbar vertebra, and terminates without any definite boundary in the *ileum*. The latter is continued to the right iliac region, where it opens into the ileo-cæcal valve and constitutes three-fifths of the small intestine. The valvulæ conniventes are extremely numerous in the jejunum, become less frequent in the ileum and disappear some distance before its termination. The diameter of the jejunum and ileum is about an inch and a half at its origin and an inch at its terminus, the diminution being extremely gradual between those two points. The whole structure is strung upon the mesentery, and is so convoluted upon itself as to depend into the umbilical, lumbar, hypogastric and iliac regions, and to be embraced within the circuit of the colon.

The muscular fibres are chiefly circular, but are obscurely decussated by others that pursue a longitudinal course. The blood-vessels of the small intestine are derived from the superior mesenteric: they are remarkable for the anastomosing loops formed by them before they enter the bowel, for their flexuous course within its coats and for the series of vascular layers formed by them between the peritoneal and muscular, the muscular and fibrous, and the fibrous and mucous coats.†

Glands of Peyer.—These bodies, called also *glandulæ agminatæ*, are seated almost exclusively in the ileum and in its mucous membrane. They present the appearance of circular, white, slightly raised spots, over which the intestine is generally destitute of villi. Each of these spots, which are particularly numerous opposite to the attachment of the mesentery, is surrounded by a circle of minute orifices which lead, like the follicles of Lieberkühn, into tubular cæca. These follicles, however, have no apparent connection with the enclosed Peyerian gland; for the latter, on being ruptured, is found to be a cavity cor-

Fig. 216.

Glands of Peyer. From Mandl.

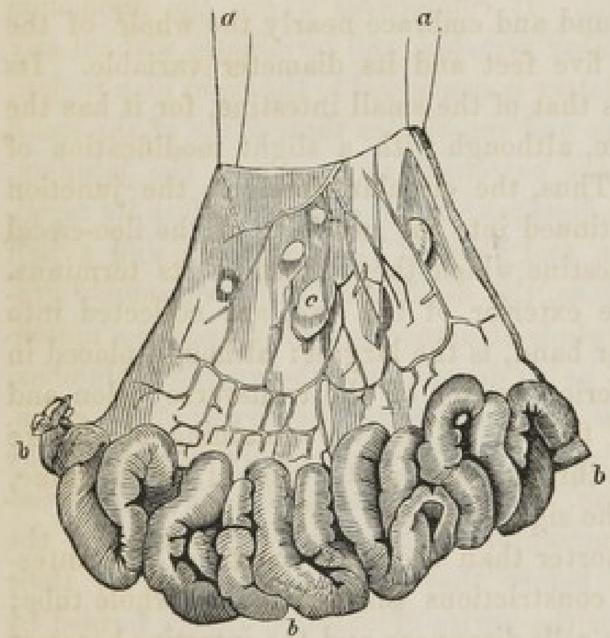
* Carpenter. Elements of Physiology, § 493.

† Cruveilhier. Anatomy, p. 370.

responding with the white spot, but without an external orifice or duct of any kind. Its contents consist of mucus, and cells in various stages of development. "There is reason to believe that at a certain period of the existence of these glandulæ, an excretory orifice is formed by a sort of dehiscence in the wall of the cavity; and that through this the product secreted by the contained cells may be poured forth."* It is these glands that become so enormously enlarged in typhoid fever, and which constitute, in their pathological condition, the essential characteristic of that disease. Fig. 216.

Function of the jejunum and ileum.—This is chiefly limited to absorption by the lacteal vessels and venous plexuses, which, however, becomes less and less active the lower it proceeds in the intestinal tube, because the villi, in this direction, are constantly on the decrease. On the other hand, the numberless glands and crypts that everywhere exist in the mucous membrane secrete a great abundance of mucus, which serves to dilute the digested fluid, but is itself added to the excrementitious products of digestion, and passes with it through the ileo-cæcal valve into the great intestine.

Fig. 217.



The mesentery.

Fig. 217. The mesentery. *a, a*, the mesentery suspended; *b, b, b*, the small intestine; *c*, mesenteric glands.

THE MESENTERY.

The mesentery is a duplication of the peritoneum to which the entire length of the small intestine is attached. It extends from the second lumbar vertebra on the left side to the iliac fossa on the right, a distance of about six inches, which therefore corresponds to the base of the mesentery. Its periphery, however, is so plicated or folded as to equal in length the intestine itself. Its double lamina encloses and conducts the blood-vessels, lacteals and nerves of the small intestine, together with its accessory glandular system called the mesenteric glands. Fig. 217.

* Carpenter. Principles of Physiology, p. 670.

THE LARGE INTESTINE.

This portion of the alimentary canal extends from the end of the small intestine to the anus. Commencing in the right iliac fossa, it extends upward to the corresponding hypochondriac region, whence it crosses the abdomen to the left hypochondrium below the spleen. It then turns downward, and forming an abrupt curve over the ilio-sacral articulation, dips into the pelvis, and after a short course terminates in the anus. The great intestine thus makes the circuit of the abdomen, so as to surround and embrace nearly the whole of the small intestine. Its length is about five feet and its diameter variable. Its organization is essentially the same as that of the small intestine, for it has the same four tunics or component laminæ, although with a slight modification of arrangement in the muscular coat. Thus, the circular fibres, at the junction of the ileum with the cæcum, are continued into the two folds of the ileo-cæcal valve, and thence into the large intestine which they invest to its terminus. The longitudinal fibres, which are the exterior of the two, are collected into three bands; one of these, the anterior band, is the largest: although placed in front at its origin, it lies at the inferior border of the transverse colon and again appears in front at the sigmoid flexure. The two remaining bands are smaller: they pursue a separate course through the greater part of the intestine, but sometimes mingle their fibres at the sigmoid curve. Fig. 219.

The longitudinal fibres are much shorter than the other coats of the intestine, whence they produce a series of constrictions throughout the whole tube; so that when the bands are divided, the cells disappear and the intestine becomes much elongated. These external constrictions of the vessel are marked by corresponding *pouches* on its interior, separated from each other by partial septa formed by an inflection of all the tunics excepting the longitudinal fibres only. These plications project into the intestine in an angular form and are very numerous, as may be verified by inflating, drying and dividing a section of the tube. Figs. 218, 219. The obvious use of these pouches is to prevent the too rapid transit of feculent matter.

The CÆCUM is a cul-de-sac, situated in the right iliac fossa, to which it is firmly attached by a process of peritoneum. Its closed end presents downwards, its open or basal end upwards. Its length seldom exceeds three inches, but it is capable of greater dilatation than any part of the alimentary canal excepting the stomach. It is in contact in front with the abdominal parietes; behind, with the iliacus internus muscle. Fig. 219, *a*.

One of the principal points of interest in the cæcum is the *ilio-cæcal valve*, which is the medium of communication between the great and small intestines. It is an elliptical slit of an inch in length, strengthened at the ends or angles by accessory fibres. The valve is composed of the mucous, fibrous and circular muscular tissue of the small intestine, which are inflected from opposite

sides so as to form two lunated folds or lips. The mucous membrane of the upper surface has the same character as that of the ileum, while the lower surface corresponds in this respect to the colon. The valve opens downwards; and its function is to prevent the return, into the ileum, of fæcal matter that has already passed through the valve into the large intestine.

Fig. 218.

The ileo-cæcal valve.

Fig. 218. Ileo cæcal valve. *a*, the terminal part of the ileum; *b*, the ileo-cæcal valve; *c*, the cæcum; *d*, the appendicula vermiformis; *e*, the commencement of the colon.

Attached to the cæcum is the *appendicula vermiformis*—a process of intestine about three inches in length and of the diameter of a goose-quill. It is given off from the lower and posterior part of the cæcum, but is variable in its direction and its uses are altogether conjectural. Sometimes its opening into the intestine presents something of a valvular arrangement.

The colon.—This division of the bowels is again subdivided into three parts, called the ascending, the transverse and the descending colon. The *ascending colon* is a contraction of the cæcum; from which it passes upwards from the right iliac fossa, through the right lumbar region and in front of the kidney, until it approaches the gall-bladder. It is firmly connected to the abdominal parietes by the peritoneum, which occasionally forms a fold or duplication behind it called the *lumbar mesocolon*. In front of it lie the convolutions of the small intestine; behind, are the right kidney and quadratus lumborum muscle. The *transverse colon* begins near the gall-bladder, where the ascending portion forms an abrupt angle and turns to the left so as to cross from the right to the left hypochondrium. In this course it is curved with its convexity presenting in front, whence it is also called the *arch of the colon*. It is suspended in the abdomen by a broad duplicature of the peritoneum called the *transverse mesocolon*, which allows it free motion and separates the stomach, liver and spleen above from the small intestines below. Fig. 219, *g*. The *descending colon* corresponds in its relations to the opposite portion; but it is less in diameter and more deeply seated. In the left iliac fossa it becomes much narrower than elsewhere, and by curving upwards, downwards and laterally, forms the *sigmoid flexure*. It is attached to the iliac fossa by the mesocolon and terminates in the rectum. Fig. 219.

The rectum commences at the top of the sacrum, and following the curve of that bone, to which it is closely related, terminates in the anus. It inclines at first slightly to the right side, but soon resumes the median line which it continues until it approaches the os coccygis, when it curves backward and ends at

the anus. The pouches so frequent in the upper portions of the large intestine are absent in this; it is also without the muscular bands, in place of which the whole tube is embraced by a tunic of longitudinal muscular fibres within which the circular layer has a remarkably robust development. The lowest of these annular fasciculi is just within the verge of the anus, and is sometimes described as a separate muscle by the name of the *internal sphincter*. The size of the rectum varies in its different parts. It is small at its commencement, but gradually increases as it descends, until near its termination, when it dilates into a capacious pouch. The *anus* is about an inch in front of the os coccygis. Its external margin is of a darker color than the surrounding integument, is supplied with sebaceous follicles and more or less covered with hair. The epidermis becomes very delicate over this surface and terminates within in a true epithelium. The point at which the skin becomes continuous with the mucous membrane is deserving of notice. "It is within the rectum, at a distance of some lines from the anus, properly so called, and is marked by a waved line, which forms a series of arches or festoons having their concavities directed upward. Sometimes there are small pouches in the situation of these arches, opening upward."* The mucous membrane of the rectum is remarkably thick and vascular, and forms a column below which pursues a longitudinal course, and being crossed by folds of the same membrane towards the anus, gives rise to the pouches just mentioned.

The rectum is replete with mucous glands and follicles which pour out an abundant secretion of their peculiar fluids. This intestine is retained in its position by a process of peritoneum called the *meso-rectum*, by which it is attached to the posterior parietes of the pelvis. Its upper part is comparatively free; but its lower and anterior portion is in contact with the bladder, so that the peritoneum dips down between them in the manner of a cul-de-sac. In the female, this pouch is interposed between the rectum behind and the vagina in front; but the two structures are intimately united below this peritoneal inflection.

The arteries of the rectum are derived from the inferior mesenteric, the internal iliac and the internal pudic. The veins enter into the mesenterics and contribute to the vena portæ.

The muscles of the rectum, which have been already described, are the sphincter ani and the transversus perinei, which are single; and the levator ani and coccygeus on each side. Fig. 219.

Follicles of Lieberkühn.—These crypts, which have been already noticed in connection with the villi of the small intestine, are abundantly distributed throughout the colon, cæcum and rectum. The illustration, Fig. 219, is from the colon. Dr. Horner, to whose researches in respect to these structures we have heretofore adverted, is disposed to attribute to them not a secreting office, as generally supposed, but a proper *absorbing function*. He thinks their number far greater than could be required for the mere secretion of mucus, especially since the mucous membrane is otherwise so amply provided for in this respect

* Cruveilhier. Anatomy, p. 380.

by the glands of Brunner and Peyer. He has not been able to detect, on their free surfaces, the lacteal foramina described by Lieberkühn and others; and he finally suggests that their function is that of absorption, which as in the villi, is accomplished without the intervention of patulous ducts, or in other words, on the familiar principle of endosmosis.*

Fig. 219.

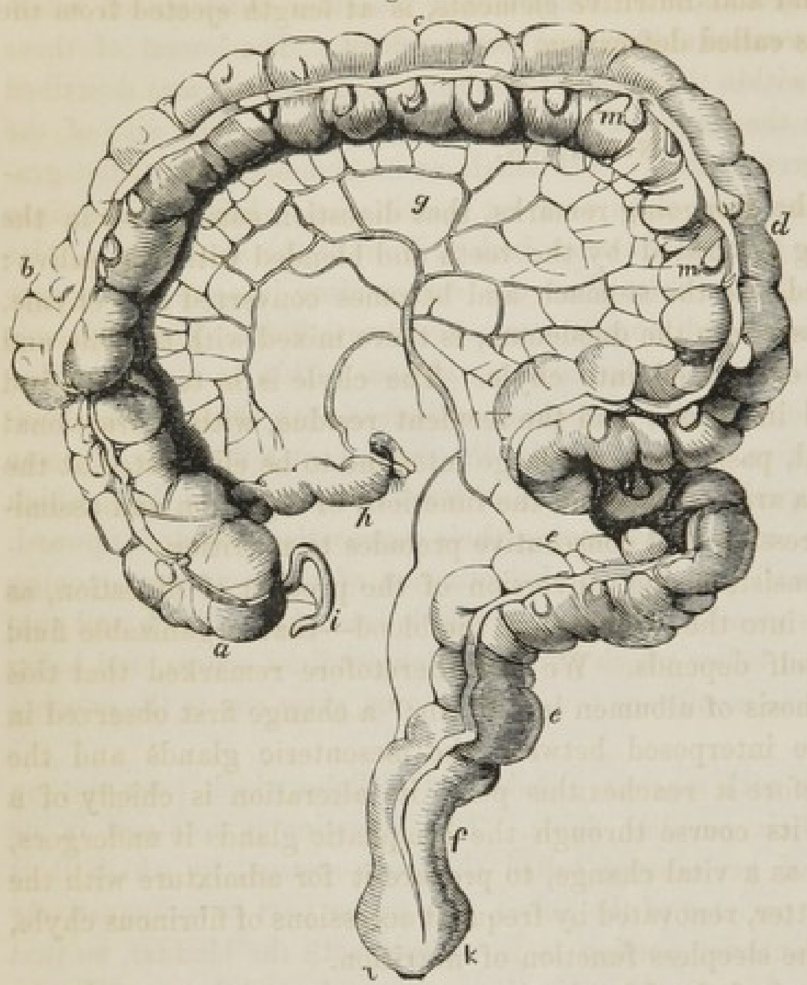


Fig. 219 represents the several parts of the large intestine. *a*, the cæcum; *b*, right or ascending colon; *c*, transverse colon, or arch of the colon; *d*, left or descending colon; *e*, *e*, sigmoid flexure of the colon; *f*, rectum; *g*, mesocolon; *h*, the end of the ileum, or its termination at the ileo-cæcal valve; *i*, appendicula vermiformis; *k*, pouch of the rectum; *l*, anus; *m*, appendices epiploicæ.

DIGESTION IN THE LARGE INTESTINE.

The digestive process in the great intestine has comparatively little influence upon nutrition, yet that it does assist in separating nutrient materials from its contents there can be no question; and there is evidence that such materials are taken up by the absorbents of the rectum and by them conveyed to the receptaculum chyli. This fact, which will be again adverted to when treating of the absorbent system, explains the additional truth familiar to physicians, that a patient whose stomach can receive or retain no aliments whatever, may be for a considerable time, even for several weeks, supported by nutritious enemata alone. Yet it is not improbable that the *venous plexuses* of the rectum may perform an analogous function to those of the small intestine, of absorbing the perfectly soluble and more homogeneous fluids that come into contact with them.

The principal use of the large intestine is to furnish a reservoir for the excrementitious residue of digestion. Whatever nutritious particles enter this portion

* Anatomy and Histology, ii. p. 56.

of the canal are absorbed and conveyed away; but the feculent residue, after remaining for some time in the pouches of the intestine and becoming more and more deprived of its fluid and nutritive elements, is at length ejected from the rectum. This process is called defecation.

NUTRITION.

It will appear from the foregoing remarks, that digestion commences in the mouth by the food being triturated by the teeth and blended with the saliva: in this state it is received into the stomach and becomes converted into chyme. In the latter form it passes into the duodenum, is there mixed with the bile and pancreatic fluids and is elaborated into chyle. The chyle is in turn absorbed by the villi of the small intestine; and the feculent residue, with a fractional part of nutritive material, passes into the large intestine to be eliminated at the anus. These phenomena are embraced in the functions of digestion and assimilation, which are the necessary and consecutive preludes to nutrition.

Assimilation, then, consists in the conversion of the product of digestion, as received by the lacteals, into the elements of the blood—that organizable fluid upon which nutrition itself depends. We have heretofore remarked that this change is the metamorphosis of albumen into fibrin;* a change first observed in those lacteals which are interposed between the mesenteric glands and the receptaculum chyli. Before it reaches this point its alteration is chiefly of a chemical nature: but in its course through the lymphatic glands it undergoes, not so much a chemical as a vital change, to prepare it for admixture with the mass of blood; and the latter, renovated by frequent accessions of fibrinous chyle, is prepared to perform the sleepless function of nutrition.

Nutrition has been amply defined by Adelon, to be the action by which every part of the body, on the one hand, assimilates to itself a portion of the blood distributed to it; while on the other hand it yields to the absorbent vessels a part of the materials that previously composed it.† The materials of nutrition, therefore, exist in the blood; and every part of the system possesses in itself the power of applying these materials to its own support and development. The perpetual waste of the animal tissues is as perpetually restored by this renovating process. Disintegration and decay are counterbalanced by corresponding reproduction of all the tissues: old matter is taken up by the absorbents, and new material is deposited in its place.

How are these metamorphoses accomplished? Modern physiology has proved that nutrition is essentially an evolution of cells, which derive their pabulum from the blood; and that every tissue possesses what has been termed an *elective affinity*, by virtue of which it selects for itself whatever materials may be requisite for its own growth and regeneration.

This process is an illustration of the cell-doctrine in all its phases. The

* Dr. Carpenter regards fibrin as a substance possessing a tendency to spontaneous organization, and therefore endowed with vital properties.

† Dunglison. Human Physiology, ii. p. 209.

germs or elementary granules are deposited where the exigency of the case requires them; the nucleus follows the elementary germ, and the cell is perfected around the nucleus. Within the cell new germs are evolved, or the latter may originate independently, as we have seen, in the organizable plasma; and thus it is that every tissue is built up of its own homogeneous elements and by its own formative power. (P. 18.) It is by this function, also, that parts that have been destroyed by wounds or by disease are restored with surprising rapidity, of which the granulation of abscesses affords a striking example.

The blood, after it has thus provided each tissue with the formative plasma requisite to its nutrition, flows into the veins, to be again conveyed to the pulmonic heart where it throws off its residuary impurities.

The nutritive process bears a certain relation to functional activity, whence it is much more rapid in childhood than in advanced age. Local causes in the healthy state augment particular organs, as seen in the crural muscles of dancers, and the arm of the laboring man. So also certain conditions of the system produce analogous, though temporary, results, of which examples occur in the uterus and mammary glands during pregnancy. One tissue may be predominantly developed above all the rest, as in obesity, which in excess becomes disease. Hypertrophy is a morbid augmentation of the nutritive function, and atrophy is the converse of it.*

THE LIVER.

The LIVER, *hepar* or *jecur*, is the largest glandular structure in the body, occupying the right hypochondriac region with part of the left hypochondriac and the intervening epigastric regions. Its average weight is about four pounds: its long or transverse diameter varies from nine to twelve inches, and its greatest thickness, measured from the posterior to the anterior margin, is from six to eight inches. These dimensions are only proximately correct, owing to the extreme variableness of the size of the liver in different individuals, and probably in the same individuals under different circumstances independently of diseased action.

The liver presents a convex upper surface, a concave or lower surface, a posterior thick and an anterior thin margin; to which are to be added several subordinate parts.

The *upper surface*, which presents upwards and forwards, is moulded as it were in the concavity of the diaphragm, to which it is attached over a considerable oval space. It is cleft in front so as to be divided into two unequal portions indicating the right and left lobes. It is separated by the diaphragm from the cavity of the thorax, while it is laterally in contact with the seven or eight inferior ribs which protect it from external injury.

* This subject is admirably discussed in its several bearings in Dr. Carpenter's Physiology, chap. xiv. § 781, *et seq.*

The *inferior surface* is slightly concave and presents a remarkable diversity of structure. In the first place, the *umbilical fissure* is seen to extend from the notch in the front margin to the posterior boundary of the liver: it derives its name from having contained the umbilical vein of the fœtus, which in the adult is reduced to a cord; and its posterior section shows also the remains of the fœtal ductus venosus, also reduced to a cord-like rudiment of its original state. The anterior part of the umbilical fissure is not unfrequently crossed by an isthmus of hepatic structure called the bridge (pons hepatis) converting the subjacent passage into a canal.

The *transverse fissure* crosses the former at right angles. It is about two inches long, commencing in the left and extending into the right lobe. It conducts the hepatic artery, portal vein and nerves to the liver, and here also the ducts and lymphatics come out: hence the name of *portæ* or gates of the liver, given by anatomists to this passage. Two smaller fissures mark this surface; one for the gall-bladder and the other for the vena cava in the posterior or spinal portion of the gland.

The anterior border of the liver is a thin edge; it is notched where it receives the round ligament, and again to the right a sulcus is often seen corresponding to the base of the gall-bladder. The posterior margin is thick and convex; it is adherent to the diaphragm by means of the coronary ligament and grooved or pieced for the passage of the vena cava.

The lobes.—The two great lobes of the liver, the right and the left, are indicated on its convex surface by the suspensory ligament and the notch in front, and on the lower surface by the umbilical fissure. The right lobe is four or five times larger than the left. It contains the greater part of the transverse fissure and gives origin to three lobular enlargements,—the lobulus spigelii, the lobulus caudatus and the lobulus quadratus, and it also accommodates the gall-bladder.

The *lobulus spigelii* is placed behind the transverse fissure, being partially concealed by the lesser omentum and the hepatic vessels. It forms a pyramidal elongation of this part of the liver between the vena porta, vena cava and the umbilical vein.

The *lobulus caudatus* is merely a process of the lobulus spigelii that extends into and is gradually lost upon the right lobe. It divides the right end of the transverse fissure from the groove that lodges the vena cava.

The *lobulus quadratus* lies also on the under surface of the right lobe, having the free margin of the liver in front and the transverse fissure behind; on its right is the gall-bladder and to the left the umbilical fissure.

Coats of the liver.—These are two in number, the peritoneal and the fibrous tunics. The *peritoneal coat* gives a complete investment excepting on the diaphragmatic border and the depression for the gall-bladder. From the peritoneal are derived most of the ligaments of the liver, five in number, viz: the suspensory, the coronary, the two lateral and the round ligaments.

The *suspensory* or *falciform ligament* is a duplicature of peritoneum that commences at the umbilicus, and following the course of the linea alba, reaches the

convex surface of the liver to which it is attached from front to back. Its anterior margin embraces a cord called the *round ligament*,—ligamentum teres—which is the residue of the umbilical vein of the fœtus. The right and left lateral ligaments are merely processes of peritoneum that extend from the diaphragm to the corresponding borders of the right and left lobes. The *coronary ligament* is that portion of the peritoneum which is reflected from the diaphragm to the posterior attached part of the liver.

The proper and inner tunic of the liver is called its *fibrous coat*. It has a white appearance like common areolar tissue, and not only covers the liver, but penetrates into its substance so as to embrace its lobulated structure and its ultimate granules. It also gives sheaths to the blood-vessels and excretory ducts, and by investing these in the transverse fissure forms the basis of the capsule of Glisson.

The color of the liver is a reddish-brown, occasionally blended with dark purple spots or patches which are perfectly consistent with a healthy condition. It is readily lacerated, the broken surfaces presenting a coarse granular character, which corresponds, as will be hereafter shown, to its ultimate structural arrangement.

Blood-vessels.—The liver is remarkable for the number and size of its arteries and veins, which are the hepatic artery, the vena portarum and the hepatic vein.

The *hepatic artery*, coming from the cæliac axis, divides into two branches in the transverse fissure, one of which is distributed to the right lobe, the other to the left; but these vessels are proverbially small in comparison with the great mass of glandular structure to which they are distributed. The ramifications of this artery terminate in the vena portarum and biliary ducts.

The *vena portæ* is formed by a junction of all the veins that come from the chylopoietic viscera, viz., from the superior and inferior mesenteric, the splenic and the gastric veins. Behind the pancreas all these veins converge to form the trunk which ascends to the transverse fissure and divides into two branches, one for each lobe of the liver. The transverse fissure, where it bifurcates and forms collectively the *sinus venæ portarum*, which is at right angles with the trunk of the vein. Like the hepatic artery, it sends branches to the ultimate granular structure, in which they give off vaginal and interlobular veins to terminate in the lobular venous plexuses formed by the capillary radicles of the hepatic vein.

The *hepatic veins* commence at the termini of the vena portæ in the acini of the liver, at which points the two systems become continuous. The hepatic vein, after collecting in many large branches, opens into the vena cava at the point where the latter forms a sulcus in the posterior border of the liver.

The *lymphatics* form two series, one deep, the other superficial. The former pass out at the transverse fissure and terminate in the proximate lymphatic glands. The superficial set is directly beneath the peritoneal coat and covers the surface of the liver in the manner of a network.

The *nerves*, which are small in proportion to the liver, are derived from the

great solar plexus and from the pneumogastric and right phrenic nerves. Those from the former source form a secondary or hepatic plexus that embraces the hepatic artery.

The biliary ducts.—These canals, to which we shall presently recur, have their origin in the ultimate granules of the liver, and combining into larger and larger trunks, finally make their exit at the transverse fissure in the form of the *hepatic duct*. This is subsequently joined by the cystic duct from the gall-bladder, forming by this conjunction the *ductus communis* which opens into the duodenum and there discharges the biliary secretion.

Fig. 220.

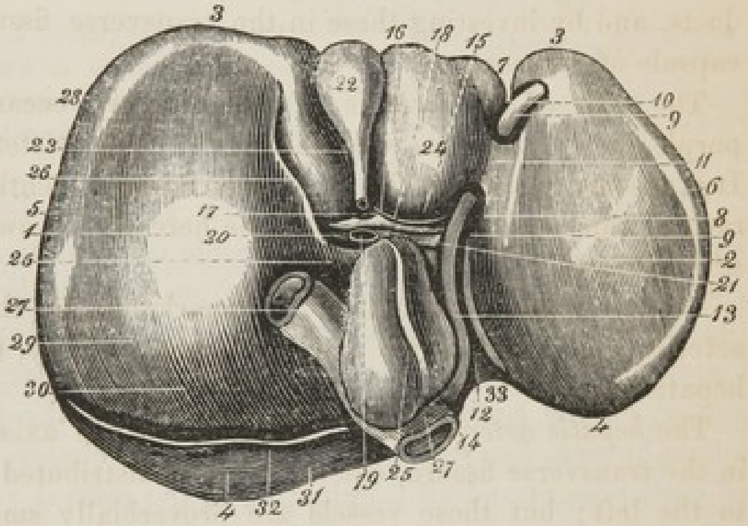


Fig. 220. Under or concave surface of the liver. 1, right lobe; 2, left lobe; 3, its anterior or inferior edge; 4, its posterior or diaphragmatic portion; 5, right extremity; 6, left extremity; 7, notch in the anterior margin; 8, umbilical or longitudinal fissure; 9, round ligament or remains of the umbilical vein; 10, portion of the suspensory ligament in connection with the round ligament; 11, pons hepatis, or band of liver across the umbilical fissure; 12, posterior end of longitudinal fissure; 13, 14, attachment of the obliterated ductus venosus to the ascending vena cava; 15, transverse fissure; 16, section of the hepatic duct; 17, hepatic artery; 18, its branches; 19, vena portarum; 20, its sinus, or division into right and left branches; 21, fibrous remains of the ductus venosus; 22, gall-bladder; 23, its neck; 24, lobulus quartus; 25, lobulus spigelii; 26, lobulus caudatus; 27, inferior vena cava; 28, curvature of liver to fit the ascending colon; 29, depression to fit the right kidney; 30, upper portion of its right concave surface over the renal capsule; 31, portion of liver uncovered by the peritoneum; 32, inferior edge of the coronary ligament in the liver; 33, depression made by the vertebral column.*

Besides the remarkable vascular system mentioned above, the liver is provided, in the fœtal state, with an *umbilical vein* which runs from the placenta to the umbilical fissure, where it bifurcates; one branch opening into the vena cava at its posterior margin, under the name of *ductus venosus;* the other being continuous with the hepatic vena portæ in the transverse fissure. This arrangement is necessary to the fœtal state alone; for in after life the trunk of the umbilical vein and the ductus venosus cease to convey blood, and are reduced to mere fibrous cords.

Structure of the liver.—The whole mass of the liver is an aggregation of granules which, with their vascular and other appendages, are connected together by processes of that areolar tissue called the capsule of Glisson. These *acini* are about the size of a millet seed, irregular in form and with certain nodular enlargements of their periphery. Each one constitutes in itself an epitome of the hepatic structure and function; and for a knowledge of these

* Dr. Clymer's edition of Carpenter's Principles of Physiology, Fig. 225.

we are chiefly indebted to the researches of M. Kiernan. The observations of this gentleman have been so frequently repeated and so generally confirmed that they constitute a highly important contribution to physiological anatomy; and the following particulars have been chiefly derived from M. Kiernan's memoir,* and the later one of Mr. Erasmus Wilson.†

The lobules are minute granular bodies arranged around the sublobular hepatic veins. Each *lobule* has a base that rests on a sublobular hepatic vein, to which it is connected by the intra-lobular vein running through its centre; while its base enters into the formation of the canal in which the sublobular vein is contained.

Fig. 221.

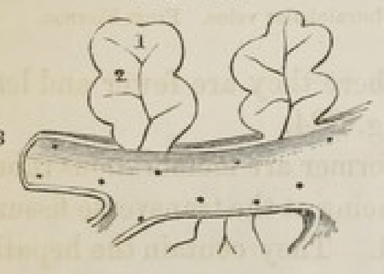
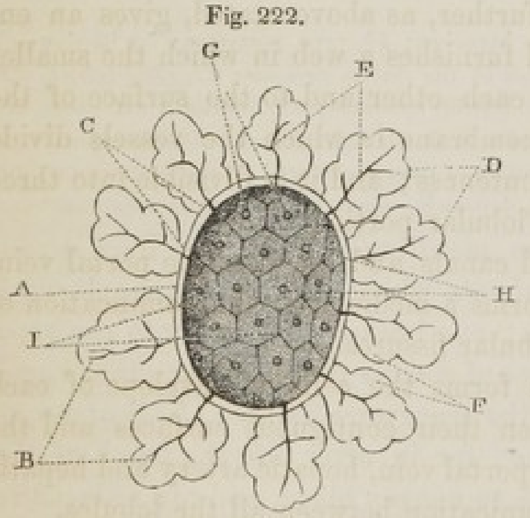


Fig. 221. Longitudinal section of a sublobular hepatic vein, showing the manner in which its parietes are formed by the lobules; and also the connection between it and the intra-lobular veins. 1, lobule; 2, intra-lobular vein; 3, sublobular hepatic vein.

The unattached periphery of the lobule, called its capsular surface, is covered by an expansion of the capsule of Glisson, by which it is at the same time connected with and separated from the contiguous lobules, and in which branches of the hepatic duct, portal vein and hepatic artery ramify. In a longitudinal section of the lobule, the intralobular vein is seen in its centre; and if, on the surface of the section, five of the projecting processes of the lobule be seen, five smaller veins will also be observed, one occupying the centre of each process and all terminating in the central vein. Fig. 221.

Fig. 222.



Transverse section of a sublobular hepatic vein. From Kiernan.

Fig. 222. A sublobular vein divided transversely, together with its constituent lobules: the hexagonal bases are seen through the parietes of the vein, together with their dividing fissures and the terminal orifices of the intralobular veins; thus: A, oblique section of a sublobular hepatic vein; B, longitudinal section of lobules, presenting a foliated appearance; C, bases of the lobules resting on the sublobular vein; D, external or capsular surfaces of the lobules; E, intralobular veins; F, veins of the lobular processes opening into the central vein; G, mouths of the intralobular veins, opening into the sublobular vein; H, bases of other lobules seen through the coats of the vein, and forming the parietes of the canal in which the vein is contained; I, interlobular fissures seen through the coats of the vein.

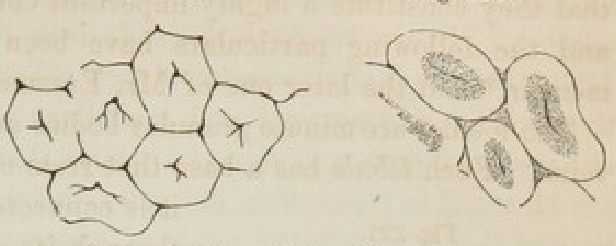
For the purpose of further elucidation we may repeat a portion of the foregoing remarks, by saying, the hepatic veins are of two classes; first, the intralobular vein which occupies the centre of each lobule and receives the blood from

* Trans. of the Royal Society of London, p. 711, 1833.

† Cyclopædia of Anatomy, art. *Liver*. Dr. Joseph Leidy of this city has also corroborated the results of these gentlemen in a valuable paper published in the *American Journal of Medical Sciences* for January, 1848.

a plexus formed in the lobule by the radicles of the portal vein; and second, those veins contained in canals formed by the bases of the lobules, applied side by side, and which veins for the most part receive the intralobular veins, as seen in Fig. 222.

Fig. 223. Fig. 224.



Hepatic lobuli and intralobular veins. From Kiernan.

The form of the lobules is angular in the deeper sections of the liver, where also they are most numerous and most compressed, Fig. 223: but at the margin and surface of the gland, where they are fewer and less closely connected, they are of a rounded form. Fig. 224.

The portal canals and capsule of Glisson.—The former are membranous tubular passages formed in the tissue of the liver, commencing at the transverse fissure and ramifying throughout the substance of the gland. They contain the hepatic ducts, the portal veins, the hepatic arteries and the vaginal branches of all these vessels, together with the nerves and absorbents, all enveloped in a sheath which is a continuation of the capsule of Glisson. If one of these portal canals be divided lengthways and its contents dissected out, its proper parietes will be found to be composed of lobules similar to those of the external surface of the liver, with the same intervening fissures. Every canal, however small, contains a branch or ramification of the artery, portal vein and duct, and these divide and subdivide until they terminate in the lobules, but are invariably contained in corresponding portal canals. The latter are lined by membranous prolongations of the *capsule of Glisson*, which further, as above stated, gives an envelope to the larger vessels and ducts, and furnishes a web in which the smaller vessels ramify: it thus connects them to each other and to the surface of the portal canals. It is a cellulo-vascular membrane in which the vessels divide and subdivide to an extreme degree of minuteness; and it is divisible into three portions, a vaginal, an interlobular and a lobular portion.*

The *vaginal portion* occupies the portal canals and encloses the portal vein, hepatic duct and hepatic artery; and it forms a medium for the ramification of these vessels before they enter the interlobular fissures.

The *interlobular portion* of the capsule forms the cellular envelope of each of the lobules, the bond of union between their contiguous surfaces and the nidus of the plexiform arrangement of the portal vein, hepatic artery and hepatic duct; and it is thus the medium of communication between all the lobules.

The *lobular portion* of the capsule of Glisson forms sheaths for the minute vessels within the lobules and constitutes the parietes of the ultimate acini.†

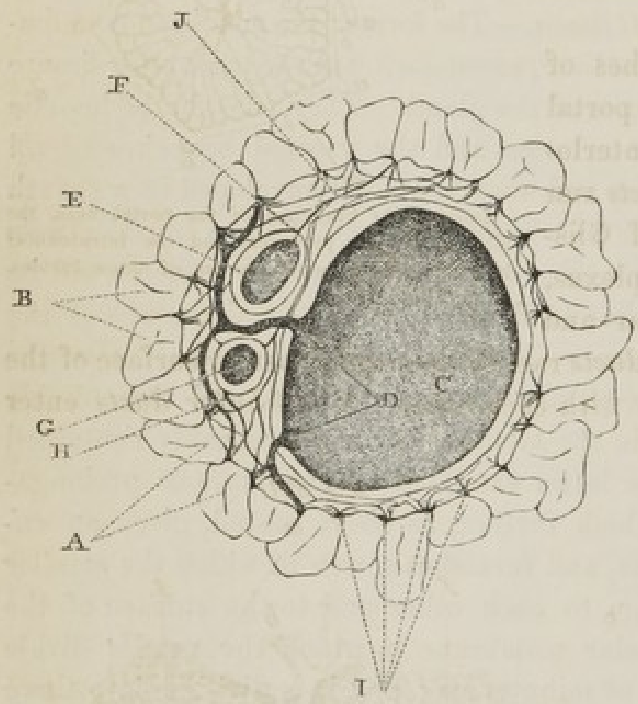
The lobules.—We now recur to the lobules in order to show in what manner they are constituted of the several parts above described. They are based, as heretofore mentioned, on the hepatic veins; and each one is composed of a

* Kiernan, *ut suprà*, p. 723.

† Wilson. Cyclopædia of Anatomy, art. *Liver*.

plexus of the portal vein, of a branch of the hepatic vein, of the terminal hepatic arteries and of a plexus of biliary ducts; and although nerves and absorbents have not been detected in them, their presence may be safely inferred from analogy. Every lobule is divisible into those smaller bodies called *acini* by Malpighi, which often appear of two colors, red or brown and yellow; whence the division into cortical and medullary portions of the acinus. More recent observations, however, appear to prove that these seemingly different substances are identical in structure; the yellow being the natural and healthy color, while the red tint is merely the result of congestion. These *acini* occupy the spaces between the venous plexuses of the lobules.

Fig. 225.



Transverse section of a portal canal in the liver. From Kiernan.

Fig. 225 illustrates the relative position of these several structures by a transverse section of a portal canal and its vessels. A, B, superficial lobules forming the parietes of the canal, and perforated by their intralobular veins; C, transverse section of a portal vein; D, vaginal branches arising from the portal vein, and dividing into interlobular branches which enter the interlobular spaces; E, transverse section of an hepatic duct; F, a vaginal branch arising from the duct and dividing into interlobular branches which enter the spaces; G, the hepatic artery; H, a vaginal branch arising from the artery and dividing into interlobular branches which enter the spaces; I, three interlobular vessels, a duct, vein and artery, entering each interlobular space; J, the vaginal plexus formed by the vaginal branches of the duct, vein and artery. The internal surface of the plexus is in contact with the large vessels; its external surface is in contact with the parietes of the canal. The vessels forming this plexus ramify in cellular tissue which, with the vessels, constitutes the vaginal portion of the capsule of Glisson. The capsule in these larger canals completely surrounds the three vessels.

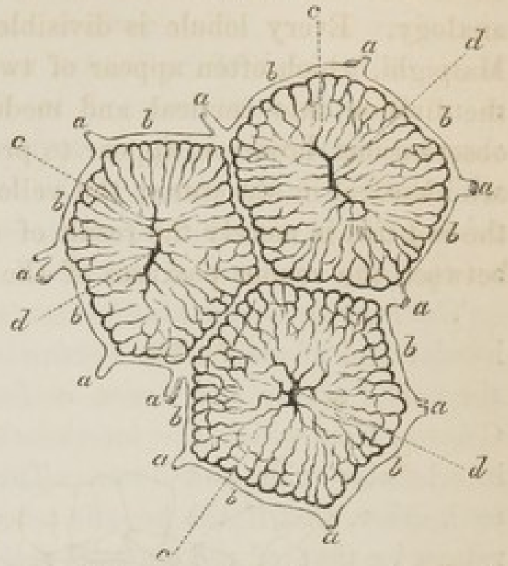
The general arrangement of the intralobular and sublobular branches of the hepatic veins has been described; and it remains to explain the distribution of the other vascular systems of the liver.

The portal vein.—The branches of the portal vein are accompanied by ramifications of the hepatic duct and hepatic artery. The vaginal branches inosculate freely in the cellular capsule that surrounds the portal vein, and form, with the vaginal branches of the duct and artery, the *vaginal plexus*. The *interlobular veins* occupy the interlobular spaces, anastomosing freely with each other and with the analogous vessels in the other lobules; thus establishing a perfect portal intercirculation throughout the whole liver. The *lobular veins* are derived from the former set: they form a plexus within the lobule, converging from

the circumference to the centre, where they terminate in the intralobular branches of the hepatic vein.*

Fig. 226 represents this vascular system as seen in three lobules. *a, a, a,* interlobular veins contained in the spaces; *b, b, b,* interlobular veins which occupy the fissures, and which, with the veins in the spaces, form venous circles around the lobules;† *c, c, c,* the lobular venous plexuses, the branches of which, communicating with each other by intermediate vessels, terminate in the intralobular veins. The circular and ovoid spaces seen between the branches of the plexuses, are occupied by portions of the biliary plexuses constituting the acini of Malpighi; *d, d, d,* the intralobular branches of the hepatic veins, in which the vessels of the plexuses terminate.

Fig. 226.

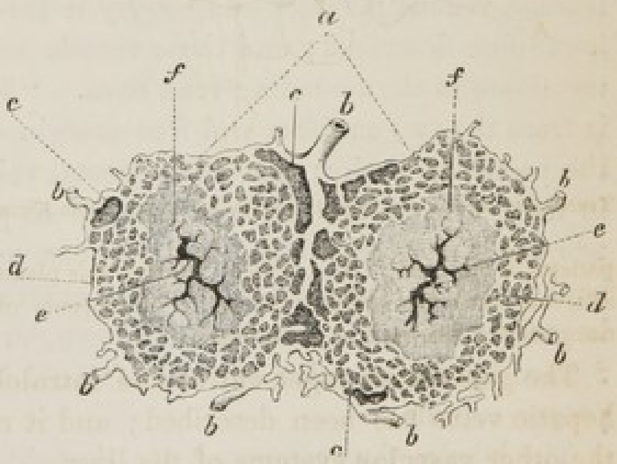


Interlobular branches of the portal vein, the lobular venous plexuses, and the intralobular branches of the hepatic veins of three lobules. From Kiernan.

THE HEPATIC DUCT.—The branches of the hepatic duct, like those of the portal vein, are divisible into the vaginal, interlobular and lobular. The *vaginal ducts* run transversely through the capsule of Glisson and assist to form the vaginal plexus, whence are derived the interlobular and lobular divisions. The *interlobular ducts* ramify upon the capsular surface of the lobules where they inosculate freely with each other. The *lobular ducts* enter the lobule, and subdividing into minute ramifications, anastomose and form a reticulated intertexture of ducts called the *lobular biliary plexus*, as seen in Fig. 227.

Fig. 227 represents the interlobular ducts entering the lobules and forming the lobular biliary plexuses. *a,* two lobules; *b, b, b,* interlobular ducts; *c, c, c,* the interlobular cellular tissue; *d, d,* the external portions of the lobular biliary plexuses injected; *e, e,* the intralobular branches of the hepatic vein; *f, f,* the uninjected central portions of the lobules. The interlobular ducts are here represented anastomosing with each other; but Mr. Kiernan remarks that he had not seen this communication. He infers the anastomosis from collateral circumstances.‡

Fig. 227.



Interlobular ducts. From Kiernan.

The biliary plexuses form a principal part of the substance of the acini. The ultimate terminations of the ducts have not yet been discovered, but it is generally supposed that they end in cæcal or closed extremities. The hepatic ducts

* Wilson, *ut suprà*, p. 168.

† This is the appearance which the venous circles present when examined by a common magnifying glass; but they are in reality formed by numerous branches.

‡ Kiernan, *loco citato*, Pl. xxiii, fig. 3.

are extremely vascular, being covered by ramifications of the hepatic artery, and their internal surface is lined by rugæ and papillæ which are mere congeries of arteries and veins. The vessels distributed upon these papillæ consist of an artery which ascends on each side of the lamina and divides into a beautiful network of capillaries, which are collected after their distribution into a small vein and returned to the portal vein. The ducts are lined by mucous membrane with an apparatus of follicles that mingles its secretion with the bile in its course to the duodenum; so that the blood-vessels of these tubes perform a double function,—that of nourishing the ducts and of secreting an auxiliary element of the bile.*

The *hepatic artery* also presents the subordinate divisions of vaginal, interlobular and lobular. The *vagina larteries* are derived from the larger trunks in the portal canals and assist in forming the vaginal plexus in the capsule of Glisson, from which the interlobular branches are given off to accompany the interlobular veins and ducts. The vaginal arteries anastomose so freely with each other, that if the hepatic artery of one side be injected, the injection will return by that of the opposite side. The *interlobular arteries* ramify upon the capsular envelopes of the lobules, being distributed principally on the interlobular ducts, around which they form a vascular network. The *lobular arteries* enter the lobules with the ducts upon which they are distributed. They are the nutrient vessels of the lobules, and terminate in the lobular plexus of the portal vein.

The *hepatic veins* commence in the centre of each lobule by means of the *intralobular* radicles, which collect the blood after its circulation through the lobular venous plexuses and convey it into the sublobular veins in the manner heretofore described; and these vessels unite to form the hepatic trunks which terminate in the ascending vena cava. "The general course of the hepatic veins is from the two surfaces and free margin of the liver towards the vena cava in the posterior border; that of the portal vein radiates from the transverse fissure in the centre of the under surface, to all parts of the circumference: hence the two veins cross each other in their course, the former proceeding from before backwards, and the latter from the centre towards the circumference."† The hepatic veins run in canals of their own, but resembling the portal canals in being formed by the capsular surface of the lobules, lined by a prolongation of the proper capsule.

The lobules thus composed are thought by some anatomists to be essentially formed of minute ramifications of the biliary ducts; or, in more precise language, they, in common with other glands, consist merely of a congeries of ducts with blood-vessels ramifying on their periphery. But the latest microscopic researches teach that the liver is an aggregation of nucleated polyhedral cells, which appear to be placed on the outside of the terminal ramifications of the hepatic ducts and constitute the proper secretory organs. "These cells are of a flattened spheroidal form and commonly lie in piles, their faces adhering to one-

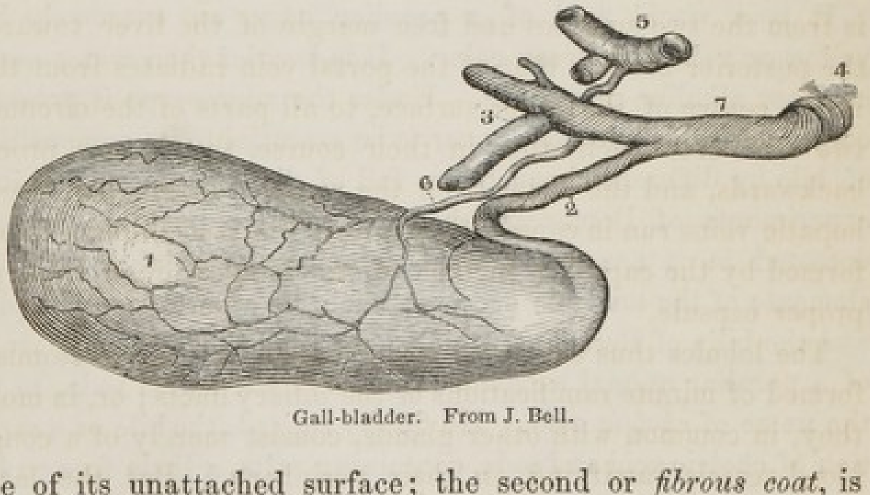
* Wilson, *ut suprà*, p. 170.

† Idem, loco citat.

another; and these piles seem to be directed especially from the circumference to the centre of each lobule. Every one of them presents a distinct nucleus; and the cavity of the cell is filled with yellow amorphous biliary matter having one or two large, adipose globules, or five or six small ones, intermingled with it. Their diameter is usually from the $\frac{1}{1500}$th to the $\frac{1}{2000}$th of an inch; and they are easily obtained in a separate condition by scraping a piece of fresh liver. The biliary matter which they contain marks them out as the real agents in the secreting process; this process consisting, it is evident, in the growth of the hepatic cells, which, in the course of their development, eliminate from the blood the biliary matter for which they have a special affinity. The mode in which the particles thus eliminated, are discharged into the hepatic ducts to be by them conveyed to the intestine, cannot be understood until the relation between the secreting cells and the ultimate ramifications of the ducts shall have been more precisely determined."*

The GALL-BLADDER, *cystis fellea*, is the recipient and reservoir of the bile. It is lodged in a depression of the inferior surface of the right lobe, being bounded on the left side by the lobulus quadratus and kept in place by a peritoneal covering. It is of an elongated conical form, about three inches long and tapering rapidly at the smaller end into a hollow tube not larger than a quill. Its direction is oblique, its greater end presenting downward and to the right, and its neck upwards and to the left side. Where it touches the liver it is not covered by peritoneum; its free surface is in contact with the commencement of the duodenum and the proximate surface of the transverse colon, which parts are usually discolored by the transudation of bile after death. The fundus of the gall-bladder projects slightly beyond the anterior margin of the liver, and its tubular end is tortuous. Fig. 228.

Fig. 228.



Gall-bladder. From J. Bell.

Fig. 228. The gall-bladder and ducts. 1, gall-bladder; 2, cystic duct; 3, hepatic duct; 7, ductus communis; 4, its termination in the duodenum; 5, hepatic artery; 6, cystic artery.

The gall-bladder has three coats: the exterior one is *peritoneal*, and embraces thew hole of its unattached surface; the second or *fibrous coat*, is a close intertexture of cellular tissue, containing numerous blood-vessels and lymphatics; the inner or *mucous coat* presents a corrugated appearance, owing to the wrinkled state of the membrane, which is continuous with that of the duodenum. In the neck of the gall-bladder the mucous coat forms several im-

* Carpenter. Elements of Physiology, § 723.

perfectly valvular folds, which are supposed to have an effect in preventing the exit of the bile. This sac receives its artery, the cystic, from the hepatic artery: the cystic vein opens into the vena portæ. Its lymphatics are abundant.

The biliary ducts.—These are three in number,—the hepatic and cystic ducts, and a common duct formed by the junction of the two former. The *hepatic duct* has its origin in the lobules, where it exists in that retiform structure already described as the *lobular biliary plexus*, and from which arise the *inter-lobular ducts*. These are continuous with the biliary vaginal plexus of the portal canals, which plexus forms larger and larger tubes until they combine in three or four considerable ducts in the transverse fissure. These again unite in a single trunk called the *ductus hepaticus*, Fig. 228, 3, about two inches long and the size of a common quill, which is joined at an acute angle by the *cystic duct* from the gall-bladder. The cystic duct, Fig. 228, 2, is about an inch in length, and passes downwards and to the left side to join the hepatic duct. This junction constitutes the common excretory duct, *ductus communis choledochus*, which is about three inches long, and terminates in the duodenum by an oblique course through its muscular and mucous coats, its orifice being marked by a construction of the duct and a papilla on the intestinal surface. Fig. 228, 7.

Beside the internal mucous coat, these ducts are formed externally of a dense fibrous tissue which is by some anatomists regarded as muscular; but this structure has not been demonstrated in man.

THE BILE.—The bile, secreted from the portal blood in the cells of the liver, is received into the ultimate ducts of the acini, and following these channels to the larger biliary canals, is poured into the duodenum. A part of it, however, does not pursue this direct course, but regurgitating into the gall-bladder through the cystic duct, remains there a longer or shorter time and becomes more viscid and inspissated than the more recent secretion.

It is a viscid fluid of a peculiar odor, an extremely bitter taste and a yellow or yellowish-green color. It is heavier than water and possesses neither acid nor alkaline properties. Under the microscope it presents a few indefinite corpuscles, which do not appear to be essential to its composition. The analyses of bile by different chemists are full of discrepancies; and it appears from the experiments of Demarcay, that the greater part of the substances hitherto detected in it are not normal constituents of that fluid, but newly-formed elements of the analytic process; such, he asserts, are the picromel of Thenard and the bilin of Berzelius, which, according to Demarcay, are mere modifications of a peculiar animal substance in combination with soda, to which he has given the name of *choleic acid*. He finally regards the bile as a saponaceous combination of choleic acid and soda, containing salts, a little free and saponified fat and some extractive matters.* It is now pretty generally agreed that the biliary fluid contains at least three distinct substances: cholesterine, choleic or bilic acid and coloring matter. The cholesterine is sparingly found in healthy bile, but forms the principal and sometimes the only constituent of gall-stones. "It is a

* Wagner. Elements of Physiology, p. 339.

whitish, crystallizable, fatty matter, somewhat resembling spermaceti; free from taste and color, insoluble in water, but dissolving freely in alcohol, from which it is deposited, on cooling, in pearly scales."* It is susceptible of crystallization, as shown in the beautiful drawing of M. Donné.† The coloring matter of bile is called *biliverdin:* it is usually of a bright yellow, but becomes green by exposure to the air and the consequent absorption of oxygen.

Uses of the liver and of the bile.—The liver secretes the bile, and the bile performs several important offices in the animal economy. 1st. It acts upon the chyme in the duodenum and renders its fatty matter more soluble and more fluid, and thereby assists in converting it into *chyle.* 2d. A part of the bile combines with the residuum left after chylification and is discharged in the excrementitious state, thus separating from the blood its superfluous hydro-carbon. 3d. It stimulates the mucous membrane and thereby increases the secretion from that surface, at the same time that it promotes the peristaltic motion of the muscular coat by a peculiar stimulus. Another and very important use of the liver in fœtal life, is its action as the exclusive decarbonizing organ before the lungs come into play to supersede it, as they do immediately after the birth of the child. Yet the liver continues throughout life to separate from the blood a large quantity of superfluous hydro-carbon acquired by the circulation through the tissues; and it combines that carbon with other elements to form the bile itself.‡

Development of the liver.—The liver is said to be the first visibly developed organ of the fœtus. According to Weber it forms half the bulk of the embryo at three weeks, which proportion continues through the first half of fœtal life; but at birth the weight of the liver is reduced to one-eighteenth of the whole body. After birth it diminishes in size still more rapidly; and at the age of puberty has acquired a relative bulk that it retains to old age;—viz. about the thirty-sixth part of the entire body.§ The rapid diminution of the liver after birth, is owing to the occlusion of the umbilical vein, by which the fœtus had received the placental blood.

THE PANCREAS.

The pancreas is a glandular body, about six inches long, of a flattened form and of a pale pinkish color. It lies in the posterior part of the abdomen, lying transversely within the epigastric region, having the spine and great vessels behind and the stomach in front. Its right extremity is in contact with and surrounded by the duodenum, with which it forms an angle. The portion to the right of the intestine turns downwards, is sometimes detached from the body of the gland, and is called the *lesser pancreas.* In its course to the left side, it

* Carpenter. Principles of Physiology, § 833.

† Cours de Microscopie, Pl. XI. Fig. 43.

‡ Idem. Opera citat., § 275.

§ Cruveilhier. Anatomy, p. 399.

becomes narrower and terminates at the spleen with which it is in contact. The pancreas is behind the mesocolon and has no proper peritoneal coat; and its investing tunic consists only of condensed areolar tissue that dips between its lobules and connects all its parts together.

The pancreas belongs to the series of conglomerate and salivary glands, which it closely resembles both in structure and in function. Its lobes are divisible into lobules, and these again into granular acini in which the ducts terminate in minute cul-de-sacs. The ducts thus arising from every part of the structure coalesce into larger canals which penetrate the gland from the circumference towards its centre, and enter the main interglandular duct nearly at right angles. This tube, the *ductus Wirsungii*, traverses the gland from end to end nearly in its middle and increases in size as it approaches the right margin of the gland, where it is joined by a short duct from the lesser pancreas. At this point also it emerges from the pancreas, being at first as on the left side of the ductus communis, but soon after joins that duct and opens with it by a common orifice into the duodenum. In some instances, however, the pancreatic duct has a separate vent.

The arteries of the pancreas are derived from the splenic, which forms a groove in its upper margin, from the pancreatico-duodenalis and from the superior mesenteric. Its nerves are derived from the solar plexus.

Uses of the pancreas.—The secretion of the pancreas is identical in appearance with that of the proper salivary glands, and chemical analysis detects in both nearly the same elements; but the pancreatic juice contains a larger proportion of solid matter in the form of osmazome, and it has more albumen than is found in saliva, but it is destitute of ptyalin. That it has an important agency in digestion there can be no question; but the nature of its action has not been ascertained.

THE SPLEEN.

The spleen is a large gland situated in the left hypochondrium, of an irregularly discoidal form and about three inches in diameter. Its external surface is convex and in contact with the diaphragm, by which it is separated from the ribs. Its internal surface is concave, directed towards the stomach and marked by an interrupted fissure called the *hilus lienis*, into which its vessels enter. This surface is connected to the stomach by a process of peritoneum, —the gastro-splenic omentum; below which are the left kidney with its capsule, and the crus of the diaphragm. The spleen has two coats: the exterior one is peritoneal and forms a complete investment; the internal tunic is formed of yellow elastic tissue which can be readily separated from the peritoneum on the concave surface. It not only invests the gland, but sends processes internally "which form sheaths for the vessels in their ramifications through the organ; and from these sheaths small fibrous bands are given off in all direc-

tions, which become attached to the internal surface of the elastic tunic and constitute the areolar framework of the spleen."* These membranous septa, by crossing in every direction, divide the gland into innumerable irregular cells or follicles which are filled with a semifluid substance resembling blood mixed with coffee-grounds. They communicate freely with each other and with the splenic vein, and they are lined by a continuation of the same membrane that lines the vein itself. Besides these elements, the spleen is composed of a profusion of arteries and veins, of lymphatics, nerves and *Malpighian bodies*. The latter are about the third of a line in diameter and resemble minute lymphatic glands: they consist of convoluted masses of blood-vessels and lymphatics, united by elastic tissue. They contain lymph which is of a milky color from the presence of a large number of lymph-corpuscles.†

Blood-vessels.—The splenic artery is a branch of the cæliac. It is a very large and seemingly disproportioned vessel when compared to the gland: it ramifies intimately throughout the spleen, but according to the experiments of Ruysch, confirmed by all later anatomists, its branches do not anastomose. Hence each branch has its peculiar local office, independent of the other portions of the structure; for if in the lower animals one of these branches be tied, the portion of the spleen to which it had been distributed shrinks and becomes blighted, while the rest of the gland is not affected by the change.‡ From this fact the spleen has been regarded, not as a single organ, but as a congeries of glands, each of which performs a separate and isolated function. In rare instances these lobules, several in number, are seen detached from the spleen and attached to branches of the splenic artery near the great end of the stomach.

The *splenic vein* is of great size and forms one of the trunks of the vena portæ. The *lymphatics*, which are very numerous, terminate in the lymphatic glands opposite the fissure and in the folds of the gastro-splenic omentum. The *nerves* are derived from the solar plexus.

Uses of the spleen.—These are positively unknown; and the many speculations that have been indulged respecting them have added little to our knowledge of the subject. The most prevalent and at the same time the most plausible opinion is, that the spleen is a reservoir which serves to relieve the portal venous system from undue congestion. This system being destitute of valves, the splenic vein has free communication with it; whence the spleen may become a ready diverticulum for the venous blood when the secretory action of the liver is feeble, and the portal circulation receives a partial check.§

* Wilson. Anatomy, p. 558.

† Carpenter. Elements of Physiology, § 506.

‡ Cruveilhier. Anatomy, p. 406.

§ Carpenter. Principles of Physiology, § 685.

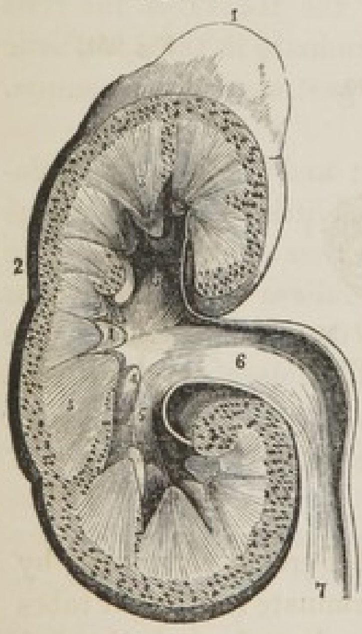
THE GENITO-URINARY ORGANS.

The urinary apparatus embraces the kidneys and capsulæ renales, the ureters and the bladder. The genital organs in man are, the testicles and vesiculæ seminales and their intermediate ducts; the penis, urethra and the prostate gland: in the female the vagina, uterus, ovaries and Fallopian tubes.

THE KIDNEYS.

The kidneys lie in the right and left lumbar regions on each side of the spine. Their shape is that of a bean; their color a brownish red. They are about four inches in length, something more than half that width, and somewhat flattened at the sides. They are in opposition behind to the diaphragm, the quadratus lumborum and the psoas magnus muscles. The right kidney is lower in the abdomen than the left, owing to the depending position of the liver, which, with the duodenum, is in contact with it; and in front of it is the ascending colon. The left kidney is placed considerably higher than the right, has the spleen above it, and in front, the stomach, colon and small intestine. The upper margin supports the renal capsule; the lower end extends a little below the last rib. These organs have no peritoneal coat, but lie behind that membrane from which it is often separated by large masses of fat.

Fig. 229.



The kidney.*

The kidney has a proper tunic belonging to the serous class, and strongly resembling the peritoneum. It is easily separated from the gland, when it presents a whitish color, a very delicate structure, is strong and elastic, and attached to the kidney by a very fine areolar tissue.

The spinal margin of the kidney is concave and marked by a deep fissure called the *hilus renalis*, through which the nerves and arteries enter, the veins come out and the pelvis of the kidney begins.

Fig. 229. Longitudinal section of the kidney, with its renal capsule. 1, renal capsule; 2, cortical or vascular part of the kidney; 3, 3, uriniferous tubes collected into conical fasciculi; 4, 4, papillæ, projecting into their corresponding calices; 5, 5, 5, the three infundibula; 6, pelvis of the kidney; 7, ureter.

Structure of the kidney.—The kidney possesses a very firm, tenacious structure, composed of two very different substances. The *exterior* or *cortical substance* covers or envelopes the whole gland. It is of a pale red color, from a sixth to a quarter of an inch in thickness and of a

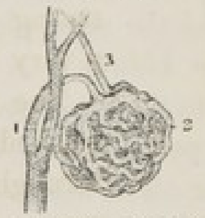
* Enlarged from Fig. 123 in Dr. Clymer's edition of Carpenter's Elements of Physiology.

granular appearance. It is the true glandular substance of the kidney, being made up of extremely tortuous blood-vessels and uriniferous tubuli, which not only envelope the conical or medullary structure within, but penetrate between the cones almost to their pointed extremities.

The *medullary part* of the kidney consists of a series of pyramidal bodies having their bases towards the surface of the gland, and their points towards its fissure. They are of a lighter red color, from ten to fifteen in number and are called the *pyramids of Malpighi*. Each one of these pyramids is a distinct gland, formed of uriniferous tubes which terminate at its apex in a rounded *papilla*.

If a microscope be applied to the cortical substance, the uriniferous canals are seen to begin there in a very convoluted manner, and are called the *ducts of Ferrien*, which, on reaching the pyramidal structure, pursue a straight course as already stated. This structure is further composed of the ultimate ramifications of the renal artery and vein which also pursue a tortuous course, and have disseminated among them a vast number of small, deep-red granules called *corpora Malpighiana* or corpuscles of Malpighi. Figs. 230, 231. Each of these granules is a tuft of capillary vessels, enclosed, according to Dr. Bowman, within an off-set or cul-de-sac of a uriniferous tube which is dilated at the point where it embraces the granule. The latter is further enclosed by a cyst or capsule perforated by an arterial twig, that suddenly breaks up into two or more branches which diverge like the petals on the stalk of a flower. The vessels resulting from these subdivisions are capillary in size, and consist of a simple, homogeneous and transparent membrane; these vessels subsequently reunite and emerge by a single venous trunk that perforates the capsule and unites with the capillary venous plexus surrounding the tortuous uriniferous tubes. The renal artery is therefore distributed upon the Malpighian corpuscles, and the renal vein arises from the capillary plexus in which the artery terminates.*

Fig. 230.



Corpuscle of Malpighi. From Dr. Bowman.

Fig. 231.

Corpuscle of Malpighi, with its envelope. From Dr. Bowman.

Fig. 230 gives a magnified view of a denuded Malpighian corpuscle with its attendant vessels. 1, the artery; 2, tuft or corpuscle; and 3, efferent vein.

Fig. 231 represents a corpuscle enclosed in its capsule. 1, the capsule; 2, division of the artery within the capsule; 3, arterial twig approaching the capsule; 4, the tortuous uriniferous tube, which by expanding forms the capsule itself; 5, the efferent vein.

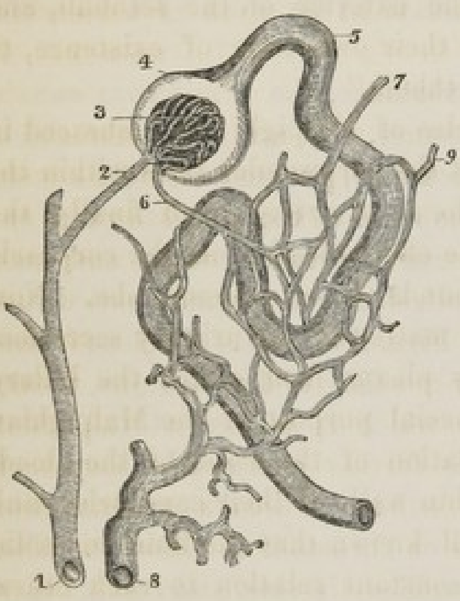
In the interstices between the corpuscles the ducts of Ferrien commence by microscopic origins, and after a very convoluted course terminate in straight tubes on the inner surface of the cortical substance. These tubes, the *tubuli uriniferi*, form the cones of the medullary portion, as heretofore observed, are lined by epithelial cells and end in papillæ that open into the pelvis of the kidney.

* Dr. Bowman, in Trans. of the Royal Society of London, 1842, p. 59.

They do not, however, run the entire length of the gland as simple tubes, but anastomose freely between their periphery and termination. The papillary end of the cone or pyramid presents many orifices, and from these the urine escapes into the renal pelvis. The cones are more or less surrounded by cortical substance, which dips down between them and is the medium through which the blood-vessels pass to and from the gland.

The annexed plan of the renal circulation in man, Fig. 232, is derived from Dr. Bowman; who observes that the relative proportions and the character of the several parts are accurately preserved.*

Fig. 232.



Microscopic structure of the kidney. From Dr. Bowman.

Fig. 232. Diagram of the secretory apparatus of the kidney. 1, the renal artery, which at 2 sends a twig to the Malpighian corpuscle; 3, the convoluted tuft formed by the artery within the corpuscle. The corpuscle itself is seen at 4, and at 5, it contracts into a tortuous uriniferous tube or duct of Ferrien; 6, the efferent vein bringing back the effete blood; this vein joins with those from other corpuscles and thus is formed the venous plexus 7, 9, around the uriniferous tube. These veins converge and end in the emulgent vein, 8.

Blood-vessels of the kidney.—The *renal* or *emulgent artery* is a branch of the aorta, very short but of large diameter. It enters at the hilus or fissure and pursues the course above described. The *renal vein*, originating in the cortical substance and escaping at the fissure, opens directly into the vena cava. The nerves are derived from the lesser splanchnic nerve and the solar plexus.

The *pelvis of the kidney* is a strong, white, fibrous pouch that is attached in a flattened form to the inner margin of the fissure, which latter opens directly into it. The renal pelvis is divided into three compartments called *calices*, one at each end, and the other intermediate or in the middle of the kidney. Each of these open sacs subdivides at its free extremity into three or four *infundibula*, which embrace the papillæ at their bases, but are open above to permit the urine to distil into the calyx and thence into the pelvis itself.†

The ureter.—The pelvis gives off a single tube called the *ureter*, which is the excretory duct of the kidney. Fig. 229, 7. Its diameter is that of a small quill. It is thin, of a whitish color and formed of two laminæ; an external one called the *tunica propria* which is fibrous and somewhat elastic; and an internal or lining coat that possesses the usual characters of mucous membranes. The ureter is from fifteen to eighteen inches in length: its course is downward and inward to the base of the sacrum, whence it curves, first downward, then forward, to reach the lower fundus of the bladder, which it perforates obliquely

* Trans. of the Royal Society of London, 1842, Pl. iv. fig. 16.

† In some anatomical works, *calices* and *infundibula* are used as synonymous and convertible terms.

between its muscular and mucous coats for about an inch, and terminates by a constricted orifice behind and on a line with the corresponding limb of the vesical triangle. The oblique perforation of the duct through the bladder acts the part of a valve in preventing the reflux of urine after it has been received into that organ.

Function of the kidneys.—This office proverbially consists in the secretion of urine, which is supposed to be effected, as in other glands, by the epithelial cells that line the uriniferous tubes; "these cells drawing the materials of their development from the vascular plexus upon the exterior of the setubuli, and delivering them up when they have completed their own term of existence, to be carried off through the open orifices of the tubuli."

We have shown in what manner the corpuscles of Malpighi are embraced in the cortical uriniferous ducts, and the fact that the corpuscular tufts within the capsule are mere capillary ramifications of the renal artery; and finally, the mode in which a single efferent vein brings the effete blood from the corpuscle and conveys it into a venous plexus that surrounds the uriniferous tube. Now this plexus is supposed to elaborate the solid matter of the urinary secretion, just as the vena portæ supplies the capillary plexus from which the biliary secretion is elaborated in the liver. "The special purpose of the Malpighian bodies appears to be, to allow of the transudation of the *water* of the blood, which is filtered off, so to speak, through the thin walls of their capillaries, and thus passes into the tubuli uriniferi. It is well known that the fluid and solid constituents of the urinary secretion bear no constant relation to each other, the amount of fluid depending mainly upon the degree of fulness of the blood-vessels; whilst the amount of solid matter is governed by the previous waste of the tissues.—The Malpighian bodies seem to act the part of a system of regulating valves; permitting the transudation of only enough fluid to dissolve the solid matter when there is no superfluity of water in the vessels; but allowing the escape of an almost unlimited amount of it when increased imbibition has rendered the vessels unusually turgid."*

The *urine* is composed in the greater part of its bulk of water united with several essential constituents, as follows: *Urea*, a peculiar highly azotized organic substance, which forms crystallizable salts with the acids.† *Uric* or *lithic acid*, which is peculiar to the urine and very sparingly soluble in water: in children, however, the urine contains hippuric in place of uric acid. These two substances are the essential and characteristic elements of the urine, which also contains an *animal extractive matter* analogous to that found in other fluids; an acid something resembling lactic acid; and a variety of inorganic salts,—muriate of ammonia, muriate of soda, phosphate of lime, sulphate of lime, magnesian salts and a trace of silica.‡

* Carpenter. Elements of Physiology, § 728.—Bowman, *ut suprà*, p. 74.

† Donné. Cours de Microscopie, Pl. XII.

‡ Wagner. Elements of Physiology, p. 422.

THE RENAL CAPSULES.—CAPSULÆ RENALES.

These bodies, called also the *supra-renal capsules*, are two in number, placed on the upper border of the kidneys. The capsule is of a triangular form, with its base upon the kidney; its anterior and posterior surfaces are flattened, the former being marked by an imperfect fissure. Each one is attached to the corresponding kidney by loose cellular tissue; that of the right side is connected to the liver by the same medium, and that of the left side lies in contact with the pancreas. Like the glands on which they rest, they are behind the peritoneum.

The renal capsule is composed of two different structures, one of which is external, the other internal. The former, or cortical substance is of a pale yellow color and seemingly consists of vertical parallel fibres, part of which, however, are arterial branches, and part venous ramifications, which last convey the blood to a plexus in the centre of the capsule. The cortical portion also contains between the blood-vessels many elongated conical bodies, with nuclei and cells in different phases of development. The *medullary* or *internal* structure of the renal capsule is constituted of a plexus of dilated veins, and an irregular cavernous structure filled with a viscid, yellowish pulp. The plexus and the lacunæ are connected by a parenchymatous structure of true cells. No central cavity nor excretory duct has been demonstrated in these organs, although such appendages have been from time to time announced.

Blood-vessels.—The capsular arteries are derived from three sources,—the phrenic, the aorta and the emulgent trunks. The capsular vein of the right side opens into the vena cava; the left, into the corresponding emulgent vein. The *nerves* come from the semilunar ganglia, and the solar and renal plexuses.

The *use* of these bodies is wholly unknown.

THE BLADDER.

The bladder is a large sac, lying behind the os pubis and in front of the rectum in the male, and presenting obliquely downward and backward; but in the female the vagina and uterus are interposed between it and the pubis. Its size and position are constantly varied by different degrees of repletion or emptiness; but when moderately distended it is egg-shaped, with the smaller end uppermost. It is divided into fundus, body, base and neck. The *fundus* or summit is the upper end, which is of a conical shape; the *basal portion* lies upon the rectum, and the *body* includes the part between the base and fundus. The *neck* projects from the front of the fundus and is sustained upon the prostate gland.

The bladder is composed of four laminæ of dissimilar structures called its peritoneal, muscular, fibrous and mucous coats.

The *peritoneal coat* affords only a partial investment; thus it covers the posterior and lateral surfaces, and dipping low down between the bladder and

rectum forms beneath the former a sort of cul-de-sac. The anterior surface is not covered by the peritoneum.

The *muscular coat* is formed of a double layer of fibres of which the external is longitudinal; the internal, both oblique and transverse. This exterior stratum is sometimes described as a separate muscle by the name of *detrusor urinæ:* its fibres, which are very thin and often scattered, originate near the neck of the bladder and diverge so as to embrace the whole organ. Or, in the more circumstantial description of Dr. Erasmus Wilson, "the anterior longitudinal fibres commence by four tendons, two superior from the ossa pubis, and two inferior from the rami of the ischia on each side, and spread out as they ascend upon the anterior surface of the bladder to its fundus: they then converge upon the posterior surface of the organ and descend to its neck, where they are inserted into the isthmus of the prostate gland, and into a ring of muscular tissue which surrounds the commencement of the prostatic portion of the urethra. Some of the anterior fibres are also attached to this ridge. The lateral fibres commence at the prostate gland and the muscular ring of the urethra on one side, and spread out as they ascend upon the side of the bladder to descend upon the opposite side, and be inserted into the prostate and opposite segment of the same ring."*

The internal muscular fibres run in various directions, being circular, transverse and spiral, with occasional interstices between their fasciculi into which the mucous membrane dips in the manner of small, superficial pouches; a conformation that becomes very distinct in hypertrophied bladders. Some other peculiarities in the muscular tissue will be presently described.

The *fibrous coat* is placed between the muscular and mucous envelopes: it is white, strong, and elastic, and sends prolongations among the fasciculi of the muscular fibres. It is the medium through which the blood-vessels and nerves are distributed to the mucous coat.

The *mucous coat* lines the bladder; it is of a reddish white color, remarkably smooth in itself, but corrugated in the collapsed state of the organ. It abounds in very minute mucous follicles, is replete with blood-vessels and abundantly provided with nerves.

Ligaments.—Several of the parts called ligaments of the bladder do not strictly deserve that name, some of them being destitute of the structure and function of true ligaments. The *lateral ligaments* are prolongations of the pelvic aponeuroses, which being continued on the inner margin of the levator ani on each side, reach the base of the bladder and the prostate gland, with which their structure is closely blended. The *anterior ligaments* are derived in the following manner: the fascia transversalis is continued down behind the symphysis pubis until it reaches the prostate gland and is reflected over it; from this point of reflection two fibrous cords, one on each side, run upon the anterior face of the bladder and constitute the ligaments in question.† The *round* or *umbilical ligaments* are two cord-like remains of the umbilical arteries of the fœtus, which becomes obliterated after birth: they are contained in folds of the peri-

* Special and General Anatomy, p. 564.

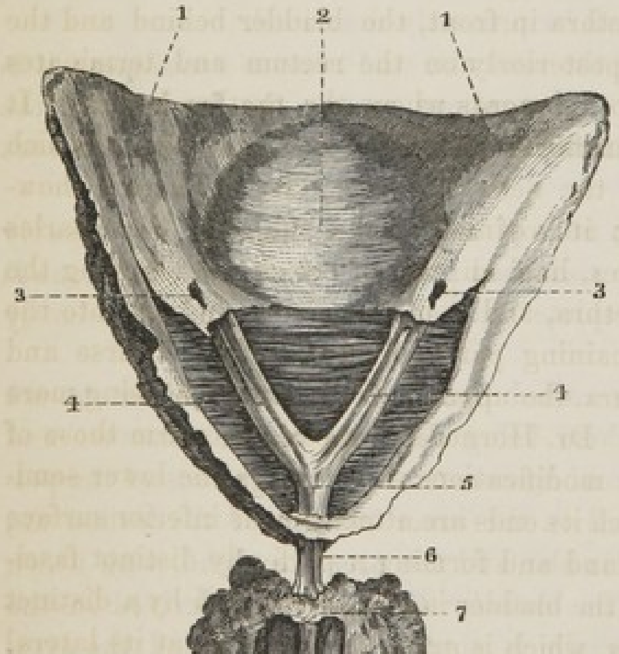
† Quain. Anatomy, p. 869.

toneum that pass up from the sides of the bladder to the umbilicus. The *urachus* is a fibrous cord that extends from the apex of the bladder, where it is blended with the muscular tissue, to the umbilicus, which it appears to enter. It is behind the linea alba and in front of the peritoneum. It is generally regarded as a canal in the embryo, although the accurate Cruveilhier observes that he has invariably found it solid both in adult and fœtal life. Two remaining cords that have some resemblance to ligaments, are seen in those folds of the peritoneum which enclose the vasa deferentia on each side, between the lateral surface of the bladder and the corresponding internal abdominal ring.

The *internal surface* of the bladder is marked by several important arrangements, among which is the *vesical triangle.* This is formed by two lines, one on each side, beginning at the orifices of the ureters and converging towards the neck of the bladder.

These elevations have been demonstrated by Sir Charles Bell to be caused by two linear fasciculi of muscular fibres, that originate from the orifices of the ureters behind, converge towards the neck of the bladder where they unite, and then run forward in a single fasciculus, which is first muscular and then becomes tendinous towards the middle lobe of the prostate gland, where its apex is inserted. Some fibres are also blended with those of the sphincter vesicæ; and Dr. Horner has traced the united fasciculus as far forward as the posterior part of the caput Gallinaginis. The use of these *muscles of the ureters* appears to be "to assist in the contraction of the bladder, and at the same time to close and support the mouths of the ureters."* This structure is very distinctly developed in the hypertrophied condition that usually attends diseases of the bladder.

Fig. 233.



Muscles of the ureters. After Sir Charles Bell.

Fig. 233 represents a portion of the inside of the bladder, with the prostate gland appended to it by the attachment of the common tendon of the muscles of the ureters. 1, 1, inside of the bladder; 2, lower fundus; 3, 3, mouths of the ureters; 4, 4, muscles of the ureters, from which the mucous membrane is dissected; 5, junction of the muscles; 6, tendon of the united muscles; 7, middle lobe of the prostate, and point of insertion according to Sir Charles Bell; 8, caput gallinaginis, the point of insertion according to Dr. Horner.

The space included in the triangle, which is about an inch and a quarter in length in each direction, is remarkably white, smooth,

* Medico-Chirurgical Trans. for 1816, p. 171.

vascular and sensitive, and destitute of the rugous folds common to other parts of the bladder. Its posterior boundary, which extends between the mouths of the ureters, is slightly elevated, and like the triangle itself is more distinct in the male than in the female. Behind this posterior boundary the bladder suddenly deepens, forming a distinct pouch called the *lower fundus* or *bas fond*, which is the well-known receptacle of urinary calculi.

Where the lines of the vesical triangle approximate directly behind the opening of the urethra, the basal mucous membrane is elevated into a small tubercle called the *uvula vesicæ*. This structure is obscure and deficient in early life, and at a later age is more or less dependent on a hypertrophied state of the third lobe of the prostate gland, which lies directly beneath. The submucous muscular fibres of the triangle run in a transverse direction and parallel to each other; but the dissections of Dr. Horner give a more circumstantial view of this structure, which is triangular like the vesical triangle inself; the anterior angle being traced to the posterior part of the caput gallinaginis, and the pubic angles to the orifices of the ureters and the adjacent muscular structure.

The *neck of the bladder*, which is continuous with the urethra, is shaped like an irregular cone with the apex directed forward. Mr. Guthrie has justly remarked that the term neck of the bladder is one which has several meanings; some anatomists confining it to one part, some to another, and others even including the whole of that portion of the urethra which passes through the prostate gland. We agree with him in restricting it to the small part surrounding the opening into the urethra, which is therefore a ring a little thicker than the contiguous parietes of the bladder, with the urethra in front, the bladder behind and the uvula vesicæ beneath it.* It rests posteriorly on the rectum and terminates in front at the prostate gland, or in other words where the urethra begins. It is at this point we find some annular fibres called the *sphincter vesicæ*, which are usually described as surrounding the neck of the bladder. There is, however, much discrepancy of observation and opinion on this subject. Sir Charles Bell describes a plane of such fibres, half an inch in breadth, embracing the lower half of the orifice of the urethra, and then dispersing, in part into the common muscular structure; the remaining part pursues its direct course and completes the investment of the urethra, the upper half of the muscle being more feebly developed than the lower one. Dr. Horner's dissections confirm those of Sir Charles Bell, with the following modifications:—he traces the lower semicircle of fibres to the prostate, to which its ends are attached; its inferior surface being above the third lobe of that gland and forming a perfectly distinct fasciculus. The upper half of the neck of the bladder is also surrounded by a distinct but much more delicate layer of fibres, which is gradually blended, at its lateral or lower ends, with the proximate muscular tissue of the bladder. The difference between the observations of these distinguished anatomists consists merely in this—that the one sees, in the sphincter vesicæ, an annular muscle of continu-

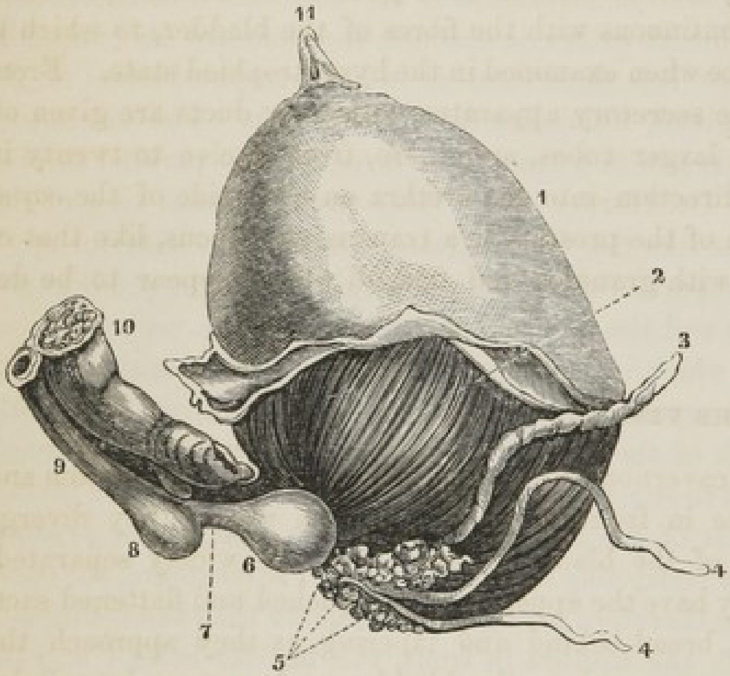
* Anatomy of Diseases of the Neck of the Bladder, p. 17.

ous structure; while the other finds two semicircular bands of which the terminal fibres have no mutual connection, but are entirely distinct.*

Vessels and nerves.—The arteries of the bladder are the *vesical*, which are branches of the internal iliac, there being one on each side. The *vesical veins* are numerous, form a plexus round the neck of the bladder and empty in to the hypogastric trunks. The nerves come from the hypogastric plexus, formed both of ganglionic and spinal filaments; which explains the familiar fact that the bladder is in part a voluntary and in part an involuntary muscle.

Function.—The bladder is merely a receptacle for the urine.

Fig. 234.



The bladder and its appendages. From J. Bell.

Fig. 234. The bladder and some of the associated parts. 1, peritoneal coat; 2, longitudinal muscular fibres, or detrusor urinæ; 3, the ureter; 4, 4, vasa deferentia; 5, vesiculæ seminales; 6, prostate gland; 7, membranous portion of the urethra; 8, bulb of the urethra; 9, urethra; 10, corpus cavernosum cut off; 11, the urachus.

THE MALE ORGANS OF GENERATION.

These parts consist, as heretofore observed, of the penis and testicles, the vesiculæ seminales, prostate gland and certain ducts.

THE PROSTATE GLAND.

This structure, which, by common consent, is compared to a chestnut, surrounds the neck of the bladder and is channelled its whole length for the urethra. It lies in the bottom of the pelvis, behind the deep perineal fascia and beneath the arch of the pubis and the anterior vesical ligaments; its lower surface is in contact with the rectum to which it is attached by cellular tissue, and its sides are between the fibres of the levator ani muscle. It is about an inch in length, rather more in its transverse diameter and nearly half an inch in thickness. The base of the prostate faces the bladder; its apex presents forward towards the urethra. It is composed of two larger lobes and a smaller or third lobe. The former are

* Horner. Special Anatomy and Histology, ii. p. 103.

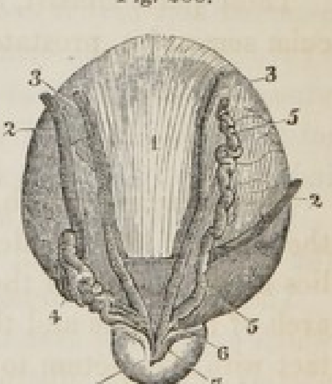
rendered obvious by the notch in the base of the gland; the third lobe is seen by inverting the parts and raising the vesiculæ seminales and seminal ducts, being placed between these last and the bladder, and in a position that corresponds with the uvula vesicæ above. It is small in the healthy state, but often conspicuous from morbid enlargement.

The prostate is of a white color and very dense structure. It consists of lobules which are subdivisible into granules, closely packed in the midst of a tissue which is regarded by Cruveilhier as analogous to muscular structure, because, he observes, it is continuous with the fibres of the bladder, to which it also bears a close resemblance when examined in the hypertrophied state. From these granules, which are the secretory apparatus, excretory ducts are given off which subsequently unite in larger tubes, and these, from twelve to twenty in number, open in a forward direction into the urethra on each side of the *caput gallinaginis.* The secretion of the prostate is a transparent mucus, like that of Cowper's gland, intermixed with granules and flocculi which appear to be derived from epithelial cells.

THE VESICULÆ SEMINALES.

These are two elongated, cavernous bodies interposed between the rectum and bladder. They approximate in front at an angle, from which they diverge towards the posterior part of the bladder, where they are widely separated. Examined from without, they have the appearance of pouched and flattened sacs, about two inches in length, broad behind and tapering as they approach the prostate gland. They are connected to the bladder and rectum by cellular membrane which also envelopes the vesicles, and has been compared to the tissue of the dartos. The vesicles themselves are formed of a grayish, firm, fibrous tissue, which, on being laid open, especially in the dried state, is seen to be divided into numerous cells separated by partial partitions. A careful dissection, however, shows each of these vesicles to be a convoluted tube, five or six inches long and a quarter of an inch in diameter, with occasional lateral cul-de-sacs. Besides the fibrous tunic of which we have spoken, the tube is lined by a mucous membrane which is continuous with that of the urethra, and like it is furnished with tesselated epithelial cells containing nuclei of considerable size and a quantity of granular matter.

Fig. 235.



Base of the bladder and associated parts. From Cruveilhier.

Fig. 235. Base of the bladder with the vesiculæ seminales, ureters and prostate gland. 1, muscular structure of the bladder; 2, 2, ureters; 3, 3, vasa deferentia; 4, vesicula seminalis; 5, same of the opposite side, dissected out to show its tubular character; 6, efferent duct of the vesicula seminalis, which joins the duct of the vas deferens to form at 7 the ductus ejaculatorius; 8, prostate; 9, urethra.

At the under surface of the prostate and at the margin of its third lobe, each vesicula forms a small excretory duct not more than a sixth of an inch in length, which joins the corresponding vas deferens coming from the testicle; the

union of these canals takes place within the prostate, and forms the *ductus ejaculatorius*, which opens into the urethra on each side of the caput gallinaginis.

The vesiculæ seminales are filled with a self-secreted mucus of a yellowish-brown color and viscid consistence; but they appear to be also reservoirs for the seminal fluid in certain states of repletion, thus performing for the testes the same function that the gall-bladder does for the liver.

THE TESTES.

These glands are placed in the scrotum and beneath the root of the penis, where they are suspended by the spermatic cord in a sac called the scrotum. They are two laterally flattened ovoidal bodies that incline obliquely downward from front to back, being convex on their anterior border and presenting a nearly plane margin behind.

These glands are variable in size and consistence at different periods of life, arising in part from differences of age, in part from congenital causes and also in part from variable degrees of excitability and indulgence.

The scrotum.—The exterior or scrotal envelope consists of the skin, sparsely covered with hair, and an internal or proper tunic called the *dartos*. This sac is marked off into two nearly equal parts by a longitudinal line or *raphé*, which can be traced to the penis in front and to the anus behind. The skin is here thin, translucent and sensitive, and the dartos may be said to line it within. The dartos is a thin fibrous membrane possessing strong contractile powers, but destitute of muscular fibres; it is a double sac of which the inner sides meet and mingle in the median line, and thus form a separate receptacle for each testis. Although it is a contractile tissue, it can be readily traced to the superficial fascia of the abdomen and peritoneum.* Meckel regarded it as a transition between cellular and muscular fibre; and Dr. Horner has detected some muscular filaments on its posterior face. Some anatomists consider it as the remains of the gubernaculum testis; and ground their opinion on the assumed fact that it does not show itself until after the descent of the testicle. Cruveilhier, on the contrary, has found it in the fœtus; and in an adult person whose testicle had never passed from the external abdominal ring, that anatomist satisfied himself that the dartos and gubernaculum exist separately and independently of each other.†

Within the scrotum are several envelopes which more or less directly embrace the testicle, and which we now proceed to mention.

The *tunica erythrodes* is derived from the fibres of the cremaster muscle, which expanding over the testicle in the manner heretofore described, give it a partial covering, distinct and of a reddish color in early life, but pale and atrophied in old age.

The *tunica vaginalis communis* is formed of the condensed areolar tissue that connects the cremaster and dartos externally with the tunica vaginalis within; so that the latter membrane lines its internal parietes. It is a thin and

* Wilson. Anatomy, p. 571.

† Anatomy, p. 447.

translucent, wide below and narrow at the abdominal ring, where a part of it can be traced into the abdominal canal and has been supposed to be a prolongation of the fascia transversalis. It thus forms two perfectly distinct sacs, one for each testicle.

The *tunica vaginalis testis* is a serous membrane, derived from the peritoneum at the period of the descent of the testicle from the abdomen. One part of it, the testicular portion, invests the testis and epididymis, being so closely adherent to the tunica albuginea within as to be separable only in filaments; while the other, or reflected portion, is connected exteriorly to the tunica vaginalis communis by loose areolar tissue. The tunica vaginalis communis is closed below the abdominal ring, so as to form an imperforate sac resembling a Florence flask with the neck uppermost. Its cavity, which is perfectly smooth, is moistened by a small quantity of serous fluid.

The *tunica albuginea* or tunica propria, forms the immediate investment of the testicle,—a firm, white membrane of the fibrous class, vascular and inextensible. It is covered by the tunica vaginalis except at its posterior border, where that membrane is reflected to form the loose part of its sac, and where also the spermatic vessels enter the testis. At the posterior margin, also, the tunica albuginea divides into two laminæ, of which the external one is continued to the vas deferens, but the other, uniting with a corresponding layer from the opposite side and thus constituting an inflection of the membrane, dips for a short distance into the substance of the gland, forming a prominent longitudinal ridge called the *corpus Highmorianum*, or by Sir Astley Cooper, the *mediastinum testis*. Fig. 237, 4. This body is strengthened by numerous flattened processes given off from the inner surface of the sac, and which, after crossing the latter from front to back, unite at the corpus Highmorianum. In their course these fibres give rise to imperfect septa, *septulæ testis*, in the body of the gland, and give support to the lobules of which it is composed. The tunica albuginea is separable by careful dissection into two laminæ, of which the inner one is highly vascular, whence it has been called by its discoverer, Sir Astley Cooper, the *tunica vasculosa*.* The blood-vessels of the testicle enter at the corpus Highmorianum; part of them forming sinuses within it, and others perforating the tunica albuginea to make their way directly to the upper and lower ends of the gland.

The internal structure of the testicle is formed of lobules of a conical, flattened shape, of which the larger ends present to the anterior and convex parts of the gland, while their pointed terminations rest on the corpus Highmorianum: they are also separated and supported by the septulæ testis, and each lobule is further enveloped in its own sheath derived from the tunica vasculosa. Each lobule may be readily lifted from its cell and is then found to consist of one or several minute tubes, *tubuli seminiferi*, which are convoluted on themselves in a remarkable manner: each tube has been found to be about seventeen feet long and $\frac{1}{170}$th of an inch in diameter, which last measurement is the same throughout.

* Structure and Diseases of the Testis, p. 15.

Fig. 237, 1, 2, 2. The tubuli of a single lobule occasionally anastomose with each other, and end in or commence by simple cul-de-sacs; but as they approach the corpus Highmorianum they coalesce into twenty or thirty straight tubes called the *vasa recta*.

The *vasa recta*, Fig. 237, 3, are twice the diameter of the seminiferous tubes; they enter the corpus Highmorianum and form in that structure a reticulated anastomosis called the *rete testis*, Fig. 236, 2, from which are given off from ten to twenty ducts that run upwards and backwards, penetrate the corpus Highmorianum and tunica albuginea and thus escape from the testis: these tubes are the *vasa efferentia*. Fig. 237, 5. At the upper border of the testicle each one is greatly convoluted into a conical form called the *conus vasculosus*, of which the apex presents towards the testicle. These cones correspond in number to the vasa efferentia that form them, and each one terminates at its basal end in a common tube: the convolutions of these tubes constitute the mass of the epididymis at the inferior end of which the tube becomes less convoluted, though yet somewhat tortuous, and is called the *vas deferens*. Fig. 236, 9, and Fig. 237, 9.

Fig. 236.

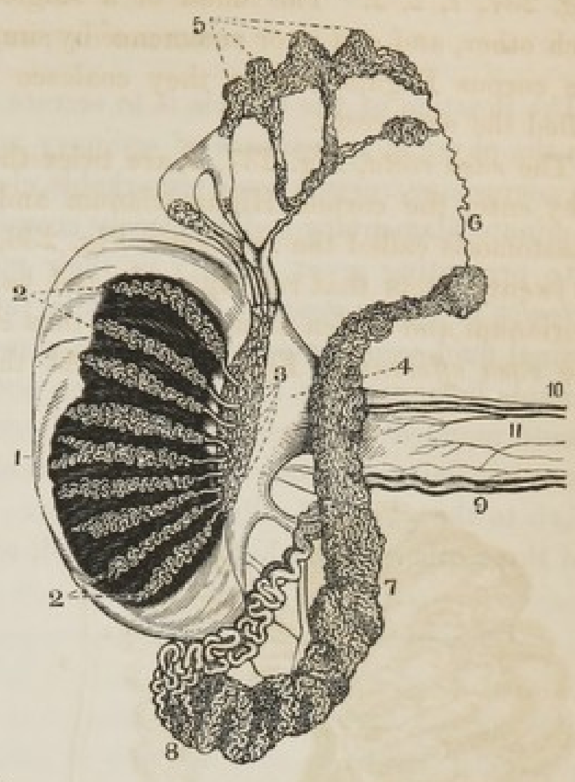
Testis injected with mercury and deprived of the tunica albuginea.

Fig. 236. Testis injected with mercury and divested of the tunica albuginea. 1, 1, lobules formed by the tubuli seminiferi; 2, rete testis; 3, 4, coni vasculosi formed by the seminiferous tubes; 5, 6, the epididymis; 7, appendix of the epididymis; 8, termination of the epididymis in the vas deferens; 9, 9, vas deferens.

The *epididymis* is an arched structure in the back of the testicle, formed, as we have stated, by the convolutions of coni vasculosi and of the single duct in which they unite. The upper part of the epididymis is much the larger, being made up of the coni vasculosi and called the *globus major:* the lower and lesser enlargement is the *globus minor*, which together with the body of the epididymis below it, is constituted of the single tube, about the fourth of a line in diameter, coming from the coni vasculosi of the globus major. The body or middle part is not attached. The globus minor is prolonged to the inferior border of the gland, where it ends in the vas deferens, which is curved upon itself and then runs upwards. The epididymis is flattened its whole length; its body or free portion is invested by the tunica vaginalis, but its two globiform extremities have that membrane only above and on the outside. The only continuous attachment of the epididymis to the testicle is at the globus major, where the vessels have their entrance and exit; the remaining portions being loosely attached by areolar tissue and the tunica vaginalis. Fig. 236, 5, 6.

Fig. 237 further illustrates the anatomy of the testicle. The several parts of the organ have been injected with mercury and then unravelled. 1, 2, 2, tubuli seminiferi; 3, vasa recta, forming the rete testis; 4, corpus Highmorianum; 5, vasa efferentia, forming the coni vasculosi; 6, a single tube formed by the junction of the vasa efferentia. This tube then becomes convoluted upon itself to form the epididymis; 7, 8, beginning of the vas deferens; 9, the vas deferens becoming a straight, isolated tube in its ascent to the abdominal ring; 10, spermatic artery; 11, spermatic cord, dissected and spread out.

Fig. 237.



The structure of the testicle injected with mercury, and its several parts unravelled. After Sir A. Cooper.

The *vas deferens*, after its origin from the inferior margin of the epididymis, runs upwards nearly parallel with that body, and more or less tortuous in its course: from this point it becomes less twisted, forms a part of the spermatic cord and enters the external abdominal ring behind the spermatic blood-vessels. It then traverses the length of the abdominal canal, and having reached the internal ring, leaves the spermatic cord and descends into the cavity of the pelvis and behind the peritoneum to the lateral and posterior margin of the bladder: it next reaches the base of that organ, runs forward and converges to meet its fellow of the opposite side, at and within the angle formed by the junction of the vesiculæ seminales. The two vasa deferentia having thus reached the under surface of the third prostatic lobe, join the corresponding ducts of the vesiculæ seminales just within the substance of the prostate, whence is formed, on each side, a common tube called the *ductus ejaculatorius*. This tube, which is less than an inch in length, runs parallel to its fellow upward and forward through the prostate; and it terminates in the prostatic portion of the urethra on each side of the caput gallinaginis.

The vas deferens is a firm, white duct, about the eighth of an inch in diameter. It is formed of two coats: the exterior one is remarkably thick, strong and of a fibrous structure; the inner one is thin and delicate, with the usual characters of mucous membrane, and the calibre of this duct is so small that a bristle will fill it through the greater part of its course. Just before it reaches the vesiculæ seminales, however, it is considerably dilated, its parietes become thinner and it is sometimes pouched or irregularly dilated.

FUNCTION OF THE TESTICLE.

The function of the testicle is to secrete the semen masculinum, a fluid that has the physical appearance of ordinary mucus, but which, when placed under the microscope, reveals some remarkable elements. Among these are multitudes of minute filamentary bodies closely crowded together, and in the very recent state presenting great activity in their motions: they are called *seminal animalcules* or *spermatozoa*. So great is their number that at first sight the seminal fluid seems to consist of them alone; but a closer inspection discovers a simple homogeneous fluid, the *liquor seminis* in which they move, and also minute rounded corpuscles, the *seminal granules*. These *granula seminis* are somewhat flattened, colorless, with a granular surface, and measure from the $\frac{1}{300}$th to the $\frac{1}{500}$th of a line in diameter. Fig. 238, 5, represents two of them, and three others, more highly magnified, are seen in Fig. 239.

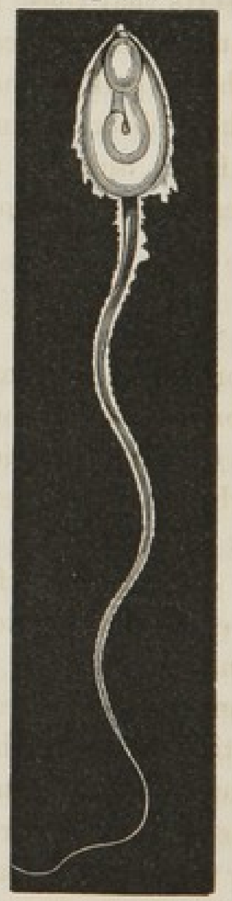
Fig. 238.

Spermatozoa and granula seminis. From Wagner.

Fig. 239.

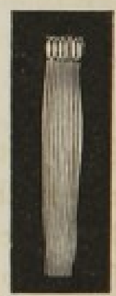
Reproductive cell containing three granula seminis. From Wagner.

Fig. 240.



Spermatozoon from the human testicle. After Pouchet.

Fig. 241.



Fasciculus of human spermatozoa, magnified about 1000 times. From Wagner.

Fig. 238. Human spermatozoa and seminal granules. 1, spermatozoon presenting its flat surface; 2, the same in profile; 3, 3, the same with the circular spot; 4, spermatozoon with something resembling a proboscis; 5, granula seminis. From Wagner.

The spermatozoa in man are extremely small, seldom exceeding the $\frac{1}{50}$th of a

line in length, having at the end a flattened, almond-shaped and perfectly transparent body. Fig. 238.

These several parts,—the granules, spermatozoa and containing liquor seminis, form the original constituents of the *reproductive cells*, or *globules d'evolution*, above described, which provide the germs for the continuance of the human species. The cells are developed within the testicle; at first the granules are diffused throughout the cell, but they subsequently assume a linear arrangement and are collected into fasciculi.

After a time, and while it is yet in the tubuli seminiferi, the cell bursts, the filamentous bodies escape and take on those peculiar motions which have led to the opinion that they are distinct animalcules. But it is now generally admitted, observes Dr. Carpenter, that they have no more claim to a distinct animal character than have the ciliated epithelia of mucous membrane, which will likewise continue its movement when separated from the body; hence they would appear to be nothing else than cell-germs furnished with a peculiar power of movement.* On the other hand M. Pouchet, who has given elaborate attention to this subject, asserts that these zoospermata have a kind of buccal apparatus, a structure continues with this called by him the *cephalothorax*, an intestinal canal and an epithelial pellicle that envelopes the whole animal, as represented in Fig. 240.† These observations seem to prove in man what has already been noticed in the inferior animals, as in the bear and the Guinea pig, that the spermatozoa possess decided animalcular characteristics.‡

THE SPERMATIC CORD.

The parts comprising the spermatic cord are in part situated in the abdomen, partly in the abdominal canal and partly between the abdominal ring and testicle. It consists of three arteries with their corresponding veins; of the vas deferens, of absorbents and of nerves, covered by a fascial envelope and by the cremaster muscle. Fig. 204, 5.

The *spermatic arteries* come from the aorta between the two mesenterics, and descending behind the peritoneum to the front of the psoas muscles, enter the abdominal canal through the internal ring; from this point each artery traverses the canal, emerges at the external ring and appears in the cord surrounded by the spermatic veins. It then descends towards the testicle; but before reaching it, divides into two branches, one going to the upper, the other to the lower part of the testis. After giving off branches to the epididymis, the artery penetrates the testis through the outer layer of the tunica albuginea, and then ramifies in the tunica vasculosa and supplies the lobes formed by the tubuli seminiferi.

Two other arteries are more or less distributed to the cord; one of these is the *deferential*, a branch of the hypogastric, which runs upon the vas deferens from

* Elements of Physiology, § 240.—Wagner. Physiology, p. 9.

† Pouchet, L'ovulation spontanée, Plate II. Fig. 4.

‡ Gerber. General Anatomy, p. 336.

the inner to the external ring, and is distributed upon the testicle and its appendages; the second accessory artery is the cremasteric, presently to be noticed.

The *spermatic veins*, two in number, commence in the testis in the tunica vasculosa; these are joined by branches from the epididymis and form a plexus of vessels before they enter the external ring, but on reaching the abdomen they unite in two and sometimes in three trunks, that finally coalesce into one and terminate in the vena cava.

The *absorbents* of the cord arise both from its exterior coats and from its internal structure; they unite upon the cord and form three or four trunks which ascend upon the spermatic veins, and follow them into the abdomen to terminate in several absorbent glands near the origin of the spermatic arteries.

The spermatic cord below the external ring is covered by superficial fascia, which loosely attaches it to the tendon of the external oblique muscle, but strongly adheres to the margin of the ring, so that the opening is concealed until the fascia is removed. This fascia descends to the lower part of the testicle, still adhering to the cremaster and surrounding it.

A second covering of the cord is derived from the cremaster muscle, which descends from its origin in Poupart's ligament and forms loops upon the cord as heretofore described. Fig. 204, 8, 9. The cremaster muscle has an artery of its own, the *cremasteric*, a branch of the epigastric.*

DESCENT OF THE TESTIS.

In the early periods of intra-uterine life, the testicle is yet in the abdomen directly beneath the kidneys; but in the fœtus of five or six months, it is placed upon the lower part of the psoas muscles, having the peritoneum on its front and sides; and this peritoneal covering becomes the future tunica vaginalis.

The *gubernaculum testis* is a cord of cellular tissue and ligamentous fibres that passes from the lower end of the testis to the bottom of the scrotum, through the inguinal canal. It is surrounded by the fibres of the cremaster muscle; or rather, in the words of Sir Astley Cooper, the peritoneum of the lower part of the abdomen passes down upon, and adheres to the gubernaculum, so as to form a small pouch in the inguinal canal to which the cremaster muscle is attached. The peritoneum which is attached to the gubernaculum, and the contiguous loose part of that membrane, descend with the testis progressively from the earliest period of the existence of the latter organ: thus, in the seventh month it has reached the iliac fossa; in the eighth month it enters the abdominal canal, and passing through that passage, makes its exit at the external ring so as to reach the base of the scrotum two or three weeks before birth, or between the eighth and ninth months. In this way the testis, the pouch formed by the cremaster muscle, and the investing peritoneum, all descend from the abdomen together. The peritoneum attached to the gubernaculum becomes the tunica

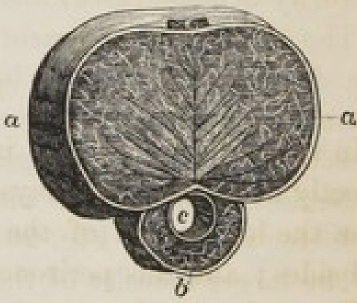
* Sir A. Cooper. Anatomy of the Testis, p. 37.

vaginalis reflexa of the adult; that portion of it that covered the testis in the abdomen, subsequently becomes the tunica vaginalis testis; and that which it draws after it from the abdomen to the testis, is the tunica vaginalis of the cord.* Immediately after this descent, the peritoneum becomes closed by adhesion, and thus forms a complete and closed sac. There is great variety in this evolution, for it not unfrequently happens that both testes are yet in the abdomen at birth, and their appearance has even been protracted to the age of one-and-twenty years. Sir Astley Cooper remarks that he has often seen them retained until the age of thirteen to seventeen years, or about the age of puberty, when they appeared to have been brought down by the excitement of the sexual feelings.†

THE PENIS.

The male organ is composed of three cylindriform bodies, two of which, the *corpora cavernosa*, are placed side by side, and the third, the *corpus cavernosum urethræ*, is situated beneath the others so as to occupy the sulcus formed by their junction, Fig. 242. These parts derive an investment from the common integuments, which terminate at the anterior end of the penis in a loose prolongation of skin called the *prepuce*, lined on its inside by an epithelial mucous membrane, and attached to the glans penis by a fold of that membrane, the *frænum præputii*.

Fig. 242.



Transverse section of the penis. From Weber.

Fig. 242. Transverse section of the penis. *a*, *a*, the corpora cavernosa; *b*, corpus spongiosum urethræ; *c*, urethra.

The *corpus cavernosum* on each side arises from the rami of the pubis and ischium by its *crus*,—a ligamentous structure that passes upwards to the symphysis, where it meets and joins its fellow of the opposite side. Each crus is of a conical form, the apex presenting towards its origin and the base being attached to the penis. The corpora cavernosa are cylindrical in shape, so that their contact forms a groove both above and below, the latter accommodating the urethra,—the former, the vessels and nerves.

The corpora cavernosa are covered at their anterior extremity by a rounded conical body, the *glans penis*. It is of a red color, extremely sensitive and covered by the prepuce, and the same epithelial covering that lines the latter is reflected over the glans. This epithelium is provided, at its base, with sebaceous follicles, *glandulæ Tysoni*, which secrete a viscid mucus. At the apex of the glans is a vertical fissure, the *meatus urinarius;* and its base is surrounded by a prominent convex ridge, the *corona glandis*, between which and the attachment to the body of the penis there is a deep contraction of the glans called its *cervix* or neck.

* Sir Astley Cooper. Structure and Diseases of the Testes, p. 43.

† *Ut suprà*, p. 44.

The structure of the corpora cavernosa is fibrous, very strong, contractile, and more than a line in thickness. The exterior fibres are longitudinal except at the origin of the crura, where they mingle with the periosteum. The corpora cavernosa are partially separated by an imperfect partition, the *septum pectiniforme*, formed of vertical fibres or cords which are strongly developed in the basal half of the penis, but much more feebly in front. Dr. Horner observes that this septum is continued at its margins into a layer of circular fibres constituting the internal coat of the corpus cavernosum.* The internal structure of these parts, as their name imports, is essentially cavernous and belongs to the erectile class of the tissues. It consists of an intertexture of veins, so closely woven together as to give the appearance of cells when the parts are inflated and dried; and of reddish prolongations, *trabeculæ*, derived from the inner surface of the fibrous cylinder, and passing from side to side, separate and support the venous plexuses. The latter receive their blood from the internal pudic arteries which terminate in the veins by the usual capillary arrangement: but Professor Müller has described another set of arteries, *arteriæ helicinæ*, which, he says, are short curled branches, much larger than capillaries and ending abruptly in free, rounded extremities: they project singly, or in tufts arising from one stem, into the venous cells, by the lining membrane of which they are supported and invested.† These vessels have not yet been satisfactorily demonstrated, and some anatomists deny their existence altogether.

The *suspensory ligament* of the penis extends from the symphysis pubis to the dorsum of the penis, being composed of dense fibrous tissue in which muscular fibres have been from time to time announced. It gives the penis an investment as far as the glans, is continuous above with the fascia superficialis abdominis, and behind with that part of the fascia femoris that covers the adductor muscles. Fig. 204, 10.

The larger muscles of the penis have been already described, viz., the *erector penis* or ischio-cavernosus; and the *accelerator urinæ* or bulbo-cavernosus. The *pubio-urethralis*, or muscle of Wilson, will be described with the urethra.

The URETHRA is a curved canal that extends from the bladder to the fissure of the glans penis, a variable distance of from seven to ten inches. It is composed of two laminæ, of which the internal or mucous is continuous with that of the bladder. The exterior layer is a strong, fibrous and very elastic tissue, that serves to connect the mucous membrane with the corpus spongiosum, and to give strength to the urethral canal its whole length.

The urethra is divided into three unequal portions, the prostatic, the membranous and the spongy.

The *prostatic portion*, as its name imports, is embraced within the prostate gland, running its whole length, or about an inch and a half. It is the most dilated part of the urethra. It does not traverse the centre of the prostate, but is much nearer the upper than the under surface of the gland. Its inferior surface is marked by a fold of mucous membrane, the *caput Gallinaginis*, or

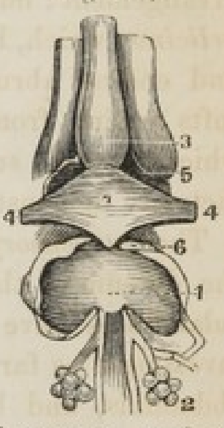
* Special Anatomy and Histology, ii. p. 107.

† Note to the American edition of Cruveilhier's Anatomy, p. 456.

verumontanum, on each side of which is an elongated depression, the *prostatic sinus:* into this sinus the ducts of the gland discharge their mucosity. Just at the anterior margin of the verumontanum are the openings of the ductus ejaculatorius of each side; and between these is a small cul-de-sac that penetrates backward into the prostate.

The *membranous portion* is the narrowest and shortest of the three: it is about an inch long, and intervenes between the prostate gland behind and the bulb of the urethra before. Above it and laterally is the arch of the pubis; below, it is contiguous to the rectum. It is formed of the mucous coat within and the fibrous layer externally, and is also invested more or less completely by the *compressor urethræ* muscle. The latter, which was first described by the late Mr. Wilson, and more fully by Mr. Guthrie, has the following position: it arises on each side from the margin of the sub-pubic arch, or, more strictly speaking, from the ascending ramus of the ischium a little below its junction with the descending ramus of the pubis, and expands so as to meet its fellow at a longitudinal median line of tendon on the upper surface of the urethra: in like manner part of the fibres pass to the under surface of the canal, and meet those of the opposite side at a second median line below, so that the membranous portion is embraced between them as by a sling.* This muscle is also called the *pubio-urethralis*, and has generally been regarded as a part of the levator ani. Its function consists in drawing the urethra upwards, and by compressing its sides acting as a sphincter.

Fig. 243.



Compressor urethræ muscle, seen on its under surface. From Mr. Guthrie.

Fig. 243. 1, represents part of the inferior surface of the prostate; 2, portions of the vesiculæ seminales; 3, bulb of the urethra; 4, 4, crura of the muscles as they come from the ramus of the ischium; 5, indicates the anterior attachment of the muscle, which penetrates the triangular ligament "to be inserted in front of it, and near the union of the corpora cavernosa;" 6, posterior attachment to the prostate gland; 7, body of the muscle.

Another small muscle, the *ischio-bulbosus*, is described as arising from the ascending ramus of the ischium and the descending ramus of the pubis, and terminating in the sides of the bulb. It is separated from the *compressor urethræ* by the deep perineal fascia, and hence is independent of the levator ani.† It seems to correspond with the transversus perinei alter of Albinoes.

The *spongy portion* of the urethra is by far the longest of the three. It commences under the symphysis pubis by a dilatation called the *bulb*, which occupies the angular space between the crura penis and extends from the root of the penis to the anus. Its most prominent part is behind, where it projects downwards and backwards. The urethra is not enlarged at this point in proportion to the interior parietes of the bulb; on the contrary, its increased diameter above the rest of the canal does not exceed the tenth of an inch. A second dilatation, the *fossa navicularis*, occurs just within the meatus urinarius.

* Guthrie. Anatomy and Diseases of the Bladder and Urethra, p. 40.

† Cruveilhier. Anatomy, p. 437.

Between the lining mucous membrane and the corpus spongiosum, are placed many lacunæ of different sizes; their orifices, which present in the forward direction, being large enough to admit a bristle. They secrete a mucosity that serves to lubricate and protect the lining membrane. Besides these lacunæ, the urethra is provided with two small bodies the size of peas, situated beneath the membranous part and between the bulb and the point of the prostate, but nearer the former, and covered by the acceleratores urinæ muscles. These bodies are *Cowper's glands.* Each one sends forward a duct nearly an inch in length, that perforates the corpus spongiosum and opens into the urethra a little in advance of the bulb. These glands are lobulated, hard, of a yellowish color, and are sometimes deficient. Some other glandules of similar character are occasionally found in front of Cowper's glands. They all secrete a viscid mucus intermixed with flocculi and granules which are composed either of normal or altered epithelial cells.*

Fig. 244.

Urethra and bladder.

The spongy portion is composed of three laminæ, an internal mucous one, an external fibrous one resembling that of the corpora cavernosa, and an intermediate structure, the proper *corpus spongiosum.* This last is a fibrous framework resembling reticulated areolar tissue, with a venous plexus so convoluted that it gives the whole the same cavernous or cellular appearance that marks the corpora cavernosa, excepting only that the cells are much smaller. It is erectile and elastic, and is supposed by some anatomists to be provided with longitudinal muscular fibres. The corpus spongiosum does not communicate with the corpora cavernosa.

Fig. 244. The bladder and urethra laid open. 1, glans penis; 2, corpus cavernosum; 3, fossa navicularis; 4, urethra with its follicles; 5, dilatation of the urethra in front of the membranous portion; 6, membranous portion; 7, caput Gallinaginis; 8, orifice of the ductus ejaculatorius; 9, prostate; 10, prostatic portion of the urethra; 11, vesical triangle; 12, its base; 13, orifices of the ureters; 14, bas-fond of the bladder; 15, 15, internal surface of the bladder.

THE FEMALE ORGANS OF GENERATION.

These consist of the vulva, vagina, uterus, Fallopian tubes and ovaria: the first two are strictly copulative, the others generative organs.

THE VULVA.

The *vulva*, or pudendum, is a collective designation for the external female

* Wagner. Elements of Physiology, i. p. 59.

genitalia, including the mons veneris, the internal and external labia, the clitoris and the orifice of the vagina.

The *mons veneris*, which is the same as in man, is the elevation of the integuments directly over the pubis. It is constituted of condensed areolar tissue and adipose matter, and in the adult is covered with hair.

The *labia externa* or *majora* are two folds of skin continuous with the mons veneris: they extend in the longitudinal direction and terminate below in an angular commissure, the *fourchette*. Like the mons veneris, they are composed of areolar tissue and fat and form the anterior boundary of the sexual organs. The internal lining of these parts is a delicate, vascular epithelium, which is furnished with mucous follicles. The distance between the fourchette and the anus constitutes the perineum and is about an inch in length.

The *labia interna* or *minora*, called also the nymphæ, are duplicatures of the epithelial membrane within the external labia. They arise from the anterior commissure of those bodies and surround the base of the clitoris, thus forming the *præputium clitoridis*. At the inferior margin of the clitoris the folds of the nymphæ unite in the frænulum, from which point they diverge and are gradually lost on the inner surface of the labia majora at the orifice of the vagina.

The *clitoris* in several respects resembles the male penis. It is formed of erectile tissue and arises by two crura from the rami of the pubis and ischium. It has also a suspensory ligament, but is imperforate and seldom exceeds the length of half an inch. Its free portion is called the *glans clitoridis;* its internal structure is similar to that of the corpora cavernosa penis, and like the latter, also, it is an erectile tissue, acted upon by a small muscle, the *erector clitoridis*. These muscular fibres arise from the rami of the pubis and ischium, pass on the under surface of the clitoris and terminate at its apex.

The *orifice of the urethra* is within the vulva about an inch behind the clitoris and directly above the vagina, where its position is marked by a small tubercle.

The *orifice of the vagina* is an elliptical opening below or behind the meatus urinarius, having a thickened margin and being bounded laterally by the nymphæ. It is usually more or less closed by a duplication of mucous membrane, the *hymen*, which exists sometimes as a perforated septum and sometimes as a semilunar fold. It is more rarely imperforate; in other instances it has two or more orifices, and again it is represented by a partial fringed margin or may be congenitally deficient. Its rupture leaves an irregular edge with thickened cicatrices known as the *carunculæ myrtiformes*.

The *vestibulum* is the triangular surface between the clitoris before and the vagina behind; the urethra opens into it and it is bounded laterally by the labia interna.

THE VAGINA.

The vagina is a canal interposed between the uterus and the vulva, and between the bladder and the rectum. Its length is from four to six inches; it is somewhat dilated near the uterus and contracted at its commencement in the vulva,

between which points it curves obliquely forward and downward, being flattened transversely and having its parietes in close apposition. It is composed of three laminæ; the *external* one is a fibrous structure, strong and contractile, and much resembling the dartos of the scrotum. The *middle layer* is constituted of erectile tissue enclosed between two layers of fibrous membrane: it commences directly within the vagina, surrounds its upper half and extends about an inch backwards in the direction of the uterus, its thickness being seldom more than two lines. This is the *corpus spongiosum vaginæ*, so called on account of its resemblance to the analogous structure in the urethra. It is also called the *plexus retiformis* and embraces a remarkable congeries of veins.

The *internal membrane* belongs to the mucous class: it is furnished with lacunæ, and is marked by transverse folds or ridges,—the rugæ of the vagina, which, however, are chiefly confined to its anterior portion. A raphé or longitudinal slightly elevated line commences on the anterior parietes of the vagina just within its orifice, and extending back is lost near the uterus, and a nearly similar line exists on the posterior surface. The epithelial covering of the mucous membrane is remarkably developed and presents an abundant papillary structure.

The *glands of Duverney* resemble both in form and function the glands of Cowper in the male. They are situated on either side of the orifice of the vagina, beneath the sphincter muscle and the superficial perineal fascia. Fig. 245. They are from half an inch to an inch long, narrow and flattened, and their excretory duct opens in front of the carunculæ myrtiformes.

The *sphincter vaginæ* muscle has been already described. It embraces the orifice of the vagina like a broad ring and covers the plexus retiformis.

THE UTERUS.

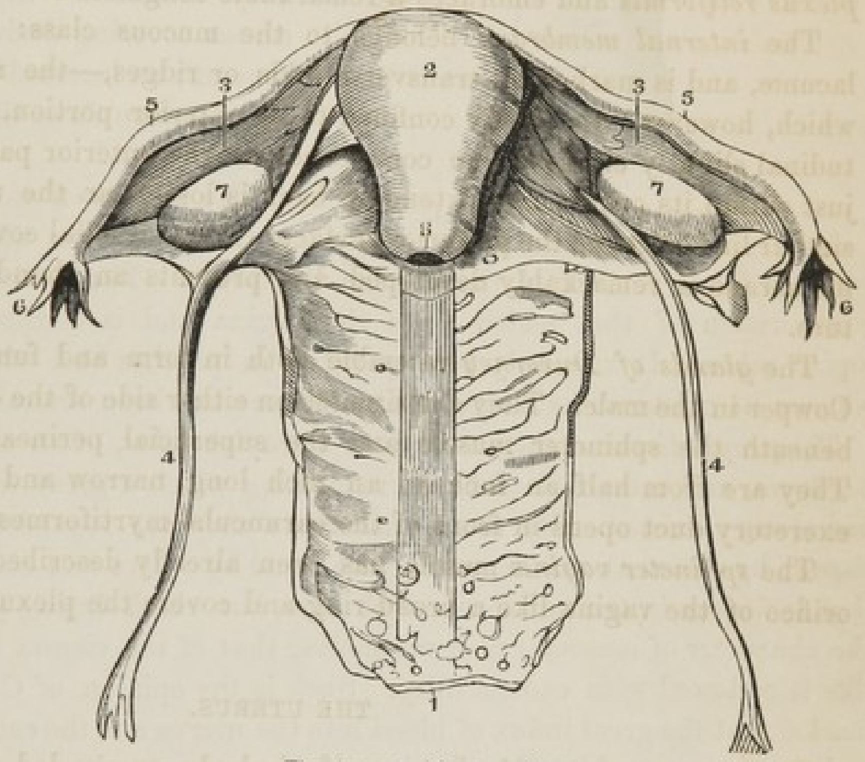
The *uterus* or *matrix* is a pyriform body, suspended in the pelvic region between the bladder before and rectum behind. It varies greatly in size; its average length is about two and a half inches, its breadth across the upper and widest part an inch and a half, and its thickness an inch. It is divided into the *fundus*, or that part above the Fallopian tubes; the *cervix* or narrowed portion below; the body, which is intermediate between the fundus and cervix, and the *os tincæ* or opening into the vagina. It is convex behind and flattened in front; with its base directed upward and forward and its neck downward and backward.

The anterior surface of the uterus has a peritoneal covering over its upper half, which membrane is reflected from it to the bladder, constituting the anterior ligament. The posterior surface is entirely invested by the peritoneum, which in this instance is reflected upon the rectum so as to form a pouch between, and is called the posterior ligament. On the sides of the uterus the anterior and posterior laminæ of peritoneum meet in a longitudinal median line, and are then reflected from it to form the *broad ligaments:* these ligaments are extended transversely to the parietes of the lesser pelvis on each side, and thus

form a partial septum in its cavity, and transmit between their laminæ the blood-vessels and nerves, the uterus and ovaria.

The *round ligaments* are given off on each side from the body of the uterus directly beneath the Fallopian tubes, whence they pass upwards and outward until they reach the internal abdominal ring; they then run through the abdominal canal, come out at the external ring, and are inserted into and lost upon the mons veneris. They are strong, fibrous vascular cords, embraced between the folds of the broad ligaments; and they are accompanied in the abdominal canal by a process of peritoneum which sometimes extends to the exit of the ligament at the external ring.

Fig 245.



The uterus and its appendages.

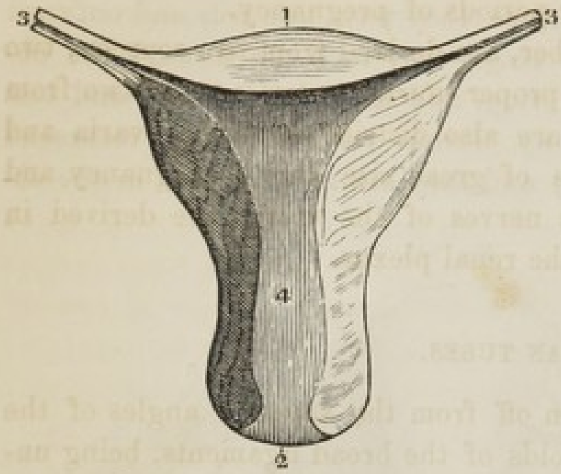
Fig. 245 represents the vagina laid open by a longitudinal section, with the uterus and its appendages *in situ*. 1, orifice of the vagina, with the carunculæ myrtiformes; 2, body of the uterus; 3, 3, broad ligaments; 4, 4, round ligaments; 5, 5, Fallopian tubes; 6, 6, their fimbriated termination; 7, 7, ovaria; 8, os tincæ.

The *cervix uteri* projects by a mammillated extremity into the vagina, and the two are joined at the base of this prominence. The cervix has a central perforation,—the *os tincæ*, of an oval shape and placed transversely. It is bounded in front by a prominence of the cervix called the anterior lip, and behind by a similarly formed but much smaller projection, the posterior lip.

The *cavity of the uterus* is triangular, with an orifice at each angle: one of these three orifices and much the largest, is continuous with the canal of the cervix and of course communicates directly with the vagina and is called the *internal orifice* of the uterus. It is smaller than the os tincæ, but the canal between those openings is somewhat dilated, flattened from front to back and marked by two longitudinal lines, one on the anterior, the other on the posterior surface. These are again crossed by transverse and erratic striæ, named from their branched appearance the *arbor vitæ*, among which are interspersed some small mucous glands and follicles, known as the *ovula Nabothi*. They are

not confined to the cervical canal, but are also found in the cavity of the body. At the angles in the upper part of that cavity are two small orifices, one on each side, opening into the Fallopian tubes.

Fig. 246.



Longitudinal section of the uterus.

Fig. 246. Longitudinal section of the uterus. 1, fundus uteri; 2, os tincæ; 3, 3, Fallopian tubes; 4, cavity of the uterus.

The uterus is composed of three very dissimilar tissues, an exterior serous covering derived from the peritoneum; an internal mucous membrane, and between these the proper structure of the organ.

The *peritoneal coat* has been already noticed, together with the manner in which it forms several of the uterine ligaments. The *mucous membrane* is a continuation of that which lines the vagina and is continued into the Fallopian tubes. It can only be separated in patches and with much difficulty; whence its existence as a separate membrane has been sometimes denied.

The *proper tissue* of the uterus is of a grayish color, of an almost cartilaginous hardness, and composed of fibres respecting which a great diversity of opinion has always existed. By some anatomists they are regarded as simple fibrous tissue; by others as muscular structure; and by others as a convertible substance that is fibrous in the unimpregnated state, but which during pregnancy acquires the character of muscular fibre resembling that of the viscera of organic life, and like it endowed with contractility. Such is the opinion of Cruveilhier, who remarks, that the great influx of blood into the uterus and the consequent distension and development of its fibres in the gravid state, reveal a structure which was before concealed by an atrophy consequent to inaction; and he adds that this view is confirmed by the microscopic observations of Roederer, the chemical experiments of Schwilgué, and also by the results furnished by comparative anatomy, which has shown circular and longitudinal muscular fibres in the uteri of some animals even in the unimpregnated state.*

The gravid uterus, however, presents two layers of fibres which have the structure and function of true muscle: the *external layer* is formed both of longitudinal and oblique fibres, the former being chiefly developed on the anterior and posterior surfaces and upon the fundus; the oblique fibres are most distinct at the sides, where they are continued upon the Fallopian tubes and the round ligaments. The *internal layer* consists of circular fibres, with some longitudinal fibres on their internal surface; but around the cervix this structure becomes annular, the fibres decussating at various angles. The muscular character of the uterine body in pregnancy, is strongly evidenced by its powerful contractions in the process of parturition.

* Anatomy, p. 466.

The internal substance of the uterus is thus composed of a mass of closely interwoven muscular or fibro-muscular fibres, together with a vast congeries of blood-vessels, which though small in the unimpregnated state, acquire a surprisingly augmented size during the later periods of pregnancy.

The *arteries* of the uterus, four in number, are derived from two sources; two from the hypogastric trunk, forming the proper *uterine arteries;* and two from the ovarian arteries, of which branches are also distributed to the ovaria and Fallopian tubes. The uterine veins are of great size during pregnancy and are then called the *uterine sinuses.* The nerves of the uterus are derived in part from the hypogastric, in part from the renal plexus.

THE FALLOPIAN TUBES.

These trumpet-shaped canals are given off from the superior angles of the uterus. They are embraced within the folds of the broad ligaments, being undulated in their course and variable in their diameter. They are four or five inches in length and extend almost to the sides of the pelvis; their diameter at the uterine orifice will only admit a bristle, but the canal at its external or free termination is as large as a quill. This outer end is broken into a triple series of fringe-like irregular processes of unequal length, constituting the *fimbriated* portion, or *corpus fimbriatum,* in the centre of which is seen the orifice of the tube called the *ostium abdominale.* One of the processes is attached to the proximate part of the corresponding ovary, by which means these structures are retained in their relative position.

The tube is in itself a strong fibrous cord resembling the tissue of the unimpregnated uterus, and it is invested by the peritoneum by being placed between the duplication of this membrane that forms the broad ligament. The internal coat is mucous, analogous to that which lines the uterus, and remarkable for presenting a gradual transition into the peritoneal coat, with which at its fimbriated orifice it is continuous; in other words, the mucous terminates in a serous membrane, and thus in the two openings of the Fallopian tubes exist the only two normal perforations of the otherwise perfect sac of the peritoneum.

The use of the Fallopian tube is that of an *oviduct.* It receives the ovum from the ovary and transmits it to the uterus and also provides it with a double envelope,—an internal one of a gelatinous or albuminous nature, and an external one, the *chorion,* which is fibrous and appears to be produced by the exudation of fibrine from the lining membrane of the tube.

THE OVARIES.

These bodies, one on each side, are placed within a duplicature of the broad ligament and behind the Fallopian tubes. They are of a flattened-oval form, reddish-white color and unequal fissured surface. They are retained in their position partly by the broad ligament and partly by an *ovarian ligament,* a rounded cord that connects them with the upper angles of the uterus, below the

Fallopian tube. This ligament is composed of mixed fibrous and muscular structure. The ovaries are about an inch in length, and their distance from the uterus is about an inch and a half. They have an external investment derived from the peritoneum; within which and closely adherent to it is the proper fibrous capsule, strongly resembling the tunica albuginea of the male, and like the latter, sending prolongations into the gland that divide it into irregular compartments resembling a network of areolar tissue. Within and lining this fibrous capsule is a vascular membrane analogous to the tunica vasculosa in man. The fibrous and vascular tissues are intimately blended into a spongy mass called *stroma*, in the midst of which are contained the *Graafian vesicles*, of which bodies ten or fifteen exist in a mature state in each ovary, besides a vast number that are imperfectly developed and never reach the perfect state.

The *Graafian vesicle* or *ovisac*, consists of two layers of which the outer one is a mere vascular thickening of the surrounding ovarian stroma; while the internal one, which is the true ovisac, is transparent and has no obvious structure. Within it is placed the *ovum*, the latent germ of the future being, between which and the ovisac is a quantity of granular matter arranged in the following manner: a series of the granules surround the ovum in a discoidal form and assume the appearance of cells so united as to form a sort of membrane, which is called by Dr. Barry the *tunica granulosa*, by others the *proligerous disk*. The granules that line the ovisac within, are also collected into a membraniform structure, the *membrana granulosa*. These two parts are connected by four hand-like extensions of the same cellulo-membranous structure, which seem to suspend the ovum in its place and are called the *retinacula*. The space between the membranes which is not occupied by the retinacula, is filled with fluid in which few or no cells can be seen.*

Fig. 247.

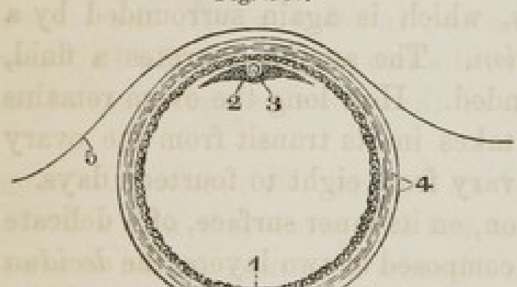


Diagram of the Graafian vesicle and ovum. After W. Jones.

Fig. 248.

Fig. 249.

Fig. 250.

Fig. 247. Diagram of a section of the unimpregnated Graafian vesicle and its contents, showing the situation of the ovum. 1, membrana granulosa; 2, proligerous disk; 3, ovum; 4, inner and outer layers of the wall of the Graafian vesicle; 5, indusium of the ovary, derived from the peritoneum: the stroma beneath it is condensed, in the natural state of parts, so as to form the tunica albuginea.

Fig. 248. The unimpregnated ovum surrounded by its proligerous disk, magnified about fifteen diameters. From Mr. Wharton Jones.

Fig. 249. Diagram, also after Mr. Wharton Jones, of a section of an unimpregnated ovum representing the thick external envelope, within which is the membrana granulosa, and, connected with the inner surface of the latter, the germinal vesicle.

Fig. 250 represents, within a square area, the unimpregnated human germinal vesicle magnified forty-five diameters. On one side of it is seen the germinal spot.

* Carpenter. Principles of Physiology, § 906.

The *corpus luteum* is a yellowish, spongy tissue, granular, friable and vascular, having a small central cavity lined by a delicate membrane. It is the cicatrix left after the escape of the ovum from the ovary, and consequently varies much in size according to the time that has elapsed since conception. At first it is large, bean-shaped and prominent, so as to occupy from a fourth to a half of the ovarium. But after parturition it diminishes in size, and in a few months a cicatrix alone remains and even this is finally effaced. Whence it happens that neither the corpora lutea, nor their remaining cicatrices, are certain indications of the number of children a woman may have borne.

Dr. C. D. Meigs has published an interesting memoir on the corpus luteum, in which he maintains that the apparent structure, form, color, odor, coagulability and refractive power of this body are similar to those of the yolk of the egg; a true *vitellary matter* "deposited outside of the inner concentric spherule or ovisac of the Graafian vesicle."*

Fig. 251

Corpus luteum. After Von Baer.

Fig. 251 is a corpus luteum taken from a female who destroyed herself by drowning, eight days after impregnation. 1, mucous tunic of the Graafian vesicle sprouting from the circumference towards the centre; 2, external tunic of the vesicle; 3, ovarian stroma; 4, ovarian membrane; 5, point at which the ovulum escaped from the Graafian follicle.†

Function of the ovario-uterine system.—The result of successful coition between the two sexes, is the injection of a certain portion of spermatic fluid into the vagina; and fecundation appears to consist in the direct communication of the male spermatozoa with the Graafian vesicle of the ovarium, through the fissure of the zona pellucida to the contained ovum, which ruptures and escapes from the ovisac. The corresponding Fallopian tube simultaneously embraces, by its fimbriated extremity, the ovarian surface, and receives the detached ovum into its canal, while the ovisac itself remains as the lining membrane of the corpus luteum. While the fecundated ovum is yet in the Fallopian tube, it acquires a gelatinous covering, the *amnion*, which is again surrounded by a membrane of fibrous texture called the *chorion*. The amnion secretes a fluid, the *liquor amnii*, in which the germ is suspended. How long the ovum remains in the oviduct, in other words what time it takes in its transit from the ovary to the uterus, is not certain, but appears to vary from eight to fourteen days.

The first action of the uterus is the secretion, on its inner surface, of a delicate cribriform membrane, the *decidua*, which is composed of two layers, the *decidua vera* that lines the uterus, and the *decidua reflexa* that covers the ovum.‡ Next follows the formation of the *placenta*, which results from the penetration of the

* Trans. of Amer. Philosophical Soc., 1847.

† Wagner. Physiology, p. 134.

‡ The annexed drawing, Fig. 252, represents the internal superficies of the uterus, with the decidua of Hunter in the progress of formation. 1, 1, 1, villi of the uterine mucous membrane, much enlarged. The matter which is to become the *membrana decidua*, is seen deposited between and upon the surface of the villi; 2, 3, uterine arteries extending into the decidua and there forming loops. See *Von Baer, in Wagner's Physiology*, p. 184.

Fig. 252.

villi of the chorion into the structure of the decidua vera. Its *fœtal portion* is derived from the umbilical vessels that diverge in every direction from the point at which they enter its substance; or, in other words, it is generated by the extension of the vascular tufts of the chorion, formed from the capillary terminations of the umbilical arteries and veins. The *maternal portion* of the placenta is formed by the enlargement of the decidual uterine vessels, and these assume the character of sinuses against which the fœtal tufts project so as to form out of it a sheath for themselves. The blood is conveyed into the maternal placenta by the uterine arteries, and is returned by the corresponding system of veins; but there is no direct vascular communication between the two placentæ.

THE MAMMARY GLANDS.

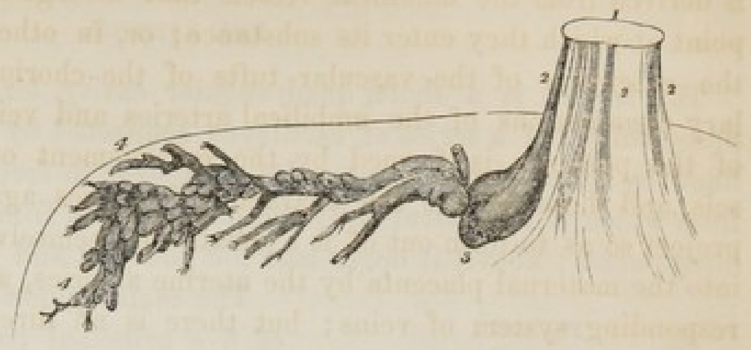
The mammary glands, always rudimentary in the male, are fully developed in the female at the period of puberty. They are situated on the upper part of the chest, over the pectoralis major muscle and between the third and seventh ribs. The form of the gland is hemispherical, and presents, on its anterior surface, a small elevation called the *mamilla* or nipple. This body is of a reddish-brown color, granulated on the surface and perforated at its apex by the orifices of the lactiferous glands. Around the base of the nipple is the *areola*, which in the virgin state is of a light red color, but becomes brown after childbirth and in the later periods of life. Its diameter at the age of puberty is about an inch, which size is doubled during lactation. In savages, and especially in the Negro, it is much larger; and in the celebrated *Hottentot Venus*, some years ago exhibited in Paris, the areola was four inches across. The areola, like the nipple, is replete with vascular sensitive papillæ; and both are also furnished with mucous follicles that secrete a viscid fluid.

Beneath the integument is a quantity of adipose matter, which also extends more or less into the substance of the gland and greatly enlarges its apparent structure. It is connected with the muscle behind and the skin before by means of a dense fibrous envelope that sends prolongations between the lobules, and largely assists to give this structure its tough and unyielding character. These prolongations have been called by Sir Astley Cooper *ligamenta suspensoria*, and their terminal ends are blended with the integuments.

The internal structure of the mammary gland appears to be arranged with great simplicity. The secretory portion consists of minute cells of which the size, when distended with milk, is not larger than a hole pricked in paper with a very fine pin, so as to be barely visible to the naked eye. They are collected into groups the size of a pin's head, and from them the milk tubes, *ductus lactiferi*, take their origin. They increase by frequent junctions and form five or six dilated portions of a conical form, and these again terminate in the straight ducts of the nipple. The orifices of the lactiferous tubes at the apex of the nipple are from fifteen to twenty in number and much contracted, so as barely to admit a bristle or a pin.

This structure is seen in Fig. 253. 1, apex of the nipple; 2, 2, 2, straight lactiferous ducts of the nipple; 3, sac-like dilatation of the ducts at the base of the nipple; 4, 4, origin of the ducts in the substance of the gland.

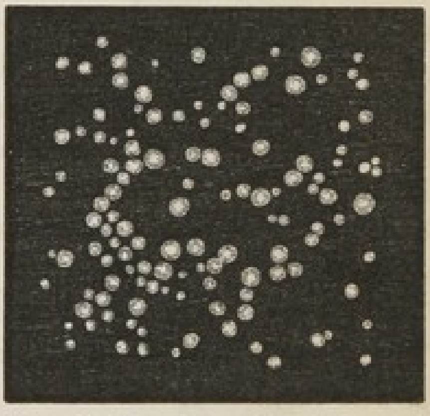
Fig 253.



Lactiferous duct of the mammary gland. From Sir A. Cooper.

The well-known function of the mammary gland is to secrete the milk; a thin fluid, of a bluish-white color in the human subject. When chemically examined, it is found to consist principally of water, casein, sugar and oil. These ingredients are in very different proportions at different times, and are blended with some extractive matter and various salts, and occasionally with free lactic acid. The casein is an albuminous substance; it differs, however, from albumen in not coagulating by heat, but undergoes this process by contact with certain animal membranes, whence the formation of cheese. This element exists much more sparingly in human milk than in that of the domestic mammiferous animals; but the former, on the other hand, contains a large proportion of oil and sugar. The milk that is secreted for the first few days after the birth of the infant, is called *colostrum*, is very different from the ordinary milk, and possesses active purgative properties, which, according to Donné, are owing to the presence of minute granular bodies that soon disappear altogether.

Fig. 254.



Milk-globules. After Donné.

Examined under the microscope, milk is seen to consist in large part of spherical bodies of very minute size; these are the oil globules, which appear to be surrounded by a thin pellicle so long as the milk remains at rest. Fig. 254.

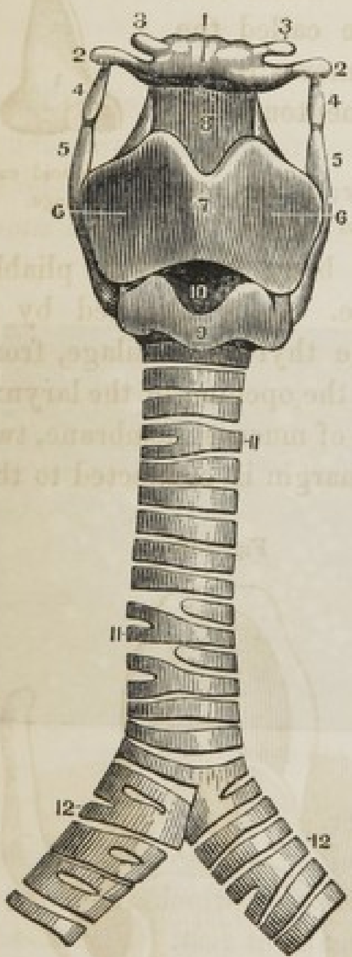
THE ORGANS OF RESPIRATION.

The respiratory organs embrace the larynx, trachea, bronchi, lungs and pleura; and with these parts it is usual to describe the thymus and thyroid glands. A part of this apparatus is contained within the thorax; another part is exterior to it; and the whole is acted upon by a complicated series of muscles, some of which have been already described in the chapter on Myology, and some others remain to be noticed.

THE LARYNX.

The larynx is a short, quadrangular cavity, larger above than below, composed chiefly of a series of cartilages connected by muscles and ligaments, and lined by mucous membrane. Its position is in front of the vertebral column, from which it is separated by the pharynx; in front it is directly beneath the integuments; above, it opens into the pharynx and below into the trachea.

Fig. 255.



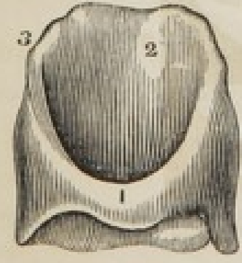
Larynx and trachea. After Weber.

The cartilaginous basis of the larynx consists of five principal parts called the thyroid, the cricoid, the two arytenoid and the epiglottis cartilages, together with some subordinate structures of the same kind.

Fig. 255. Larynx and trachea viewed in front. 1, os hyoides; 2, 2, its cornua; 3, 3, its appendices; 4, 4, lateral thyro-hyoid ligaments; 5, 5, superior cornua of the thyroid cartilage; 6, 6, body of that cartilage; 7, pomum Adami; 8, middle thyro-hyoid membrane or ligament; 9, cricoid cartilage; 10, middle crico-thyroid membrane; 11, 11, trachea; 12, bronchi.

The *thyroid cartilage* is of a quadrilateral form, and composed of two continuous halves that meet at an angle in front. The upper anterior edge is notched, and directly beneath this notch is an angular prominence that projects in the upper part of the neck, and known as the *pomum Adami.* The flattened sides of the thyroid cartilage are its *alæ* or wings, extending obliquely backwards and terminating above in two processes, the *superior cornua*, and below in two shorter prolongations, the *inferior cornua.* The side of each ala presents an oblique line with a tubercle at each end for the insertion of the sterno-thyroid muscle, and for the origin of the thyro-hyoid and inferior constrictor muscles of the pharynx. Fig. 255, 6, 258, 1.

Fig. 256.



Cricoid cartilage.

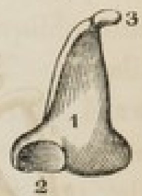
Fig. 256. Cricoid cartilage seen in front. 1, anterior face; 2, internal face of the posterior parietes; 3, facets for articulation with the arytenoid cartilages.

The *cricoid cartilage* is a ring, narrow in front, where it is barely a quarter of an inch wide, and broad behind, where its vertical width is nearly an inch. This latter surface is marked by a longitudinal prominence for the attachment of the esophagus, and the upper margin of the cartilage is irregularly horizontal with two articulating

surfaces for the arytenoids. Its points of junction with the thyroid cartilage are marked by two prominent lateral tubercles, and from each side arises the crico-thyroid muscle. Figs. 255, 9, 256 and 258, 6.

The *arytenoid cartilages* are placed on the posterior summit of the cricoid, one on each side. They are triangular in shape and somewhat elongated. The anterior face is uneven and slightly convex, and divided by a slight transverse ridge into two nearly equal surfaces. The posterior face is concave and gives attachment to the arytenoideus muscle; the anterior face is covered by the common mucous membranes and gives attachment to the *chordæ vocales*, or vocal ligaments. These cartilages are each surmounted by a much smaller one called the *corniculum laryngis*, or tuberculum Santorini, which moves freely on the arytenoid to which it is attached by ligamentous filaments. Fig. 257.

Fig. 257.

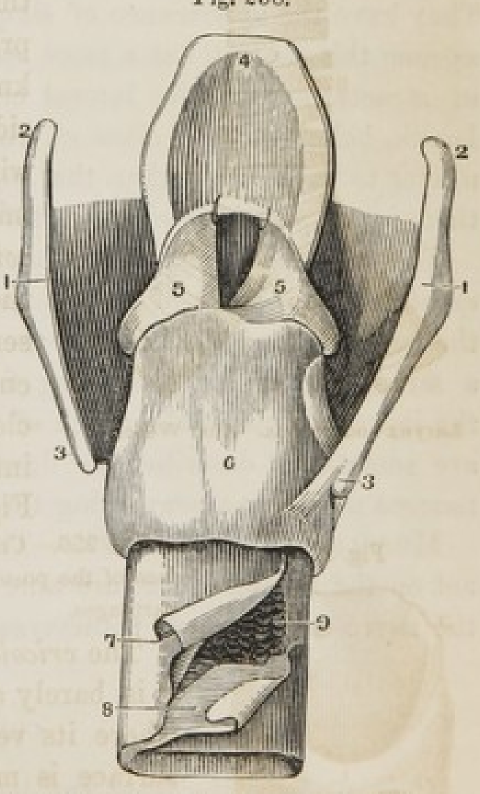


Arytenoid cartilage.

Fig. 257. One of the arytenoid cartilages. 1, its triangular body; 2, base, with its articular face for the cricoid cartilage; 3, apex, with the corniculum laryngis.

The *epiglottis* cartilage is an elliptical, flattened body, of a soft, pliable and elastic nature and fibro-cartilaginous structure. It is attached by a pedicle at its lower end to the entering angle of the thyroid cartilage, from which point it stands in a vertical position in front of the opening of the larynx. It is attached to the base of the tongue by three folds of mucous membrane, two of which are lateral, the third central. Its lateral margin is connected to the superior thyro-arytenoid ligament by some elastic fibres covered by mucous membrane. The whole surface of the epiglottis is marked by foramina that indicate the position of mucous follicles. In the act of deglutition this cartilage falls backward so as to form a complete valvular closure to the opening of the larynx, thus preventing the ingress of food and drink into that cavity.

Fig. 258.



Posterior view of the larynx. After Weber.

Fig. 258. Posterior view of the larynx. 1, 1, thyroid cartilage; 2, 2, its superior cornua; 3, 3, inferior cornua; 4, epiglottis; 5, 5, arytenoid cartilages; 6, cricoid cartilage; 7, trachea, with its posterior fibrous coat dissected up; 8, its transverse muscular coat; 9, mucous membrane with its glandulæ.

LIGAMENTS.—The *middle thyro-hyoid ligament* extends from the upper edge of the thyroid cartilage to the margin of the base and cornua of the os hyoides, so as to cover the entire intervening space. Fig. 255, 8. It is a thin but strong fibrous expansion, perforated by the superior laryngeal artery and nerve. This ligament is bounded on each side by a rounded fibrous cord that extends from the end of the superior cornu of the thyroid cartilage, to

the terminus of the os hyoides on each side. It generally embraces in its middle portion a cartilaginous body, named from its size and shape *cartilago-triticea*, and the cords themselves are the *lateral thyro-hyoid ligaments.* Fig. 255, 4.

The *middle crico-thyroid ligament* is a triangular plane of fibrous tissue, attached by its base to the cricoid cartilage and by the apex to the lower edge of the thyroid, and can be traced continuously with the lower margin of the inferior thyro-arytenoid ligament. Being inelastic, it limits the separation of these two cartilages. Fig. 255, 10. The *lateral crico-thyroid ligaments* are placed to the outside of the former one, and are composed of fibres that run obliquely upward and outward from the cricoid to the thyroid cartilages. They assist the middle thyro-hyoid ligament, and also limit the backward and forward motion of the parts to which they are attached. The articulation between the inferior cornu of the thyroid cartilage and the side of the cricoid, is furnished with the usual apparatus of capsular ligament and synovial membrane.

The *thyro-arytenoid* or vocal ligaments, are four in number, two on each side. The superior cords pass between the centre of the anterior face of the arytenoid cartilage and the inner angle of the thyroid. They are composed of loosely blended fibres of fibrous elastic tissue, continuous above with the aryteno-epiglottidean ligament. They are much more distant from each other than the inferior chords.

The inferior *thyro-arytenoid ligaments* are the true *chordæ vocales,* and are extended from the base of the arytenoid cartilage to the angle of the thyroid. They have the appearance of simple flattened cords and in ordinary dissections assume this shape; but a more careful inspection shows them to be continuous in structure with the lateral crico-thyroid ligaments, and all, according to Lauth, belong to the class of elastic fibrous tissues. They are placed much nearer to each other than the superior ligaments are, and the fissure between them is the *glottis* or *rima glottidis.*

The ligaments of the epiglottis are two in number: one of them, the *hyo-epiglottid,* is a band of elastic tissue that extends between the anterior face of the cartilage and the body of the hyoid bone. The *thyro-epiglottid ligament* is a strong fasciculus, extending from the lower extremity of the epiglottis to the inner margin of the notch of the thyroid cartilage. The *fræna epiglottidis* are sometimes described as ligaments, but they are mere duplicatures of the mucous membrane connecting the epiglottis with the base of the tongue.

MUSCLES OF THE LARYNX.—The intrinsic laryngeal muscles, or those which act on the larynx alone, are nine in number, of which all are in pairs excepting the thyro-arytenoideus transversus.

CRICO-THYROIDEUS.

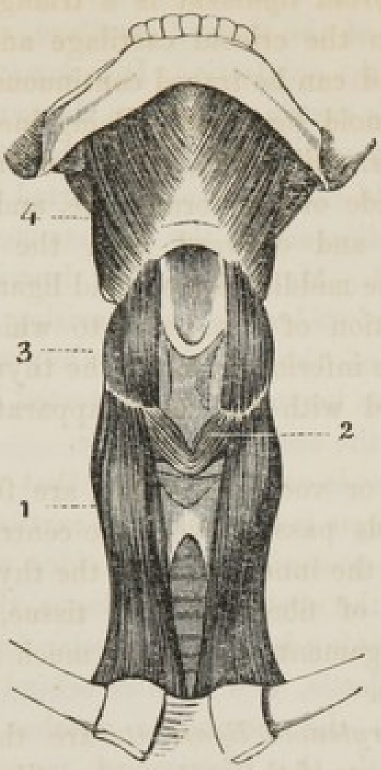
Origin—from the front and lateral surfaces of the cricoid cartilage, the fibres running obliquely upwards and outwards.

Insertion—by two portions, one into the under and lateral part of the thyroid cartilage, the other into its inferior cornu.

Action—to draw the thyroid and cricoid cartilages towards each other. Fig. 259, 2.

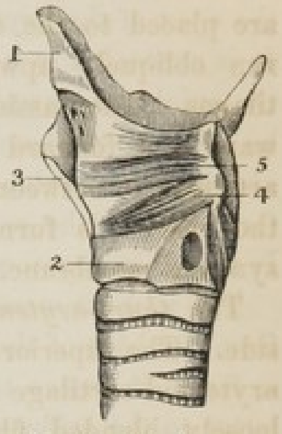
Fig. 259.* Muscles of the larynx and front of the neck. 1, sterno-thyroideus; 2, crico-thyroideus; 3, thyro-hyoideus; 4, mylo-hyoideus.

Fig. 259.



Muscles of the larynx, &c.

Fig. 260.



Muscles of the larynx.

The *crico-arytenoideus lateralis* arises from the upper part of the side of the cricoid cartilage, and runs obliquely upwards and backwards to the base of the arytenoid cartilage, into which it is inserted. Its action is to draw the arytenoids outward, and thereby to expand the rima glottidis. Fig. 260, 4.

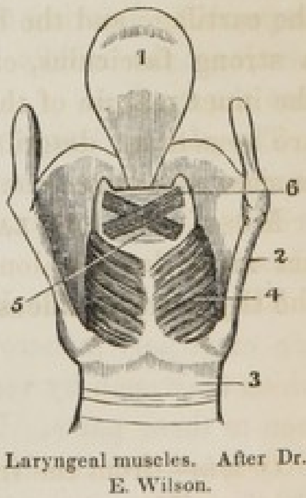
Fig. 260. Muscles and cartilages of the larynx. 1, epiglottis; 2, cricoid cartilage; 3, thyroid cartilage; 4, crico-arytenoideus lateralis; 5, thyro-arytenoideus.

The *crico-arytenoideus posticus* arises from the concave surface on the back of the cricoid cartilage, and running obliquely upwards and outwards, is inserted into the base of the arytenoid cartilage at its outer margin. Its action is to draw the arytenoids backward, and consequently to make the vocal ligaments tense. Fig. 261, 4.

The *thyro-arytenoideus* arises from the internal angle of the thyroid cartilage, near the vocal ligament, and running backwards parallel with it, is inserted into the anterior margin of the arytenoid cartilage. Fig. 260, 5.

Fig. 261. Laryngeal muscles, &c. 1, epiglottis; 2, thyroid cartilage; 3, cricoid cartilage; 4, crico-arytenoideus posticus; 5, arytenoideus transversus; 6, arytenoideus obliquus.

Fig. 261.



Laryngeal muscles. After Dr. E. Wilson.

The *arytenoideus obliquus* extends from the base of one arytenoid cartilage to be inserted into the apex of the other. It is very small and is sometimes deficient. Fig. 261, 6. The *arytenoideus transversus* is often regarded as a part of the last described muscle. It is stretched from side to side between the arytenoid

* This cut was inadvertently omitted from its proper place, p. 193.

cartilages, so as to fill up their posterior concave surface, and acts by approximating the arytenoid cartilages and thus constricting the rima glottidis. Fig. 261, 5.

The *thyro-epiglottideus* is a delicate and often obscure fasciculus that arises from the internal angle of the thyroid cartilage, and is inserted into the lateral edge and lower part of the epiglottis. It is sometimes double. Its action is to draw down the epiglottis cartilage, whence the synonym of *depressor glottidis.*

The *aryteno-epiglottideus* is a small fasciculus of scattered fibres running from the apex of the arytenoid cartilage to be inserted into the side of the epiglottis. It is concealed in a duplicature of the mucous membrane, and acts by drawing the epiglottis downward. Mr. Hilton has described another fasciculus which he calls the *aryteno-epiglottideus inferior*, arising from the arytenoid cartilage above the attachment of the chorda vocales, whence it runs upward and forward over the sacculus laryngis to be inserted into the side of the epiglottis. It acts in common with the associated muscle.

The *mucous membrane* is continuous with that of the mouth, being reflected from the base of the tongue to the epiglottis cartilage: having covered this body in front, it passes to its posterior face and sides and is then reflected from the latter to the orifices of the arytenoid cartilages, thus forming the upper orifice of the larynx. This opening is of a triangular form, broader in front where it is bounded by the epiglottis, and smaller behind where it ends at the arytenoideus muscle. When the membrane reaches the arytenoid cartilages, it becomes continuous with the pharyngeal mucous membrane covering the posterior face of the larynx. From these parts the membrane descends into the laryngeal cavity, and dipping between the vocal ligaments on each side, forms two long, narrow *laryngeal pouches*, the ventricles of Morgagni. Each cavity presents an elliptical opening into the larynx, and though of variable dimensions in different persons, has an average length of about three-quarters of an inch. At the anterior part of each ventricle is a smaller cavity, or rather a depression of the lining membrane, which has from time to time been announced as a new discovery and described by Mr. Hilton as the *sacculus laryngis.** Leaving the inferior vocal cords, the membrane covers the cricoid cartilage, the middle lateral crico-thyroid ligaments, and is thence prolonged into the trachea.

The *glottis*, though variously defined by different anatomists, may be regarded as the space that intervenes between the lower vocal ligaments and the upper orifice of the larynx, and the fissure between these ligaments is the *rima glottidis.*

The *glands* of the larynx are of two kinds. One set, the *epiglottid glands*, are extremely numerous in the epiglottis cartilage on the posterior face of which they open by very small but visible ducts. They secrete the mucus common to these parts. The same name is sometimes but erroneously given to a fatty mass that lies between the thyro-hyoid ligament and the apex of the epiglottis. The *arytenoid glands* are situated in the mucous fold that is reflected

* Cruveilhier. Anatomy, p. 431.

from the epiglottis to the arytenoid. There are many of them, and although usually described as elongated glands, some anatomists suppose them not to be glandular but cartilaginous structures, whence their synonym of *cuneiform cartilages.*

Blood-vessels and nerves.—The laryngeal arteries are branches of the superior and inferior thyroids. The nerves are the superior laryngeal, which is the sensory nerve given off from the pneumogastric to supply the mucous membrane,—and the recurrent laryngeal, also a branch of the pneumogastric, which is distributed to the muscles and is the nerve of motion to these parts.

Function.—The larynx is the organ of *voice*, which with all its modifications results from the action of the laryngeal muscles on the inferior thyro-arytenoid ligaments; for while these remain the power of voice continues, even when the surrounding parts are divided and in a measure destroyed. When the front of the thyroid cartilage is drawn down they become tense; and on the other hand, when the cartilage is elevated the ligaments are relaxed, and from this action the *pitch* of sound is regulated. The rotary motion of the arytenoid cartilages also causes the approximation of these ligaments and is necessary to the perfection of tone. Again, when the vocal chords are at rest the rima glottidis resumes the angular form. It is obvious, therefore, that there are two sets of movements concerned in vocalization,—the adjustment of the relative position of the vocal chord and the regulation of tension. By referring to the description of the muscles given above, it will be seen that the arytenoid cartilages are caused to diverge by the action of the posterior crico-arytenoid muscles; for they draw the outer corners of those cartilages asunder and open the rima glottidis. The tension of the ligaments is caused and modified by the opposition or separation, as already remarked, of the thyroid and cricoid cartilages; for they are drawn tense by the crico-thyroid muscles and by the extrinsic sterno-thyroids, and they relax by means of the thyro-arytenoid and thyro-hyoid muscles. The rima glottidis can be closed at will during either inspiration or expiration; and both coughing and sneezing consist in a spasmodic action of this kind.*

Besides its agency in the production of voice, the larynx is the only medium of communication between the lungs and the external air. This function is of a strictly passive nature, for, in the healthy condition of parts, respiration is perfect in proportion to the repose and consequent relaxation of the whole laryngeal apparatus.

THE TRACHEA.

The trachea is a vertical tube placed between the larynx above and the lungs below. It has the esophagus and vertebral column behind, while in front it may be distinctly felt and moved beneath the integuments. In its unextended state it is between four and five inches in length and about an inch in diameter; being,

* Carpenter. Elements of Physiology, § 975.

like the larynx, more strongly developed in the male than in the female. After entering the cavity of the thorax it divides into two branches called *bronchi*, opposite the third dorsal vertebra and behind the arch of the aorta. Of these bronchi the right is the larger and diverges from the trachea nearly at a right angle: the left preserves a more oblique course, and each of these tubes soon disappears in its respective lung. The right bronchus is about an inch long; the left nearly twice that length.

The structure of the trachea is made up of cartilage, fibrous tissue, muscle and mucous membrane. The cartilaginous part is arranged in flattened rings, which, however, are only segments of circles, being deficient in that third of the tube which is next the spine. These rings are placed transversely; they are about two lines wide, half a line in thickness and an inch and a half in length. The lower cartilages are occasionally bifid, having a fissure on one or both sides; an arrangement common also to the bronchial portion of the tube, which for the most part has eleven or twelve rings on its left limb and but eight on the right. As they approach the lung they become more and more irregular, until they are finally blended with the pulmonary cartilages.

The fibrous structure of the trachea belongs to the yellow elastic tissue. It commences at the cricoid cartilage, and not only covers the rings in front, but forms a distinct sheath for each, which sheath is much thicker on the external face of the rings and terminates with these behind. Its elasticity is so great that it readily contracts the trachea to its natural length after it has been subjected to extension; and it is remarked by Meckel that it resembles the fibrous tissue of arteries in being abundantly supplied with blood-vessels.

The posterior third of the trachea is very differently constructed from the annular portion, for in place of cartilage, it has a basis of strong elastic fibrous tissue arranged in longitudinal bands. These bands are not equal and continuous, but present occasional interstices of an oblong form that adhere firmly to the mucous membrane within and to the muscular structure without.

The *muscular structure* of the trachea is about half a line in thickness and exists only in its posterior third. It is arranged in a single layer of which the fibres run transversely, being attached to the ends of the cartilaginous rings and to the connecting fibrous tissue.

The trachea is lined throughout by a continuation of the mucous membrane of the air-passages. Its posterior surface is replete with muciparous tracheal glands, placed behind the muscular coat and opening between its fibres by short excretory ducts. They are numerous in the elastic fibrous tissue that connects the cartilaginous rings, being for the most part minute ovoidal bodies, yet sometimes attaining the size of a small bean.

The *function* of the trachea is that of a passive tube for the ingress and egress of air to and from the lungs. It also performs an important part in expelling its own and the pulmonary secretions both in health and disease; and a material aid is derived from its muscular coat, which by contracting, diminishes the calibre of the trachea and facilitates the expulsory action.

THE LUNGS.

The two lungs, *pulmones*, are situated within the chest and fill nearly all its cavity excepting that occupied by the heart. They are in the form of a double but very irregular cone, of which the apices are above, the basal portion below. They correspond, therefore, to the general configuration of the chest and are developed in proportion with it. Thus enclosed they are bounded immediately in front by the sternum; directly behind by the vertebral column; while the ribs and intercostal muscles constitute their intermediate protection excepting below, where the lungs rest upon the diaphragm. The apices of the lungs extend a little above the first rib, and the angular margin of the base terminates only at the inferior edge of the thorax in front and behind, as formed by the last ribs, so that their average vertical length may be assumed at about sixteen inches. Externally the lungs are convex in accordance with the form of the thoracic cavity; the apex is also rounded, but their internal surface is concave for the reception and accommodation of the heart, and the basal aspect is of the same form, owing to the upward pressure of the diaphragm.

The posterior margin of each lung is excavated the greatest part of its length, whence is formed an intermediate sulcus, the upper half of which receives the bronchiæ, blood-vessels and nerves, while its inferior part serves for the attachment of the pulmonary ligaments. Fig. 264.

The right lung is divided into three lobes by two grooves extending obliquely from above downwards, and from behind forward. The upper of these grooves passes almost through the body of the lung, but the lower fissure is much smaller. The left lung is divided into two lobes only by a single deep fissure, and it further differs from the lung of the opposite side in having an excavation in its substance in which the lower part of the heart is lodged. Fig. 262.

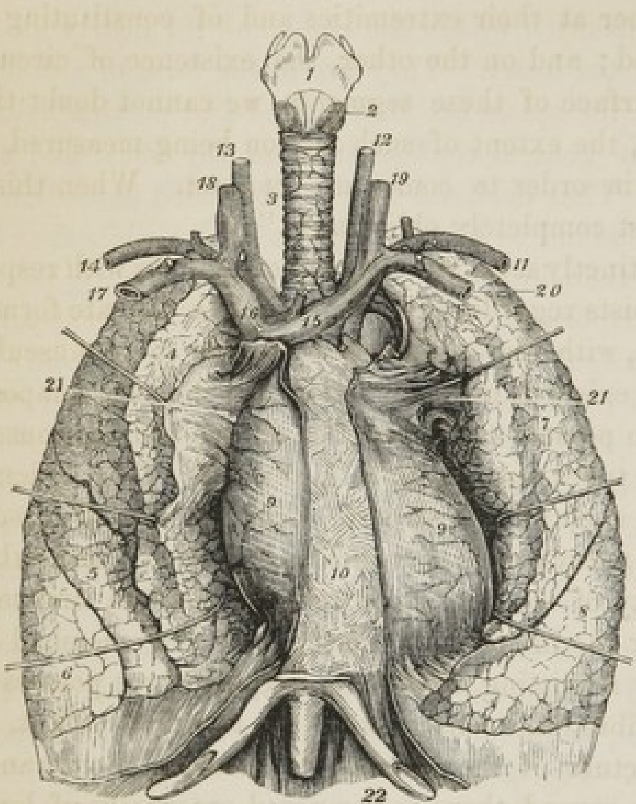
The color of the lungs varies with age. In infancy they are of a pinkish hue; in adult life grayish with black spots; in advanced years they become much darker, and all these changes are compatible with a perfectly healthy condition.

The weight of a healthy lung is dependent on the greater or less quantity of air it contains. In the fœtus that has not breathed the lung is solid and sinks in water; but after respiration has once been established, it invariably swims on the surface excepting when infiltrated with serum, hepatized, or otherwise altered by morbid conditions of its tissues.

Each lung is suspended and kept in its relative position by several *pulmonary ligaments*, hereafter to be described, and by its *root*, which is composed of the pulmonary artery, the pulmonary veins and nerves and the bronchial tubes: all these, before entering the lung, are embraced in a common fasciculus by a reflection of the pleura, which thus binds them together and at the same time confines them to the parietes of the thorax so as to constitute the proper suspensory apparatus of the pulmonary organs. To see this arrangement distinctly the lungs should be separated with the hands, when the roots, formed in the manner

described, will be observed to face each other in the concave surface of each organ.

Fig. 262.



Anterior view of the lungs. From Bourgery.

Fig. 262. The larynx, trachea and lungs, with the heart enclosed in the pericardium, as seen in front. 1, thyroid cartilage; 2, crico-thyroid muscle; 3, trachea; 4, 5, 6, upper, middle and lower lobes of the right lung; 7, 8, upper and lower lobes of the left lung; 9, 9, pericardium investing the heart; 10, mediastinum; 11, left subclavian artery; 12, left primitive carotid; 13, right primitive carotid; 14, left subclavian artery; 15, left vena innominata; 16, right vena innominatum; 17, right subclavian vein; 18, right internal jugular; 19, left internal jugular; 20, left subclavian vein; 21, 21, root of the lungs; 22, ligamentum pulmonis.

THE BRONCHIA.—Where the trachea ends the bronchi begin; and these, as we have seen, are soon buried in the substance of the lung, the right bronchus entering the upper part of the corresponding lung,—the left bronchus passing beneath the arch of the aorta and penetrating the lung near the middle of its root: here the air-tubes assume a modified arrangement of their component parts, and from the point of perforation are called *bronchia*. Each one divides into two equal branches, and this division is repeated until each ultimate ramification terminates in its proper air-cell. In this course the cartilaginous part of the tube is divided, not in rings as in the trachea, but into curved and angular segments of unequal size which embrace the whole tube and give it a cylindrical form. These cartilages are connected together by a continuation of the elastic fibrous tissue of the trachea; and they continue to diminish in size, yet retain their cartilaginous character, though reduced to mere points in the interior of the lungs.

"The mucous membrane is prolonged to the very last ramifications, where it becomes extremely thin. The longitudinal elastic fasciculi, which were limited to the membranous portion of the bronchi, are expanded over the entire surface of the bronchial tubes beyond their first subdivision. The *muscular fibres*, which are confined to the membranous portion in the trachea and bronchi, become circular on the inner side of the bronchial ramifications and form an

uninterrupted but very thin layer precisely resembling the circular fibres of the intestinal canal. When we consider, on the one hand, the arrangement of the cartilaginous segments, which appear, as it were, shaped expressly for the purpose of fitting between each other at their extremities and of constituting an apparatus capable of being moved; and on the other, the existence of circular contractile fibres on the inner surface of these segments, we cannot doubt that they are moved upon each other, the extent of such motion being measured by the space they have to traverse in order to come into contact. When this is effected the canals must be almost completely obliterated."*

These circular fibres may be distinctly seen, and the only question is with respect to their real nature; some anatomists regarding them merely as a delicate form of elastic fibrous tissue, while others, with Cruveilhier, believe them to be muscular. A sort of compromise of opinion exists in the supposition that they are composed of fibrous tissue "which seems to possess the properties of non-striated muscle, and by which the diameter of the tubes appears to be governed." The difficulty perhaps consists in conceding to such minute structures the function of muscle; but microscopic anatomy gives us many proofs that such an objection is untenable; while the remarkable contractility of the bronchial tubes in asthma and some allied affections, as well as under the influence of mechanical and chemical stimulus, can only be explained by admitting that their circular fibres possess all the characteristics of muscular fibre, and consequently are identical with it.

To repeat, therefore, the structure of the ultimate or so called membranous ramifications of the bronchia, we regard them as composed externally of longitudinal filaments of elastic fibrous tissue, within which is placed a continuous series of circular muscular fibres; and the tube is lined by the common mucous membrane of the air-passages.

This membrane retains its characteristic appearance, though with some modifications, throughout the bronchial tubes. In the bronchi it is thick and firm, and studded, as in the trachea, with an infinitude of crypts or orifices of mucous follicles. As it descends into the smaller ramifications, it becomes paler and thinner, until in the membranous tubes it is smooth, diaphanous and of an extreme tenuity. The longitudinal folds mark the mucous membrane through the cartilaginous bronchia, but they become obscure and finally disappear in the ultimate ramifications, where also the mucous follicles can only be detected by the aid of the microscope.

THE AIR-CELLS.—These cells are the terminal dilated portions of the ultimate bronchial tubes. Each one may be compared, on a very reduced scale, to a pin's head with its shaft. The air-cells, however, are not round, but irregular both in size and form, varying from the $\frac{1}{200}$th to the $\frac{1}{70}$th of an inch in diameter. The multitude of these cells and the great space they must afford by their collective internal surface, may be in some measure conceived of from the calculation of Rochoux, that the number of air-cells grouped around each terminal bronchus is little less than 18,000, and that the total number in the lungs amounts

* Cruveilhier. Anatomy, p. 420.

to six hundred millions. These cavities communicate freely with their respective air-tubes, and to a certain extent with each other: but the extent of this communication has been a subject of much diversity of opinion, the prevalent idea, however, being this—that each cell communicates exclusively with its respective bronchial tube. Without entering into this discussion it may be sufficient to observe, that the injected and corroded preparations of Dr. Horner, which I have carefully examined, are satisfactory evidence of the correctness of the views of this distinguished anatomist, which he himself observes were also those of Helvetius, Duverney and several others of the older anatomists, viz.: that all the cells of a lobule communicate freely with each other, but that there is no communication between the cells of different lobules: and he compares each lobule to a sponge with a pipe attached to it, which would represent the associated bronchial tube.* Each lobule is therefore a *miniature lung* which performs its functions independently of all the others. Fig. 263.

Fig. 263.

Terminal vesicles of the human lung, attached to a bronchial tube. After Wagner.

Those cells which are in immediate proximity to the tube open into it by distinct circular openings; while other cells communicate with it by opening into these and into each other.

Fig. 263 represents the terminal vesicles of the lung, hanging to a branch of the bronchia as berries hang to their stalk.

We have seen that these tubes are lined by mucous membrane; and it has been generally taught that the air-cells are also covered within by a continuation of the same tissue. Mr. Rainey, however, seems to have proved that such is not the fact, and that the cells, on the contrary, are lined by a very thin fibrous membrane; and he further observes that this arrangement agrees with the phenomena attendant on acute inflammation of these structures. For example, inflammation of the bronchial mucous membrane is attended by symptoms which characterize inflammation of other mucous membranes; while inflammation of the membranes lining the air-cells—pneumonia—is accompanied by a deposition of fibrine as in inflamed conditions of the common fibro-cellular tissue.†

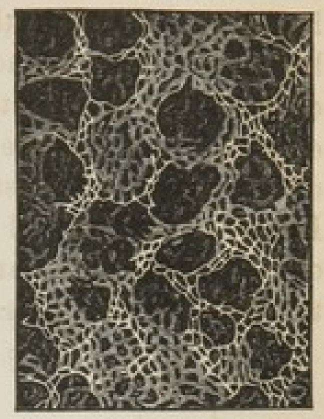
Arteries.—These are of two classes; one called *pulmonary*, for conveying the blood to the air-cells for the purpose of arterial renovation; and another set called *bronchial*, which are devoted to the nourishment of the lungs. The *pulmonary artery*, arising from the right ventricle of the heart, divides and subdivides in the manner heretofore described until its ultimate ramifications assume the capillary form in the substance of the lungs. These capillaries completely surround and line the air-cells with a minute and intricate plexus of vessels, so arranged that it forms the parietes of contiguous cells and is thus exposed on both sides to the contact of the air—a disposition that greatly favors the aëration of the contained blood. Fig. 264. This pro-

* Anatomy and Histology, ii. p. 171.

† Medico-Chirurg. Trans., vol. 10, p. 585, 1845.

cess performed, the vital fluids pass into the capillary veins and thence into the two pulmonary veins on each side to be poured by them into the left auricle.

Fig. 264.



Arrangement of the capillary vessels in the air cells of the lungs. From Dr. Carpenter.

The *bronchial vessels* have also been noticed in their appropriate place. The arteries of this class penetrate to every part of the lung and anastomose with the ramifications of the pulmonary artery; and in like manner the bronchial veins inosculate with those of the pulmonary set.

Lymphatics.—These are very numerous and terminate in the tracheal and bronchial glands.

The *nerves* of the lungs are chiefly derived from the pneumogastric and its branches, but they derive others from the ganglionic system. They form a large plexus behind the bronchi, and penetrate the lung in company with the ramifications of those tubes.

Fig. 265.

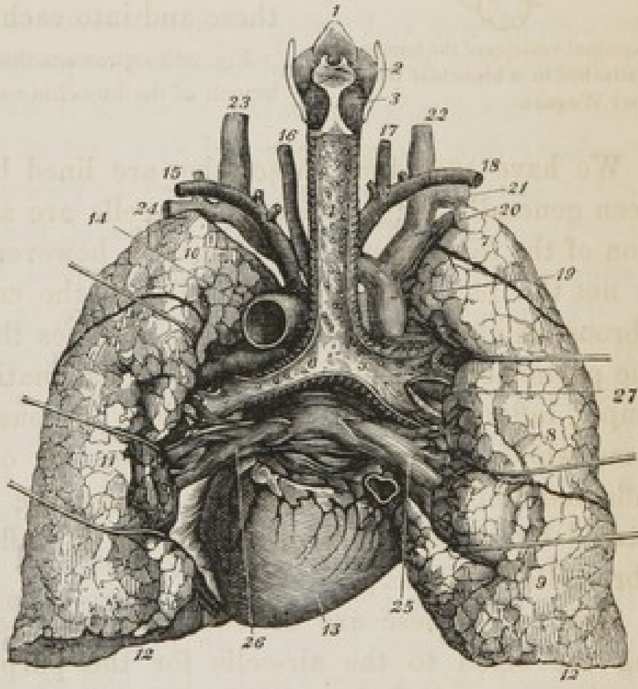


Fig. 265. Posterior view of the larynx, trachea, lungs and heart. 1, epiglottis cartilage; 2, oblique arytenoid muscle; 3, posterior crico-arytenoid muscles; 4, trachea with its mucous follicles; 5, 6, right and left bronchi; 7, 8, 9, right lobes of the lungs; 10, 11, left lobes; 12, 12, base of the lungs; 13, heart; 14, aorta; 15, left subclavian artery; 16, left primitive carotid; 17, right primitive carotid; 18, right subclavian artery; 19, vena cava descendens; 20, right vena innominata; 21, right subclavian vein; 22, right internal jugular; 23, left internal jugular; 24, left subclavian vein; 25, 26, pulmonary veins; 27, pulmonary artery of right side, which is also seen bifurcating as it enters the left lung.

Posterior view of the lungs. From Bourgery.

Pulmonary tissue.—The several tissues of the lungs constitute what is called their *parenchyma.* From the foregoing description it will be seen that this parenchyma is made up of blood-vessels, lymphatics, nerves, air-cells and bronchial tubes, all united together by strong areolar tissue and enclosed within a serous envelope called the pleura.

The root of the lungs.—This name is applied to that part of the lungs at which the bronchi, nerves and arteries enter and the veins come out: it is about an inch and a half long and half as much in breadth, there being one on each

side and something nearer the apex than the base. Fig. 262, 21, and 264, 27. That portion of the inner surface of the lung behind the root, is in relation with the posterior mediastinum and vertebræ; but the surface in front of the root is in relation with the anterior mediastinum and is concave for the lodgment of the heart.

THE PLEURA.

The pleura, like other serous membranes, is thin, diaphanous, extensible and moderately elastic, with a smooth and highly polished free surface, and there is a pleura for each lung. It belongs to the class of reflected membranes, and could it be separated from its attachments, would present an entirely imperforate sac. It is disposed in the following manner: it lines the entire parietes of the chest from the sternum in front to the root of the lung behind; and this portion of the membrane is called the *pleura costalis*. At the root of the lung it is reflected from the costal surface to the lung itself, which it completely embraces, entering into its fissures and giving a partial cover to the pericardium; this is the *pleura pulmonalis*. Another and continuous portion is reflected from the root of the lung to the diaphragm below of which it covers the whole superior or thoracic surface; this, though regarded as a part of the pleura costalis, is usually designated as the *diaphragmatic pleura*, or pleura phrenica. Again, that division of the membrane that meets its fellow of the opposite side to form the vertical septum of thorax hereafter to be described, is the *mediastinal pleura*.

The pleura costalis terminates above in a conical cul-de-sac that projects above the first rib, and receives the corresponding part of the lung. The diaphragmatic pleura forms in each side of the chest a duplication called the *ligamentum pulmonis*, attached above to the pulmonary veins,—below to the side of the pericardium in front of the vertebræ, and serves, therefore, to attach the lung at these two points. Fig. 262, 22.

The pleura costalis is readily separated from the thoracic parietes and is thicker than the pulmonary part of the membrane, while the diaphragmatic portion holds in these respects an intermediate place. The pleura is everywhere moistened by a serous exhalation; and as the lungs completely fill the chest, it will be understood that its free surfaces are in contact throughout.

The pleura, in its healthy state, has no perceptible blood-vessels. Its exterior surface, however, becomes highly vascular in inflammation; yet Cruveilhier and other anatomists suppose that these vessels do not belong to the pleura but to the proximate exterior tissue. It abounds with lymphatics that terminate in the mammary and intercostal glands, but no nerves have been detected in it.

The MEDIASTINA.—As each pleura constitutes a perfect sac, their junction in the median line of the thorax forms a vertical septum in that cavity, extending from the sternum in front to the spinal column behind. The two membranes

do not, however, come into contact, but are placed at different distances from each other in different parts of their course, so as to form three continuous cavities, each one of which accommodates certain of the thoracic viscera: these inter-pleural pouches are the *mediastina*.

The *anterior mediastinum* is a triangular space that extends between the inner surface of the sternum to the front of the pericardium. The external surfaces of the pleura are here almost in contact, but are more widely separated above, where they enclose the thymus gland of the fœtus and its atrophied remains in adult age. Lower down this mediastinum is chiefly occupied by areolar tissue with some interspersed lymphatic glands. Its upper and expanded part is sometimes called the *superior mediastinum*.

The *posterior mediastinum* is embraced between the pleuræ, where they are reflected forward from the spine to meet the pericardium and root of the lungs; a narrow space in which are contained the descending aorta, the azygos and superior intercostal veins, the pneumogastric and splanchnic nerves, the thoracic duct and esophagus, together with many lymphatic glands, all connected by an abundant areolar tissue.

The *middle mediastinum* is the cavity intermediate between the other two, containing the heart with its pericardium and the origin of the aorta, the descending vena cava, the pulmonary arteries and veins and the bifurcation of the trachea.*

FUNCTION OF THE LUNGS.

Respiration is a complex function, depending on the simultaneous action of several distinct organs for its perfect accomplishment; and its object is *to eliminate carbonic acid from the blood and to supply its place with oxygen.* In other words, this function, called *hæmatosis* or *sanguification*, converts the venous into arterial blood.

Whence this constant accumulation of a deleterious element? It is derived in part from that wearing away of the tissues which is continually in progress in the human body; and in part from the action of the muscular and nervous systems, for it is observed that where these systems are strongly developed, there is a proportionate elimination of carbonic acid from the lungs. Another source of this element is animal heat, which is a peculiar characteristic of warm-blooded animals and results from the combustion of the oily portion of the ingesta; for these enter into combination with oxygen and form carbonic acid.

In the function of respiration the lungs are nearly passive. The dilatation of the cavity of the chest, which is simultaneous and identical with *inspiration*, is accomplished by the scaleni and intercostal muscles, aided by the serratus magnus, and more indirectly by the other muscles connecting the spine with

* The mediastina are variously described in different works on anatomy, not only in reference to their boundaries, but their contents and even their number.

the scapula. By these movements the chest is expanded upwards, forwards and laterally.

The diaphragm also performs a very important part of this function and is indeed the principal dynamic agent in ordinary inspiration. By the contraction of its muscular fibres, its upward convexity is greatly diminished and its tendinous centre brought nearer to a plane surface, the abdominal viscera are at the same time pressed downwards, and the abdomen in consequence rendered more prominent.

Expiration, or the act by which air is expelled from the lungs, is effected by the contraction of the abdominal and other muscles proceeding from the trunk of the body, but chiefly by the former; for being inserted into the ribs they draw down the latter in the expiratory act, which is moreover greatly aided by the elasticity of the costal cartilages.

Respiration, therefore, consists in an alternate expansion of the chest, or inhalation, and contraction of that cavity, or expiration, by which means oxygen is introduced and carbonic acid thrown out. This effect, however, is not complete with every respiratory action, a part only of the air contained being changed: thus it has been estimated that the quantity of air remaining in the lungs after ordinary expiration is one hundred cubic inches, whilst the amount actually expired does not generally exceed twenty cubic inches.

Respiration (including the inspiratory and expiratory acts), is, under ordinary circumstances, repeated from fourteen to eighteen times per minute; and it is also found that the pulse beats about four and a half to five times during each respiratory act. These proportions, however, are much varied, and both the pulse and respiration are greatly accelerated by physical exertions, mental emotions and certain diseases. Such a condition occurs from obvious causes in inflammatory fevers, and more especially in pleuritis, pneumonia and acute catarrh; and the reverse is observed in typhus fever, wherein a morbid state of the blood diminishes the frequency both of the pulse and of respiration.

Respiration is partly voluntary, partly involuntary. The will can suspend it for a short period, but a sense of necessity compels its resumption.

The function of respiration results from the action of two series of nerves, one sensory, the other motor, of which the centre is the upper part of the medulla oblongata. The obvious influence of the olivary bodies in these actions has led physiologists to call them the *respiratory ganglia;* but according to Solly the corpora restiformia have as much agency in this function as the first-named ganglia. There is considerable discrepancy of opinion on these questions; but it may answer our present purpose to observe, that the *sensory nerves* connected with respiration are the pneumogastric and certain branches of the trigeminus.

Thus if the pneumogastric nerve be compressed or divided on both sides, the respiratory movements become embarrassed and less frequent, or, in other words, great difficulty of breathing takes place; yet as the function is not altogether suspended, we infer the agency of some other nerves, and this is found in that part of the trigeminus or fifth pair which is distributed to the face. The

actions, however, of this nerve are not easily explained, and we chiefly know them in their effects: the inspiratory movement is peculiarly and forcibly excited by impressions made on them, especially by the contact of cold air or water with the face; and Dr. Carpenter and other physiologists remark that the first inspiration of the new-born infant is excited solely in this manner. "An inspiratory effort is often made as soon as the face has emerged from the vagina of the mother; whilst, on the other hand, if the face be prevented from coming in contact with cool air, the inspiratory effort may be wanting."

The *motor nerves* concerned in respiration are chiefly the phrenic and the intercostals; but in order to convey, at a glance, the direct as well as the collateral influence of the *respiratory nerves*, we subjoin from Sir Charles Bell the following facts, illustrative of the action of each of these nerves.

The division of the facial nerve (portio dura) suspends the motion of the nostril, lips, &c.: a similar operation on the recurrent branch of the pneumogastric, destroys the voice: when the laryngeal branch of the par vagum is cut, there is an end to "the consent of motion" between the muscles of the glottis and those of the chest. Divide the phrenic nerve and the motion of the diaphragm ceases; while the division of the spinal accessory suspends the respiratory motion of the sterno-mastoid and trapezius muscles.* The embarrassment to the respiratory function that results from a section of the pneumogastric trunk, has been already noticed.†

The *chemical phenomena* of respiration are briefly as follow. It has been estimated that when 1174 parts of oxygen are taken into the lungs, one thousand are thrown off or excreted in the form of carbonic acid; the residue or, 154 parts, (amounting to 15 per cent. of the whole), enters into combination with the sulphur and phosphorus of the original elements of the body, converting these into sulphuric and phosphoric acids.

The quantity of carbon exhaled from the lungs in the form of carbonic acid, is subject, for obvious reasons, to great variation; but it has been proximately calculated that the average amounts in twenty-four hours to 17,856 cubic inches, containing about five ounces and a half of solid carbon. The proportion is increased by exercise, by a full diet and by low temperatures; while, on the other hand, it is much reduced in quantity during sleep and by the use of meagre aliments. The carbonic acid exhaled, forms about four per cent. of the whole volume of air inspired during twenty-four hours, which last has been calculated at 266 cubic feet.‡

Changes effected in the blood.—We have already observed that the venous blood arrives in the lungs charged with carbonic acid, which last is given off ready formed and its place supplied by oxygen; whence it follows that the

* The Nervous System of the Human Body, p. 143.

† In *asphyxia* there is a total suspension of the respiratory function, either from the presence of water as in drowning, or from the breathing of carbonic acid gas or other deleterious vapors. All the other vital actions are suspended at the same time; but they are often restored after a considerable interval of seeming death, on fresh air being admitted to the lungs.

‡ Carpenter. Elements of Physiology, §§ 689, 686.

blood is oxygenized by the inspiratory and decarbonized by the expiratory act. In what manner these changes are effected, has not been positively determined; but the proportion of oxygen, carbonic acid and nitrogen in the two conditions of the blood, as ascertained by analysis, are given in the following table.*

	Arterial blood.	Venous blood.
Oxygen	23.2	15.3
Carbonic acid	63.2	71.6
Nitrogen	14.5	13.1

THE THYMUS GLAND.

This remarkable appendage of fœtal life is placed in the upper part of the anterior mediastinum, between the sternum in front and the trachea behind. It is of a somewhat triangular form with the base upwards, and in its fullest development extends from the base of the heart opposite the fourth dorsal vertebra, to the thyroid gland. It is not a single but a double gland, the two halves being separated by areolar tissue and entirely independent of each other. It is of a soft consistence and reddish color, and embraced by an envelope of condensed areolar tissue. Internally it is composed of lobules arranged around a central cavity in each lobe; and when more closely inspected, the lobules are themselves formed of vesicles or secretory cells which open into pouches at the base of the lobules, there being several of the former to one of the latter. These pouches in turn discharge into a central cavity or reservoir, which extends the whole length of the gland. It is lined by a mucous membrane thrown into bands by subjacent ligamentous fibres.

The thymus gland, in its more perfect condition, contains a milky fluid, which is said to contain a small number of red corpuscles with a multitude of other corpuscles of the nucleated class, some being circular, others discoidal.

Although in conformation the thymus has all the characters of a true gland, it has no excretory duct and its uses remain in a great measure conjectural. It is first seen in the fœtus between the first and second months, from which period it continues to increase in size until the ninth month, when it has reached its maximum of development. It gradually increases in size after the birth of the child until the expiration of the first year, when it dwindles away, until, at the age of puberty, it has lost its glandular character and nothing remains of it but a small, condensed mass of cellular tissue.

The arteries of this gland, which are large in the fœtal state, are derived from the internal mammary and the thyroidal trunks; and the veins chiefly empty into the vena innominata of the left side. The nerves come from the superior thoracic ganglion of the sympathetic, with filaments from the pneumogastric nerve. The lymphatics, also, are very numerous.

* From Magnus, in Carpenter, *ut suprà.*

Function.—It may be reasonably inferred from the preceding facts, that the thymus gland is in some way subservient to the growth of the fœtus and of the first periods of infancy; but the mode in which this end is accomplished is yet a mystery. The generally received opinion among physiologists is, that this gland performs the function "of elaborating and storing up nutritive materials to supply the demand which is peculiarly active during the early period of extra-uterine life. This elaborating process probably corresponds with that performed by the glands of the absorbent system, and the product, as in the preceding cases, seems to be conveyed away by the lymphatics. It is possible that the thymus gland may further stand in the same relation to the lungs as the spleen to the liver, and the supra-renal capsules to the kidneys; that is, as a *diverticulum* for the blood transmitted through the bronchial arteries before the lungs acquire their full development in comparison with other organs, or when any cause subsequently obstructs the circulation through their capillaries."*

THE THYROID GLAND.

This gland is situated on the upper front part of the trachea and on the contiguous lateral portions of the larynx. These lateral portions are connected by a continuity of structure called the *isthmus*, variable in size and form, and sometimes absent, and the whole has been compared to a crescent with the horns directed upwards. In some instances the isthmus is enlarged into a third lobe that ascends in an elongated conical form as high as the fissure of the thyroid cartilage. It is concave behind, owing to its contact with the rings of the trachea; and convex in front, where it is covered by the sterno-hyoid and sterno-thyroid muscles, the fascia of the neck and the integuments.

The lateral lobes are also convex in front and covered by the sterno-thyroid muscle: they surround the inferior part of the thyroid cartilage, the first and second rings of the trachea, and come into contact behind with the contiguous surface of the esophagus. Behind each lobe is the corresponding primitive carotid artery and internal jugular vein.

This gland is of a reddish-brown color and of a firm consistence. It is embraced by a delicate, closely adherent proper membrane, which gives it a polished appearance, and which is itself covered by loose cellular tissue. Examined internally, the gland is observed to be lobulated and to bear a general resemblance to the structure of the thymus body. Its lobes are composed of partially divided lobules, and these are again divisible into vesicles or cells containing a transparent, viscid secretion which under the microscope presents numerous corpuscles, apparently the nuclei of cells in various stages of development. These vesicles communicate freely with each other, but not with

* Carpenter. Principles of Physiology, § 688.

any central cavity or reservoir, as in the thymus gland; nor is there any excretory duct.

An interesting but not constant feature of the thyroid gland is its muscle. This fasciculus of fibres extends from the inferior margin of the base of the os hyoides to the upper border of the isthmus. It is more frequently, however, placed on the left of the median line, in which case it arises from the upper edge of the corresponding lobe and is inserted into the base of the os hyoides laterally. It was first described by Duverney about a century ago, and again by Sœmmerring at a later period.* Its use appears to be, to draw the gland upwards towards the hyoid bone. This muscle has been described by various anatomists, and has been generally regarded as of extremely rare occurrence; but Dr. Godman, as the result of much careful observation, came to the conclusion that it exists in three cases out of five; and he supposes that it has often been overlooked on account of its lateral position, and the proximity of its fibres to those of the thyro-hyoid muscle.†

The blood-vessels of the thyroid gland are large and numerous. Its arteries are the superior and inferior thyroids, the former derived from the external carotid, the latter from the subclavian. An additional artery is sometimes derived from the arteria innominata or from the arch of the aorta. The veins correspond with the arteries, and are remarkable for their size and number. The nerves come from the pneumogastrics and from the cervical ganglia of the sympathetic. The lymphatics, which are also abundant, terminate in the cervical glands.

Function.—This is yet a mystery; but it appears to be analogous to that of the thymus gland by affording a diverticulum to the cerebral circulation, and to aid in the elaboration of nutritive materials, which, received into the absorbent vessels, are thence poured into the veins.

SECRETION.

As a sequel to the foregoing description of the visceral organs, we propose in this place to notice the general characters of the secretory function;—that process by which, as its name imports, substances of any kind are *separated* from the blood.

This function, like that of digestion and nutrition, is a varied form of cell-growth; but while in *nutrition* every tissue separates from the blood and appropriates to itself the materials of its own development, *secretion* elaborates a peculiar fluid for a special office in the animal economy. Such, at least, is the case with respect to the greater part of the secretions—the bile, the gastric and pancreatic fluids, the saliva, milk and tears, together with the product of the mucous and serous membranes. Another form of secretion is that which

* De Corporis Humani Fabrica, vi. p. 38.

† Anatomical Investigations, p. 57. Philadelphia, 1824.

separates the refuse elements of the blood in order that they may be thrown out of the system altogether; and this function, though of a strictly secretory nature, is designated by the more definite term of *excretion*. The kidneys and skin afford examples of excretory organs; and we may here observe, that although carbonic acid is eliminated in a very different manner, it forms a large proportion of the excreted products of the system. It is conveyed by the veins, as we have seen, to the lungs and liver, from which organs it is finally thrown off. Hence the process of respiration itself is regarded by some physiologists as one of secretion.

There is yet an intermediate series of secretions which are neither eliminated among the refuse materials of the economy, nor blended with extraneous matters in order to perfect a vital process: we allude to the products of the thyroid and thymus glands, the spleen, the renal capsules, &c. These secretions, although derived from the blood, are delivered back into the circulating current through the medium of the lymphatic system, to effect purposes and to undergo metamorphoses as yet but little understood.*

Secretion, in its more restricted sense, consists in the action of cells which deposit their products on a free surface communicating more or less directly with an external outlet. The organs of this function are chiefly the *glands*. The structure and uses of these parts will be fully noticed in another place; but we may here remark, that the most perfect gland consists of an aggregation of *follicles* that open directly or indirectly into a common channel, and thus deliver the product of their action into a special recipient provided for that purpose. The liver is an example of this highest type of glandular organization. Its multitudinous follicles empty themselves into the ducts of which they form the internal parietes, and these ducts finally coalesce into a single canal. Such also is the construction of the pancreas, the salivary glands and some others. The other extreme, or the more simple glandular organism, is seen in the synovial capsules and serous membranes, which are covered by epithelial cells of the secretory class. But in the mucous membrane we find an intermediate structure, consisting of an *inversion* of the surface at multitudinous points, each one of which is a follicle lined by epithelial cells. A follicle, therefore, is a perfect but epitomized gland; and it will now be understood that the largest gland, as already stated, is but a congeries of these follicles lined with epithelial cells, and that the one is the mediate, the other the immediate, agent of secretion. Hence the axiom in the present state of physiological science,—that in all secretory organs, the cells covering the membranous surfaces and lining the follicles and tubes, constitute the real and only secretory apparatus.

Fig. 266.

Fig. 266 illustrates the preceding proposition; it represents a longitudinal section of three ultimate follicles of the mammary gland lined with nucleated secreting-cells. From Dr. Carpenter.

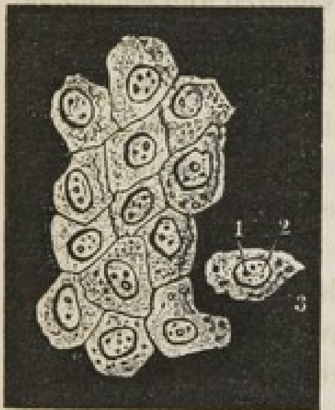
The important function performed by these minute organs, leads us to inquire briefly into the nature and diversity of the *epithelial cells* in different parts of

* Carpenter. Elements of Physiology, § 711.

the system.* Two principal varieties of form have been observed in these bodies, whence their classification into the tesselated and cylindrical epithelia.

TESSELATED EPITHELIUM.—The cells of this variety, when seen under the microscope, are flattened, with irregular or polygonal margins and of variable size. They are sometimes isolated from each other, and sometimes in close contact in the manner of a mosaic pavement. The smallest of these cells are found on the surface of the heart; the largest cover the posterior face of the cornea, the peritoneum and the tunica vaginalis testis: but in one form or other they are spread over all the serous and synovial membranes, the lining membrane of the blood-vessels, the ultimate follicles or tubuli of nearly all the glands connected with the skin and mucous membranes, and also upon the latter membranes generally where the cylindrical epithelium does not exist. Those of the plexus choroides have a characteristic roundness that serves to distinguish them, together with a yellowish color and granulated structure. In the mucous membrane of the tympanum and in the ducts of many excretory glands, they are globular and arranged in a single stratum.†

Fig. 267.



Tesselated epithelium. After Henlé.

Fig. 267. Tesselated epithelial cells, from the peritoneum in front of the pelvis. 1, cell; 2, nucleus; 3, nucleolus.

The epithelial cells of the lips and mouth generally, and of the pharynx and esophagus as far as the cardiac orifice of the stomach, are of the tesselated variety; and in these, as in some other parts, they are arranged in two layers, of which one is superficial, the other deep-seated. The deeper lamina, according to Mr. Nasmyth, consists of nuclei only; but in the exterior layer true cells are developed which are always flattened and scaly in form. These last are connected together by a tenacious, jelly-like secretion replete with minute granules, probably the nucleolar elements of undeveloped cells, (p. 19.) The superficial scales are constantly detached with the mucous secretion, while the deep-seated ones, assuming in turn the same position, are exfoliated in like manner.

CYLINDER OR COLUMNAR EPITHELIUM.—The form of these cells is that of an elongated cone tapering at the basal or attached end, while the free surface is comparatively broad and flat. Each cell contains a pellucid nucleus near its basal extremity, and this nucleus has its distinct nucleolus or primitive granule.

Fig. 268.

Fig. 269.

Fig. 268. Free ends of the columnar epithelial cells, as seen on looking down upon the mucous membrane of the stomach. From Drs. Todd and Bowman.

Fig. 269. The same cells viewed obliquely. 1, free ends; 2, attached extremities, enclosing nucleated nuclei. From Drs. Todd and Bowman.

* In a strictly histological arrangement the epithelial structures should be classed with the dermoid tissues; but we have found it more expedient to introduce them here.

† Henlé. Anatomie Générale, i. p. 231.

We have remarked that the tesselated epithelium extends as far as the cardiac orifice of the stomach; but here it gives place to the *columnar* form, which lines all the depressions of the gastric mucous membrane and is continued throughout the inferior sections of the alimentary canal to the anus, where it terminates by a denticulated membrane in the exterior epidermis. The columnar epithelium also lines the larger ducts that open into the alimentary canal or upon the external surface of the body, and is thus seen in the ductus communis choledochus, the salivary ducts, those of Cowper's glands and the prostate, the vas deferens and the urethra. In all these situations it comes into connection with the tesselated epithelium, which usually lines the more delicate canals of the glands as well as their terminal follicles. Moreover the two forms in some places pass by insensible transitions into each other, the tesselated scales gradually assuming the elongated conical form.*

Ciliary epithelium.—This variety, which has already been noticed by the synonym of *vibratile cilia* (p. 21), is a modification of the tesselated and columnar epithelia, in which their free edges are fringed with hair-like processes of extreme tenuity. These processes or *cilia* maintain through life a perpetual vibration, which, as Dr. Clymer observes, has been proved by experiment to be an inherent molecular power, "independent of muscular influence and of the vascular and nervous systems." This motion continues even after death; but longer in cold-blooded than in warm-blooded animals.

A remarkable fact connected with these epithelial cells is the evident simplicity of their structure; for the three varieties, as we have seen, differ only in the degree of their elongation and in the occasional presence of the ciliary fringe. But a yet more surprising circumstance is the multiform secretions elaborated by these simple, cell-bearing follicles. In the liver they secrete bile; in the stomach the gastric juice; in the salivary glands the saliva; in the intestines mucus; in the kidneys urine; yet the difference is not in structure, but in function. Secretions totally distinct from each other are products of precisely similar organisms; and of this ultimate fact we know nothing more than that it is so. The cells that secrete the gastric juice, for example, are precisely similar to those that provide the mere intestinal mucus.

Secretion, therefore, is in the largest sense a vital process; but it is necessary to distinguish between secretion and *transudation*, which last is a mere physical property of fluids that may and does take place in the dead as well as in the living body, on the familiar principle of exosmosis. Not only water transudes in this way, observes Dr. Carpenter, but various substances that are held in complete solution by it, especially albumen and saline matter. It is in this manner that the blood absorbs fluids from the digestive cavity, and pours out the serosity that fills the interspaces of the areolar tissue, and the various serous cavities.†

* Carpenter, *ut suprà*.

† Principles of Physiology, § 824.

ANGEIOLOGY.

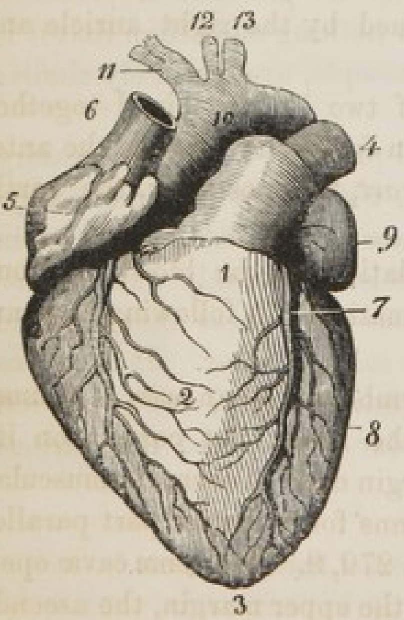
DESCRIPTION OF THE VASCULAR SYSTEM.

THIS department of anatomy embraces the whole circulatory system, the heart, arteries, and veins, together with the associated apparatus of lymphatic vessels and glands.

THE HEART.

The heart is a cavernous muscle and the centre of the circulatory system. It lies between the two laminæ of the pleuræ that form the mediastinum, with the vertebral column behind, the sternum in front and the diaphragm beneath; being partially enveloped by the left lung. Its shape is conoidal, whence its triple division into base, body and apex; and its position is in all respects oblique, for it presents from right to left and from above downward. Its average length, for it is extremely variable in size, is about five inches, and its basal diameter four inches; but much larger and smaller proportions are consistent with a healthy condition. It is of greater bulk in persons of robust muscular conformation; while in delicate persons, and especially in women, its development is comparatively feeble. From a multitude of experiments made by European physiologists, the average weight of the adult heart may be assumed at eight ounces, which is liable to variations from the age, sex and other circumstances of the individual. Bizot, however, ascertained that stature exercised but a slight influence on the size of the heart.

Fig. 270.



Heart. From Bourgery.

Fig. 270. Anterior view of the heart in a vertical position; 1, base; 2, body and right ventricle; 3, apex; 4, pulmonary artery; 5, right auricle; 6, vena cava superior; 7, anterior coronary artery, running along the anterior fissure that separates the ventricles; 8, left ventricle; 9, left auricle; 10, the aorta; 11, arteria innominata; 12, left primitive carotid; 13, left subclavian.

The heart is invested and kept in its position by a membrane called the *pericardium*, composed of two laminæ. The external layer is fibrous, strong and opaque, and has the general characters of the dura mater. It only adheres to the heart at its basal margin, whence it is extended upon the great vessels, viz. upon the aorta as high as the arch, upon the contiguous trunk of the pulmonary artery, and upon the descending vena cava for a short distance above its termination; and it also covers the trunks of the pulmonary veins and the terminus of the ascending cava. It is thus that each of these vessels receives a distinct but partial sheath from the pericardium, which is reflected from these several attachments in the manner of a loose sac that encloses the heart. It is in contact above with the thoracic fascia, and below with the cordiform tendon of the diaphragm. The pleuræ are contiguous to it on each side; behind it are the vessels of the posterior mediastinum, and in front it is in relation with the sternum.

The *serous coat* of the pericardium is a delicate, polished, transparent membrane that not only lines the sac formed by the fibrous coat, but is also closely attached to the whole surface of the heart. It gives a common sheath to the aorta and pulmonary artery, but invests the vena cava and the four pulmonary veins only on their anterior surfaces. In fat persons it is often raised from the fibres of the heart by interposed peletons of adipose matter, and always contains a small quantity of serous halitus.

Thus invested the heart lies upon the tendinous centre of the diaphragm, its base presenting upwards and backwards and its apex pointing at the junction of the fifth rib with its cartilage. The heart is composed of two auricles and two ventricles, which are distinctly marked off on its exterior surface. The auricles form the basal end of the organ, the ventricles its body and apex, and the two portions are separated by deep fissures. The inferior surface is flat where it is in contact with the diaphragm, and this, which is composed of the left auricle and left ventricle, is called the left or posterior side of the heart; while the upper and convex portion, formed by the right auricle and right ventricle, is the right or anterior side.

This organ, therefore, is in reality composed of two hearts, joined together side by side, separable in structure and differing in function; whence the anterior portion is sometimes called the *pulmonic heart*, the posterior, the aortic or *systemic heart*.

If we now examine in the order of the circulation of the blood, the four cavities which correspond to this external conformation, the following appearances will present themselves.

The RIGHT AURICLE, named from a fancied resemblance to an ear, is a musculo-membranous sac of a flattened form next the heart, but convex on its external free surface. It has also a dentated margin derived from its muscular structure, which is arranged in long slender columns for the most part parallel to each other and called the *musculi pectinati*. Fig. 270, 9. The venæ cavæ open into this auricle,—the descending vein entering at the upper margin, the ascending vein at the lower. "The direction of these two vessels is such, that a stream

forced through the superior cava, would be directed towards the auriculo-ventricular opening; in like manner a stream rushing upwards by the inferior cava, would force its current against the septum auricularum; which is the proper direction of the two currents during fœtal life."* Where these two veins meet, there is a transverse thickening of the auricular parietes occasioned by the junction of the two veins and known as the *tuberculum Loweri*. Fig. 271, 12.

The *Eustachian valve* is a duplication of the lining membrane of the auricle that surrounds about one-half of the orifice of the inferior vena cava, and is extended between it and the fossa ovalis, upon which latter structure it is gradually lost. Its form and function are imperfect in the adult, but in the fœtus it assists in directing the current of blood to the foramen ovale and the left auricle. Fig. 271, 10.

The *fossa ovalis* is a circular depression in the septum between the two auricles, and marks the position of the fœtal foramen ovale or opening that communicates between the two auricles before the birth of the child. The thickened margin of this fossa is sometimes called the *annulus* of *Vieussens*. The fossa ovalis sometimes retains a perforation in adult age; in other instances it is cribriform, and either conformation seems to be compatible with the healthy function of the heart.

The *coronary vein* opens into the right auricle on the left side of the Eustachian valve, and its orifice is guarded by a fold of the lining membrane, the *valvula Thebesii*, that prevents the return of blood when the auricle contracts. Fig. 271, 13.

The auriculo-ventricular orifice, also called the *ostium venosum*, is about an inch in diameter with a smooth margin.

The *musculi pectinati*, already mentioned, when examined within the auricle, are seen to be vertical fasciculi of muscular fibres, commencing at the auricular margin of the cavity and inserted near the ostium venosum. Other and smaller fibres are placed obliquely and next the parietes of the auricle, thereby giving the latter an increased power of contraction.

The RIGHT VENTRICLE is placed anteriorly in the body of the heart. It is of a conical form, the apex presenting towards the corresponding part of the heart itself. Its posterior wall, or that which separates it from the left ventricle, is flat, but its anterior parietes partake of the general convexity of this surface. Its thickness is about a quarter of an inch. Fig. 270, 2.

When laid open, the muscular structure is seen to be arranged in columns, *columnæ carneæ*, which pass in different directions and have different attachments. Some of them, for example, arise from the side of the ventricle, run upward in elongated, rounded fasciculi, and terminate in delicate tendinous cords, *chordæ tendineæ*, inserted into the margins of the tricuspid valve. Fig. 271, 3. Others of these fasciculi are attached laterally, their whole length, to the wall of the ventricle, and have been compared by Cruveilhier to pilasters, in contradistinction to the isolated columns. A third series of these fasciculi are free except at their extremities, both of which are attached to the walls of the ventricle.

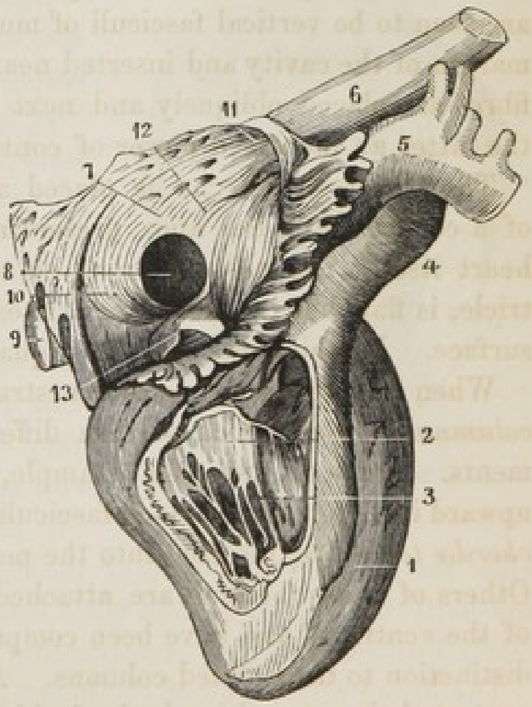
* Wilson. Human Anatomy. Edited by Dr. Goddard, p. 507.

This ventricle has two openings, one leading to the right auricle, the other into the pulmonary artery. The former, called the ostium venosum, is of a rounded form, is provided with a triple duplication of the lining membrane, called the *tricuspid valve.* Each of the parts of this valve is triangular, and retained in its place and at the same time allowed the requisite degree of motion by the chordæ tendineæ, which run, as before stated, from the fleshy columns to the margin of the valve. In this course they diverge and bifurcate, and unite again in a reticulated manner, before their final insertion into the valve. The function of this structure is to prevent the reflex of blood from the ventricle back into the right auricle. Fig. 271, 2.

The *pulmonary orifice* is that which leads into the pulmonary artery. Its base presents an annular thickening of the structure of the ventricle, from which arise the *semilunar valves*, three in number, formed by a duplication of the lining membrane of the cavity. In the quiescent state of the ventricle these valves are in a horizontal position; but when the muscle contracts to force the blood into the pulmonary artery, they become nearly vertical. The free margin of each valve is furnished with a little seed-like cartilage, the *corpuscula arantii*, which come into contact when the valves are down, and the mouth of the artery is thus completely closed. The valves do not present a plane surface within the artery, but form a pouched cavity or *cul-de-sac*, the *sinus of Valsalva*, which is best seen by injecting the artery with wax.

The pulmonary artery, after its origin from the right ventricle, divides and subdivides to be distributed through the lungs, in the manner hereafter to be described; and the four pulmonary veins, taking up this blood, return it to the heart by pouring it into the left auricle, which latter cavity comes next to be described in the course of the circulatory system.

Fig. 271.



Interior of the right auricle and ventricle. From Bourgery.

Fig. 271. A view of the interior of the right auricle and right ventricle. 1, the right ventricle; 2, tricuspid valve; 3, chordæ tendineæ; 4, pulmonary artery; 5, the aorta; 6, descending vena cava; 7, the right auricle; 8, orifice of the ascending vena cava; 9, vena cava ascendens; 10, valvula Eustachii; 11, orifice of the descending vena cava; 12, position of the tuberculum Loweri; 13, valvula Thebesii overhanging the orifice of the coronary vein.

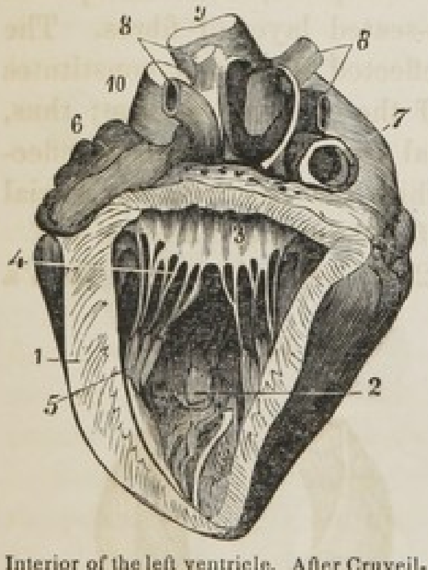
The LEFT AURICLE, as we have seen, assists in forming the base of the heart. Fig. 272, 7. It is smaller than the right auricle and its proper auricular portion is more serrated, its musculi pectinati are smaller, and its general parietes thicker than the corresponding parts of that cavity. When the inter-auricular septum is held up to the light, it is

seen to present a round, diaphanous spot which indicates the former situation of the foramen ovale of the fœtus and of the fossa ovalis of the right auricle. Excepting the pectinated fibres of its auricular portion, this cavity has smooth muscular walls of considerable strength. It has five openings, of which the largest is the *ostium venosum* or passage into the left ventricle, of an oval form and an inch and a quarter in its long diameter. The auricular cavity is of an irregular quadrangular shape; a pulmonary vein enters at each of the angles, two on the right side and two on the left, all destitute of valves. Fig. 272, 8.

The LEFT VENTRICLE is in the posterior and back part of the heart, constituting a large portion of the body of that organ and projecting, at its apex, beyond the right ventricle. Its parietes are much thicker than those of the right side, but the difference in the capacity of the two cavities is inconsiderable. The muscular structure has the same arrangement in both, but the walls of the left ventricle are more than twice the thickness of the opposite side. The *carneæ columnæ* are similar, but that part of the cavity that is proximate to the aorta is without these columns and perfectly smooth. Fig. 272, 5.

The *ostium venosum*, or opening into the auricle, is guarded by a fold of the lining membrane, the *mitral valve*. Fig. 272, 3. This valve is composed of two segments or leaf-like processes of unequal size, the larger one being placed between the ostium venosum and the orifice of the aorta. They are attached to each other and to the fleshy columns by *chordæ tendineæ* similar to those of the opposite side of the heart. Fig. 272, 4. The semilunar valves at the mouth of the aorta are also analogous to those of the pulmonary artery, being three in number and having the corpuscula arantii in their free margins. The fossæ formed in the artery, here also called the *sinuses of Valsalva*, differ in no respect from those of the opposite side.

Fig. 272.



Interior of the left ventricle. After Cruveilhier.

Fig. 272. The left ventricle laid open. 1, its parietes; 2, its cavity; 3, mitral valve; 4, chordæ tendineæ; 5, columnæ carneæ; 6, right auricle; 7, left auricle; 8, 8, the four pulmonary veins; 9, aorta; 10, pulmonary artery.

The ventricles are a little larger than the auricles, but the capacity of each cavity is nearly the same and may be assumed as two ounces. The parietes of these cavities, however, are of very different thickness. Since the left of the two ventricles requires most power in distributing the blood, it is nearly half an inch thick, while the average thickness of the right ventricle does not exceed two lines; and both these cavities, from their less active function, are altogether more delicately formed than the corresponding ventricles.

The lining membrane of the heart, *endocardium*, is very thin, smooth and diaphanous, and possesses the properties of serous tissue. It dips into the sinuosities formed by the columnar and pectinated muscular fibres, and forms by

duplication the several valves of the heart. From this organ it extends to the mouths of the pulmonary artery and aorta, becoming there continuous with the lining membrane of those vessels, and forming the two sets of the semilunar valves, or at least their cardiac surfaces.

Muscular structure.—The muscular structure of the heart is based upon what the anatomist Lower called the *tendinous circles*, into which he traced the origin and insertion of all the muscles of this organ. These circles, to which Cruveilhier has given the name of *fibrous zones*, are four in number; one surrounds each ostium venosum, and another is found encircling the orifice of each of the great vessels going from the heart. Those that surround the auriculo-ventricular openings receive all the chordæ tendineæ, either directly from the fleshy columns or indirectly from the tricuspid and mitral valves, of which they form a constituent part and thus strengthen the endocardial structure of these valves.

The arterial zones in like manner encircle the openings of the aorta and pulmonary artery, and give off processes which pass into and strengthen the semilunar or sigmoid valves. The muscular structure of the substance of the heart is a network of decussating fibres arranged in three concentric laminæ, one of which is superficial, a second intermediate and a third internal.

The *superficial fibres* commence at the base of the heart and pursue a spiral course to the apex; those of the anterior or right side passing from right to left, while those of the left side run in the opposite direction. The two sets of fibres meet and decussate at the heart's apex, forming a remarkable gyration called the *vortex;* they do not, however, terminate at this point, but turn upward towards the base of the heart and form the deep-seated layer of fibres. The latter stratum, which is expressively called the reflected fasciculus, constitutes the proper parietes of the ventricles and gives off the columnæ carneæ; thus, in the words of Cruveilhier, the anterior superficial fibres form, by their reflection, the deep layer of the posterior parietes, while the posterior superficial fibres, after being reflected, form the deep layer of the anterior parietes.

This involution of fibres is represented in Fig. 273; a drawing taken from a

Fig. 273.

Spiral and involuted arrangement of the fibres of the heart.

Fig. 274.

Gyration of the heart's fibres at the apex. From Lower.

human heart that was first boiled, and the pericardium subsequently removed.* This arrangement of the muscular structure of the heart was well known to the distinguished anatomist, Lower, who has conveyed his idea of it by a drawing of which Fig. 274 is a copy.†

Between the two laminæ thus constituted by the external and reflected planes of investing muscle, is placed another stratum forming "in each ventricle a sort of barrel or truncated cone, which is applied to that of the opposite ventricle: the superior openings of these cones correspond to the auriculo-ventricular orifices; while the inferior, which are smaller, leave opposite the apex of the heart two considerable intervals, filled up by the common fibres." These proper fibres are extremely tortuous. In the opinion of Cruveilhier they are attached by their extremities to the auriculo-ventricular zones, describing more or less complete circles and intersecting each other at very acute angles.‡

The muscular fibres of the auricles are formed first into a superficial plane that covers the anterior surface of both auricles. The proper or deep-seated layer of the left auricle is constituted of a network of circular and oblique fibres, all of which can be traced to the ostium venosum, which they so invest as to form sphincter muscles. The corresponding fibres of the right auricle are also arranged in decussating series, and can be traced to the auriculo-ventricular orifice of that side. The septum between the auricles is also muscular, its fibres being in part continuous with those of the circular layer of the auricles, and partly derived from the ostium venosum contiguous to the septum.

These several arrangements of muscular tissue are best seen by boiling the heart of any of the larger animals, that of the ox for example, and removing the pericardium from its surface; when, by a patient process of dissection, the three laminæ of the ventricles above described are brought into view, together with one or more subordinate ones in the left and thicker ventricle. The continuity of fibres, however, at the apex, by which the external layer is reflected to form the inner wall of the heart, is not so readily demonstrated; but the stellated intertexture of fibres where that arrangement commences at the apex, is readily brought into view.

The *arteries* of the heart are the *coronary*, two in number. They are the first vessels given off from the aorta, and run from the base of the apex anastomosing freely with each other. Fig. 275, 3, 4. The *right coronary artery* passes under the pulmonary artery and makes its appearance in the fissure between the right auricle and right ventricle, which it follows until it reaches the posterior surface and the apex of the heart, ramifying as it goes. Fig. 270. The *left coronary artery* comes also from the aorta and bifurcates behind the pulmonary artery; one branch runs in the inter-ventricular fissure on the anterior surface of the heart and terminates at its apex; the other branch follows the groove between the left auricle and left ventricle, and is distributed on the under surface of the heart.

The *coronary veins* commence at the apex of the heart and form two princi-

* Cyclopædia of Anatomy, art. *Heart*. † Ibid.

‡ Anatomy, p. 489.

pal trunks, the greater and lesser coronaries, which finally coalesce in a single vessel that opens, as we have seen, into the right auricle.

The nerves are chiefly derived from the cervical ganglia of the sympathetic.

PHYSIOLOGICAL REMARKS.

The office of the heart is to receive the venous blood from all parts of the system; to transmit it to the lungs for the purpose of converting it into the arterial state; to receive it again after this important change of properties, and finally to throw it into the aorta for redistribution throughout the body. The order in which this agency is accomplished, is as follows:—The venous blood, brought from all parts of the system by the two venæ cavæ, is poured by those vessels into the right auricle, where it mingles with the blood from the heart itself brought by the coronary vein. The auricle now contracts and forces the blood through the ostium venosum into the right ventricle. The latter contracts in turn, and throws the blood into the pulmonary artery, its reflux into the right auricle being prevented by the tricuspid valve: so also its return from the pulmonary artery is checked by the three semilunar valves at the mouth of that vessel. The pulmonary artery, by its numberless ramifications, conveys the venous blood to the capillary system of the air-cells of the lungs, where it becomes arterialized by a process hereafter to be noticed. It is then received into the radicles of the pulmonary veins, and conveyed by these vessels to the left auricle. The auricle contracts and the blood flows into the left ventricle, which, also contracting, forces its contents into the aorta. The reflux of blood from the left ventricle to the left auricle is precluded by the mitral valve, and when it has been received into the aorta, its return to the ventricle is opposed by the presence of the three semilunar valves which guard the orifice of that great artery. The arterial blood thus received into the aorta is distributed to every part of the body, to be brought back by the veins and poured by the two venæ cavæ into the right auricle as before, and thence again to perform the circuit of the heart and lungs. The heart is chiefly stimulated to action by the presence of the blood; the influence of the nervous system being altogether accessory and subordinate.

It has been mentioned that the capacity of each cavity of the heart is about two ounces, which is also nearly the quantity of blood expelled from each ventricle on its contraction; for the ventricles do not completely empty themselves at each systole. The whole amount of blood in the body is supposed to pass through the heart in three, or at most, four minutes, and consequently to circulate afresh fifteen or twenty times in an hour. Moreover, experiment has proved that these calculations allow of more time than is absolutely necessary to the function in question.

The circulation of the blood is therefore twofold: that which transmits the blood from the right side of the heart, through the lungs and thence to the left side, is called the *pulmonic circulation;* while that which sends the blood from the left side along the arteries and brings it back to the right side, is called the

greater or *systemic circulation.* This double circulation corresponds to the conformation of the heart, which is essentially a double organ, one half of it constituting the pulmonic, the other half the systemic heart.

The contraction or *systole* of the two auricles is perfectly synchronous; so also is that of the two ventricles; but when the auricles are in a state of contraction, the ventricles are in a state of dilatation or *diastole*, and *vice versâ*, so that there is a perpetual alternation of motion in the two sets of cavities. The auricular and ventricular sounds follow each other with great regularity and without any appreciable pause or interval; but the time occupied by the act of contraction is estimated at double that of dilatation.

The systole or contraction of the ventricles, as before remarked, forces the blood into the arteries, and this motion also produces the pulse, and corresponds, moreover, with the impulse or beat of the heart against the parietes of the chest. The latter effect is owing to the peculiar spiral arrangement of the muscular fibres of the heart, by which its apex is made to perform a corresponding movement from right to left and from behind forward, during which it is forcibly impelled against the wall of the thorax at the junction of the fifth rib with its cartilage.

The *sounds* of the heart possess great interest both in a physiological and pathological sense. They are called the first and second sounds; and the actions that give rise to them have been subjects of much discussion and discrepancy of opinion. The *first sound* is coincident with the contraction of the ventricles and consequently with the pulse. It is dull and prolonged, and appears to result partly from the heart's impulse against the thorax, partly from the rush of blood into the aorta and pulmonary artery, and partly again from the forcible contraction of muscular fibres of the ventricles. The *second sound* is by general consent attributed to the sudden filling of the semilunar valves with blood at the moment when the contraction of the ventricles has ceased, and when the commencing dilatation produces a tendency to the reflux of blood from the aorta and pulmonary artery. This sudden transition of the valves from a state of relaxation to complete tension, gives rise to an audible click which is itself the second sound of the heart.* The healthy action of the tricuspid and mitral valves, contrary to what might be supposed, is wholly destitute of sound.

THE PULSE.—The contractions of the heart, and consequently the pulse, are extremely varied in the same individual from the influence of health, disease, age, sex, mental emotions and the condition of the digestive organs. Thus the pulse of an infant soon after birth beats from 130 to 140 times in the minute; in adult life it averages 75 or 80, and in advanced age falls to 50 or 60 pulsations. The pulse of the adult female exceeds that of the adult male by ten beats in a minute. Posture also affects the frequency of the heart's action. It is accelerated in the erect position, diminished in sitting, and is yet slower in the recumbent state. It is quickened during the process of digestion, and more than all, by exciting emotions of the mind.

* Carpenter. Elements of Physiology, § 573. Dunglison. Human Physiology, ii. p. 162. See also Dr. Pennock's ed. of Dr. Hope's Treatise on the Diseases of the Heart, &c., pp. 55 to 90.

THE ARTERIES.

The ARTERIES are firm, elastic, cylindrical tubes that arise from the ventricles of the heart and extend by numberless ramifications to every part of the body. They originate in two large trunks which divide and subdivide, and gradually diminish in size until their terminal branches are no longer visible to the unassisted eye. These trunks are the aorta and the pulmonary artery, the former belonging to the systemic, the latter to the pulmonic circulation. Neither of them is continuous with the proper structure of the heart, but they are united by a fibrous tissue, while the inner membrane alone continues unaltered from the one structure to the other.

The arteries are essentially formed of three coats, known as the external, middle and internal.

The *external coat* is composed of a condensed intertexture of areolar tissue that invests the arterial tube, and is the medium of its connection with surrounding parts. It is destitute of fat and never becomes infiltrated with serum, is possessed of considerable contractility and is regarded by Cruveilhier as analogous to the dartoid tissue. It is readily dissected from the middle coat, and loosely connected with the exterior cellular membrane by which it is surrounded. This structure is by some anatomists called the nervous, by others the cellular coat. Such is its tenacity, that a ligature tightly drawn round the arterial trunk divides the two inner laminæ, but leaves the external one entire.

The *middle* or *proper coat* of the arteries is that which gives the vessel its cylindrical form and firmness. It is composed of annular fibres, which, however, do not pass completely around the vessel, but terminate by meeting at very acute angles. It is of a yellow color, and from its great elasticity, which shows itself both in the longitudinal and transverse directions, is often called the elastic coat. It is also designated the *muscular coat*, from the fact of its being composed essentially of muscular fibres.

The middle coat, according to Henlé, is itself divisible into two layers of which the fibres run in different directions; the external being annular, as above described, and the internal ones longitudinal.* The latter are obscure in the small vessels, but quite distinct in those of larger calibre; and these two sets of fibres are now generally classed with the muscular system of organic life. The longitudinal fibres were insisted on by nearly all the older anatomists, yet they were denied by Meckel and by most later observers. The microscope, however, appears to have decided this question in the affirmative.

The *third* or *inner coat* is a thin, smooth, polished and very delicate membrane, which appears to be continuous with the endocardium. Its physical characters resemble those of serous membranes, and like them it is moistened by a serous exhalation. It is divisible into two laminæ; the internal one answers to the general description just given, and belongs to the class of tes-

* Henlé. Anatomie Générale, ii. p. 33.

selated epithelia; the exterior layer is pierced by numerous minute foramina, and is marked by longitudinal streaks or fibres, whence it is called by Henlé the *striated coat* of the artery. It possesses to a certain extent the elasticity of the exterior layers, and though so delicate in appearance possesses considerable firmness.

Besides these three tunics composing the arteries, they derive a loose envelope from the surrounding cellular tissue called the *sheath*, which is developed with particular strength around some of the large vessels, and is traceable in part to the fibrous structure of the contiguous fascia. Such sheaths sometimes enclose not only the artery, but the attendant vein and nerve.

Some deep-seated arteries, and especially those of the brain, possess the three essential tunics in a more attenuated form than the arteries elsewhere. For example, those of the brain are so thin that the middle coat was at one time supposed not to exist in them. Hence the cerebral arteries collapse when they are empty, are more subject than other vessels of this class to rupture during life, and the blood is more distinctly seen through these parietes.

The arteries are for the most part deeply seated in order to protect them from injury; they communicate freely with each other by *anastomosis*, which becomes more frequent in proportion as the vessels are distant from the heart. Anastomosis is of several kinds; it may be by inosculation, in which two arteries coming from opposite directions open into each other; in other instances the vascular trunks are connected by transverse vessels that meet the former at right angles; and again, the anastomosis by convergence is that in which two arteries join to form a larger trunk. Anastomoses are rare among large arteries; but in the smaller vessels they are developed to such an extent, that large trunks may be obliterated by ligature and yet the circulation will be fully maintained by anastomotic communication.

The arteries also terminate in the capillary system, and by this arrangement become everywhere continuous with the veins, whence is established the circle of the circulation of the blood.

The arteries are supplied both with arteries and veins, *vasa vasorum*, or, more specifically, *vasa arteriarum*, which are derived from the contiguous trunks. They can be readily demonstrated in the middle coat, but are very obscure in the inner layer. The *veins* of this system are derived in a corresponding manner with the arteries.

The arteries are also provided with *nerves*, and they are said to be more numerous in the systemic than in the pulmonary class of vessels. They are, moreover, larger and more numerous in the smaller than in the large arteries. Thus the trunk of the aorta and the arteries of the neck, chest, abdomen and skull, derive their nervous filaments from the organic system only; while the arteries of the extremities, on the contrary, receive filaments from the contiguous nerves of animal life. In some arteries no nerves have hitherto been demonstrated, as in the umbilicals; and they rapidly diminish and disappear in the visceral arteries.*

* Meckel. Anatomy, i. p. 115.

Function of the arteries.—The proverbial function of the aortic system of vessels, is to convey the decarbonized blood from the heart to every part of the body.

THE AORTA.

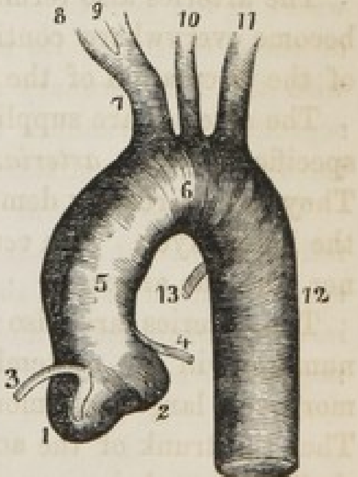
The aorta is the largest artery of the human body and the trunk of the arterial system. It arises from the left ventricle of the heart, at a point opposite the body of the fourth thoracic vertebra. It is not continuous with the heart's structure, but, as heretofore shown, is connected to it by a ring of fibrous tissue that distinctly marks the boundary between its cavity and the ventricle. The muscular fibres of the heart, however, form an annular border for a short distance round the commencement of the vessel, and the two are connected by cellular tissue; while the endocardium of the one and the internal coat of the other, present an unmodified continuity of structure.

The aorta at its origin is about an inch in diameter; and it presents at this point the three dilatations resulting from the position of the semilunar valves, already described as the sinuses of Valsalva. Fig. 275, 1, 2.

The aorta is divided into three sections,—its arch, its thoracic and its abdominal portions. Of these the *arch* is seen to originate opposite the left side of the body of the fourth cervical vertebra, whence it ascends at first obliquely forwards and a little to the right, behind the middle bone of the sternum, until it reaches the second intercostal space on the right side. Fig. 275.

The aorta now changes its course and makes a curve towards the left side, being directly behind the junction of the upper and middle bones of the sternum, and on a level with the body of the second thoracic vertebra. This is the *transverse* part of the arch: it gives off the three great arteries that go to the head and upper limbs, and in front of it are placed the thymus gland and the vena innominata, while behind it are the trachea and the left recurrent nerve.

Fig. 275.



Arch of the aorta. Modified from Quain.

Fig. 275. Arch of the aorta and the vessels given off from it. 1, 2, dilated origin of the artery, showing the position of the sinuses of Valsalva; 3, right coronary artery; 4, left coronary; 5, ascending aorta; 6, its arch; 7, arteria innominata; 8, right subclavian artery; 9, right primitive carotid; 10, left primitive carotid; 11, left subclavian artery; 12, descending or thoracic aorta; 13, remains of the ductus arteriosus of the fœtus.

This much of the arch is called its *ascending limb:* it lies at first in front of the right pulmonary artery and has the superior vena cava at its right side; but as it continues to ascend the pulmonary artery is found at the right side of the aorta. This portion of the vessel is contained within the sac of the pericardium, the serous layer of which invests it at every part except where it lies in contact with the pulmonary artery.*

* Cyclop. of Anat. and Phys., art. *Aorta.*

The *descending* portion of the arch is the smallest of its three divisions: it commences where the transverse portion ends at the left side of the second dorsal vertebra, and inclining downwards reaches the body of the vertebra below (third dorsal), at the inferior margin of which the arch of the aorta is merged into the great thoracic trunk without any line of demarkation. This descending portion lies immediately behind the division of the pulmonary artery, and the two vessels are connected by the ligamentous remains of the ductus arteriosus. It is in contact with the thoracic duct and esophagus, which lie on its inner side; and it is crossed by the left pneumogastric nerve.

The arch of the aorta thus formed, encloses within its curve the pulmonary artery at its point of bifurcation, the left auricle, the left recurrent nerve and the root of the left lung.

From the termination of the arch the aorta descends in a vertical direction, and is called the thoracic aorta until it perforates the hiatus aorticus of the diaphragm, Fig. 275, 12; after which, until its bifurcation into the primitive iliacs, it bears the name of abdominal aorta. We now proceed to describe the branches given off by this great vessel.

THE CORONARY OR CARDIAC ARTERIES.

The vessels are two in number, the right and left coronary arteries. They are the first branches given off from the aorta, as heretofore observed, having their origin immediately beyond the semilunar valves.

The *right coronary artery* is first seen between the pulmonary artery and the right auricle, whence it takes an oblique course towards the right side of the heart, being lodged in the fissure that separates the right auricle and ventricle. Following the track of this fissure it gets to the posterior face of the heart, where in the groove between the ventricles it divides into two branches: one of these continues its way in the auriculo-ventricular groove and anastomoses with the left coronary artery; the other branch follows the inter-ventricular septum, gives branches to each ventricle, and terminates by anastomosing with the left coronary at the apex of the heart. Fig. 270.

The *left coronary artery* is given off from the aorta nearly opposite to its fellow. It is at first behind and concealed by the pulmonary artery, but soon appears on the left of that vessel, enters the inter-ventricular fissure and divides into two branches, which are distributed to both surfaces of the heart in the manner already described (p. 392).

THE ARTERIA INNOMINATA.

This large trunk arises from the transverse portion of the arch of the aorta at its commencement, and runs obliquely upwards and to the right side until it arrives opposite to the sterno-clavicular articulation, where it bifurcates into the right subclavian and right carotid arteries. It is thus placed behind the first bone of the sternum and in front of the trachea which it crosses obliquely;

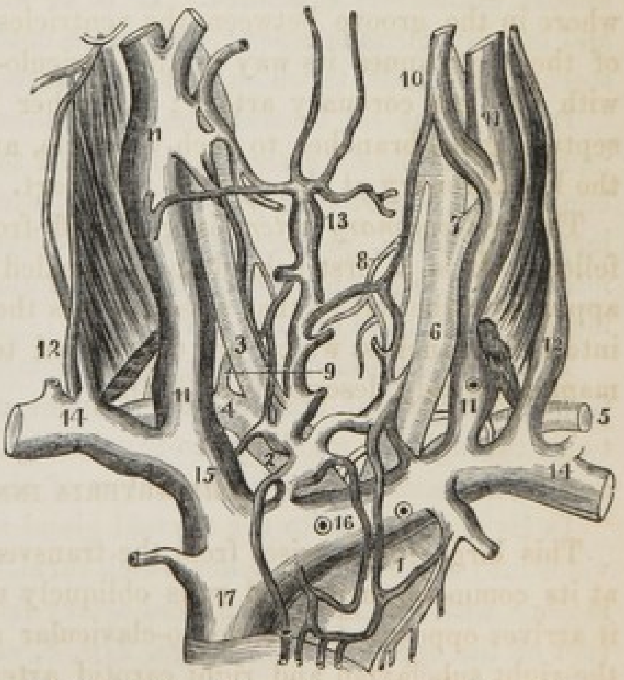
on its right side is the vena innominata, and on its left the thymus gland and left carotid artery. Its length varies from an inch to two inches. Fig. 275, 7.

THE COMMON OR PRIMITIVE CAROTID ARTERIES.

These vessels have a difference of origin, and are consequently varied in length and in some respects in relative position; for the right carotid being given off from the arteria innominata, is shorter than its fellow; while the left carotid arises from the highest part of the arch of the aorta, close to the arteria innominata. From these points, however, they have an analogous course and termination. As they emerge above the upper bone of the sternum, each carotid is covered by the sterno-hyoid, sterno-thyroid and sterno-mastoid muscles. Its course is nearly vertical from its origin to its termination on a level with the upper border of the thyroid cartilage. The primitive carotid gives off no branches and preserves an equal calibre throughout. On its inside are the trachea, the thyroid gland, the larynx, the esophagus and the pharynx; in other words, these parts separate the two arteries from each other. Behind it are the transverse processes and the longus colli muscle; and it is crossed obliquely in front by the omo-hyoid muscle, on a level with the lower part of the thyroid cartilage. The carotid throughout the greater part of this course is distinctly felt pulsating beneath the skin; and its central and upper portion is covered only by the integuments, the platysma myoides, and the fascia of the neck.

The primitive carotid has important relations with the internal jugular vein and pneumogastric nerve; for all three are embraced in a common *sheath* derived from the deep cervical fascia. The vein lies on the outside of the artery, and the nerve is placed between them. Fig. 276, 3, 6, and Fig. 277, 1.

Fig. 276.



Relative position of the arteries and veins of the neck.

Fig. 276. Relative position of the arteries and veins of the neck. 1, aorta; 2, arteria innominata; 3, right primitive carotid; 4, right subclavian artery; 5, left subclavian artery; 6, left primitive carotid; 7, its bifurcation into the internal and external carotids; 8, superior thyroid artery; 9, vertebral artery; 10, facial vein; 11, internal jugular; 12, external jugular; 13, thyroidal vein; 14, 14, subclavian vein; 15, vena innominata or brachiocephalic vein of right side; 16, same of left side, called also the transverse vein; 17, vena cava descendens.

The primitive carotid bifurcates at the upper border of the thyroid cartilage, opposite the

angle of the jaw, and thus forms the external and internal carotids, the one going to the exterior of the head and face; the other to the brain. Fig. 276, 7.

THE EXTERNAL CAROTID ARTERY.

This vessel extends from its origin just indicated to the condyle of the lower jaw, at which point it divides into two great branches, the temporal and internal maxillary. It ascends in a nearly vertical direction, being at first on the inner side of the internal carotid; but it soon becomes the most superficial of the two, and for a short distance is covered only by the integuments and platysma myoides. It soon after sinks beneath the stylo-hyoid and digastric muscles, and in its further progress disappears in the parotid gland, where it is crossed by the facial nerve. It is also crossed near its origin by the hypoglossal nerve, and behind it is separated from the internal carotid by the stylo-glossus and stylo-pharyngeus muscles, and by the glosso-pharyngeal nerve. During its short course it gives off many large and important arteries to the thyroid gland, the tongue, the face, the pharynx, the ear, &c., and we next proceed to examine them in the usual order of succession. Fig. 277, 2.

THE SUPERIOR THYROID ARTERY.

The *superior thyroid artery* arises from the external carotid at or near the point of bifurcation, behind the angle of the jaw. It runs downwards and forwards in a tortuous manner, until it reaches the thyroid gland, upon which it is almost exclusively expended. It is at first covered by the platysma myoides and omo-hyoideus muscles; but before entering the gland it passes under the sterno-thyroideus, to which muscles it furnishes a variable number of twigs.

It also gives off several small branches which have received the following names:—The *hyoid artery* is distributed to the parts connected with the hyoid bone. The *superior laryngeal artery*, which runs inwards with the superior laryngeal nerve, perforates the thyro-hyoid ligament, and thus reaches the interior of the larynx, where it is distributed to the internal muscles, glands and mucous membrane of that cavity.

The *crico-thyroid artery* sometimes comes off from the main trunk, sometimes from the laryngeal branch. It is spent upon the crico-thyroid muscle, sends twigs through the middle crico-thyroid ligament to the interior of the larynx, and then anastomoses with its fellow of the opposite side.

In its distribution to the thyroid gland the thyroid artery divides and subdivides into numerous branches which furnish every part of the structure, anastomosing with the inferior thyroid artery from below, and with the superior thyroid of the opposite side. Figs. 276, 8, and 277, 4.

In some instances the superior thyroid is given off from the common carotid;

and more rarely it forms a common origin with the lingual and even with the facial artery. Sometimes the artery is double. Fig. 277, 4.

THE LINGUAL ARTERY.

The lingual is given off from the inside of the external carotid half an inch or an inch above the superior thyroid. It is at first superficial, but is soon covered and concealed by the digastric and stylo-hyoid muscles; it afterwards passes between the hyo-glossus muscle and the middle constrictor of the pharynx to reach the under surface of the tongue, along which it runs to the apex. The hypo-glossal nerve runs nearly parallel with the lingual artery until they reach the posterior border of the hyo-glossus muscle, where they separate. The lingual artery gives off in its course the following branches:

The *dorsalis linguæ*, which is sometimes represented by a single vessel, and in other instances by several, arises from that part of the artery which is beneath the hyo-glossus muscle. It is distributed to the upper part of the surface of the tongue, about its base, to the palate, tonsils and epiglottis.

The *sublingual branch* runs outwards between the mylo-hyoid and genio-hyo-glossus muscles, to be distributed upon the sublingual gland, the adjacent muscles, and to the gums and lining membrane of the mouth.

The *ranine branch*, *arteria ranina*, is the continuation of the lingual. It runs forward on the under surface of the tongue, between the lingualis and the genio-hyo-glossus muscles and beneath the mucous membrane, and terminates at the tip of that organ by anastomosing with the artery of the other side. It sends off many small twigs in its course, and is accompanied by the gustatory branch of the trigeminus nerves and by the ranine vein. Beneath the apex of the tongue the two ranine arteries are superficial, one being on each side of the frænum linguæ.

The lingual artery sometimes forms at its origin a common trunk with the facial or with the superior thyroid artery. Fig. 277, 5.

THE FACIAL ARTERY.

The facial is also called the external maxillary artery. It comes off from the external carotid just above the lingual, and beneath the stylo-hyoid and digastric muscles. Emerging from its deeper connections, it runs forward and upward to reach the lower jaw, over which it crosses in front of the masseter muscle. In this part of its course, the artery is immediately beneath the skin, where its pulsations may be distinctly felt. It next passes forward to the angle of the mouth, ascends on the side of the nose, and terminates by anastomosing with the ophthalmic artery at the inner canthus of the eye. It gives off the following branches in its course. Fig. 277, 6.

The *inferior palatine artery*, which ascends to be distributed to the velum palati, spreading in small twigs upon the arch of the palate and the uvula. It also sends branches to the Eustachian tube, the tonsils and the styloid muscles.

The *submaxillary branches* are distributed to the gland of that name. The *submental branch* is given off just before the artery passes over the jaw, and runs forward over the belly of the digastric muscle and beneath the origin of the mylo-hyoideus, to reach the symphysis. It now ascends upon the front and central part of the jaw, to be distributed to the chin and lower lip; anastomosing at the same time with the inferior maxillary artery at its exit from the anterior mental foramen, and with the inferior coronary artery of the mouth. Fig. 277, 7.

The preceding branches are given off from the facial before it leaves the neck. After it curves over the jaw and reaches the face, it sends off another series in the following order.

The *inferior labial* arises from the facial on the side of the jaw, and running forwards beneath the depressor anguli oris muscle, is distributed upon the muscles of the lower lip and the proximate integuments.

The *inferior coronary artery* comes from the facial near the angle of the mouth, and penetrating the orbicularis oris muscle, takes a tortuous course through the lip, to which it is distributed. It anastomoses with its fellow of the opposite side. Fig. 277, 8.

The *superior coronary artery* comes also from the facial at the corner of the mouth and is distributed upon the upper lip, inosculating with its fellow. A twig from this vessel runs along the septum to the point of the nose. Fig. 277, 9.

The *lateral nasal artery* runs upwards at the side of the nose, beneath the levator labii superioris alæque nasi, sends branches to the ala and dorsum, and then anastomoses with the artery of the septum narium, and the ophthalmic and infra-orbitar arteries. Fig. 277, 6.

The *angular* or *lateral nasal artery* is the continuation of the facial. It ascends on the side of the nose, gives branches to the cheek and eyelids; and growing gradually smaller, arrives at last near the inner canthus of the eye, and inosculates with the ophthalmic artery.

The facial artery sometimes forms with the lingual a common origin from the external carotid.

THE PHARYNGEAL ARTERY.

The *pharyngeal*, or inferior pharyngeal, is a delicate, elongated vessel of variable origin. It generally arises about half an inch above the bifurcation of the primitive carotid, from which point it ascends vertically between the external and internal carotid, to the cranium. Fig. 277, 11. Its branches are the following.

The *pharyngeal branches*, which go to the pharynx, the Eustachian tube and tonsil. A twig distributed to the soft palate is called the *palatine* branch. It encircles the palate of its corresponding side, and anastomoses with its fellow of the opposite side.

The *meningeal branches* enter the cranium at two points; one at the posterior foramen lacerum, in company with the jugular vein; and the other through the foramen lacerum anterius. Both are distributed upon the dura mater.

THE OCCIPITAL ARTERY.

The occipital comes from the external carotid nearly opposite the facial artery, and turning upwards, gets below the posterior belly of the digastric muscle and the parotid gland, and in front of the transverse process of the atlas. It then curves backward under the trachelo-mastoid, splenius and complexus muscles and emerges near the central ridge of the occiput. It next perforates the trapezius muscle, and rising almost vertically, sends off its branches over the whole posterior face of the cranium. Fig. 277, 10, 12, 12. The following are its branches.

The *sterno-mastoid* is a small but constant twig that goes to the sterno-mastoid muscle.

The *auricular branch* runs to the back part of the concha of the ear.

The *cervical branch* is distributed to the muscles on the back of the neck. Fig. 277, 13.

The *meningeal branch* enters the cranium through the posterior foramen lacerum, and is distributed to the contiguous part of the dura mater.

The *superficial branches* diverge in several small and tortuous vessels, which supply first the posterior bellies of the occipito-frontalis muscle, then cover the occipital region and end by inosculating with the contiguous branches of the temporal artery, by which arrangement a vascular network is formed over nearly the whole surface of the cranium. Two branches given off from the occipital in this course deserve notice; one of these passes through the mastoid foramen into the cranial cavity and is distributed on the dura mater; and another reaches the same cavity through a small foramen in the occipital spine.

THE POSTERIOR AURICULAR ARTERY.

The *auricularis posterior* is given off a very short distance above the occipital at the lower margin of the parotid gland. Sometimes it is absent, and is always a very small vessel. In some instances it is derived, not from the external carotid, but from the occipital and even from the pharyngeal artery. Directly after its origin it ascends under cover of the parotid gland across the styloid process and over the digastric muscle, and then rises up behind the ear. In this course it sends twigs to the gland and digastric muscle, and then furnishes the two following branches. Fig. 277, 14, 14.

The *tympanic artery*, *arteria tympani*, runs to the root of the ear-cartilage, inosculates with the tympanic branch of the internal maxillary, and spreads itself around the meatus externus and upon the membrana tympani.

The *stylo-mastoid branch* is of considerable size. It enters the stylo-mastoid foramen, and reaching the internal ear, gives branches to the membrana tympani, the stapedius muscle, the semicircular canals and the cells of the mastoid process.

After giving off the preceding branches this artery ascends behind the ear,

gives twigs to the concha of the ear, to the posterior auris muscle and to the fascia of the temporal muscle, where it ends by inosculating with the smaller branches of the temporal artery.

Immediately after the external carotid has given off the posterior auricular branch, it ascends vertically in the substance of the parotid gland, to which it gives small branches; but when it reaches the level of the neck of the lower jaw, it loses its name of external carotid by dividing into two large vessels, the *temporal* and the *internal maxillary*. Fig. 277, *.

THE TEMPORAL ARTERY.

While the internal maxillary curves under the jaw, the temporal artery runs directly forwards through the substance of the parotid gland, between the meatus auditorius and the condyle of the lower jaw, and then appears directly in front of the ear, where it is superficial. Fig. 277, 15. Ascending from the base of the zygoma, it lies beneath the integuments and upon the temporal muscle until it reaches about two inches above the meatus of the ear, where it divides into two branches. The following arteries are given off in this course.

After some inconstant twigs to the masseter muscle and parotid gland, the temporal gives off the *transverse facial artery—transversalis faciei*—within the substance of the gland. This vessel, which is the size of a crow's quill, runs through the parotid, and emerges from it on the face just below the malar bone: it then pursues a horizontal course across the cheek nearly parallel with the parotid duct, and resting on the masseter muscle. It is distributed to the surrounding muscles and integuments, and terminates by anastomosis with the infra-orbitar and facial arteries on the side of the face. Fig. 277, 15′.

The *middle temporal artery* arises from the temporal a short distance below the zygoma, perforates the temporal fascia, and sends many branches to the temporal muscle, which anastomose with others from the deep-seated temporal arteries. Fig. 277, 17.

The *anterior auricular arteries* come from the middle temporal. They are distributed to the ear,—the pinna, lobus and external meatus, and anastomose with the posterior auricular arteries.

The temporal artery ascends between the skin and temporal muscle, and further divides into an anterior and posterior branch.

The *anterior temporal artery* runs forward over the temporal fascia, to be distributed upon the orbicularis oculi and occipito-frontalis muscles and the integuments of the cranium. It also anastomoses with the supra-orbitar and frontal branches of the ophthalmic artery. Fig. 277, 18.

The *posterior temporal artery* is the larger of the two. It curves backward above the ear upon the temporal fascia, and is distributed to the pericranium of the lateral, upper and posterior surfaces of the head, inosculating with its fellow of the opposite side, and with the occipital and posterior auricular arteries. Fig. 277, 16.

The smaller twigs perforate the bone through numberless small foramina and terminate in the diploic structure.

THE INTERNAL MAXILLARY ARTERY.

This important vessel leaves the external carotid, or in other words separates from the temporal artery, within the parotid gland, and runs between the neck of the lower jaw and the external pterygoid muscle. It then curves forward until it touches the posterior wall of the antrum, still covered by the ramus of the lower jaw and by the temporal muscle, and terminates in the spheno-maxillary fissure at the bottom of the orbit, at which point it gives off its terminal branches. In this course the artery is extremely tortuous, and besides some twigs to the adjacent parts, distributes the following important branches.

The *tympanic artery—arteria tympanica*—runs behind the articulation of the lower jaw, enters the fissure of Glasser and is distributed upon the laxator tympani muscle, the membrana tympani and the cavity of the tympanum.

The little *meningeal artery—meningea parva*—passes through the foramen ovale, and getting within the cranium is distributed upon the dura mater. Sometimes it is a branch of the following vessel.

The *great meningeal artery—arteria meningea magna*—called also the middle artery of the dura mater, is given off by the internal maxillary directly after its origin. It runs vertically beneath the external pterygoid muscle to the foramen spinale of the sphenoid bone, through which it passes and thus enters the cavity of the cranium. It extends along the middle fossa of the skull to the anterior inferior angle of the parietal bone, at which point it is often lodged in a canal formed in the bone; and it then diverges to the sagittal suture in many arborescent ramifications which extend posteriorly to the occiput, and which are received into corresponding furrows on the cranial bones. Just within the cranium it sends branches to the dura mater near the sella turcica; and one named the *vidian*, enters the aqueduct through the vidian foramen and supplies the facial nerve, ramifying on its neurilemma and anastomosing with the styloid branch of the occipital artery.

The *inferior maxillary* or dental artery—dentalis inferior—enters the posterior mental foramen, at which point it sends off a small branch, the *mylo-hyoid*, to the muscle of that name. It traverses the canal its whole length, and gives twigs to each of the teeth: these twigs enter the orifice in the fang and are distributed upon the pulp, and the artery subsequently escapes from the anterior mental foramen and appears on the side of the chin, where it anastomoses with its fellow of the opposite side and with the inferior coronary and submental arteries.

The *deep temporal arteries*—arteriæ temporales profundæ—are two in number, the anterior and the posterior. They run upwards beneath the temporal muscle, to which they are chiefly distributed, and finally anastomose with the other temporal arteries. Small twigs from this source penetrate the malar bone

into the orbit to supply the fat and periosteum of the socket, and in part the lachrymal gland.

The *pterygoid arteries* are several small branches distributed upon the pterygoid muscles.

The *buccal artery*—arteria buccalis—perforates the buccinator muscle, upon which and the other muscles of the cheek it is almost exclusively expended. It inosculates with the other arteries of the face.

The preceding branches of the internal maxillary artery are given off while that vessel is in connection with the muscles. A short distance before it enters the spheno-maxillary fissure, and while in that fissure, it supplies the following additional arteries.

The *superior maxillary*—alveolaris—is given off at the tubercle of the lower jaw behind the antrum, and takes a tortuous course towards the face and cheek. It gives branches to the buccinator muscle, and the adipose tissue beneath it; other branches terminate in the antrum; and a third set enter the foramina of the bone, in order to reach the alveoli, and are distributed on the molar and bicuspid teeth of the upper jaw.

The *infra-orbitar artery* arises from the internal maxillary in the spheno-maxillary fissure, and sending some small twigs to the periosteum and fat of the orbit, enters the infra-orbitar canal and makes its exit from the infra-orbitar foramen below the orbit. During this course it sends ramuscles upward to the rectus inferior and obliquus inferior muscles, and to the lachrymal gland. Before emerging it also sends a branch downward which goes to the canine and incisor teeth and to the adjacent gum. On reaching the infra-orbitar foramen, this artery is finally expended upon the levator anguli oris and levator labii superioris, and inosculates with the other arteries of the face,—the buccal, the facial and the nasal. The infra-orbitar artery is accompanied through its bony canal by the nerve of the same name, and they make their exit together.

The *descending palatine artery*—palatina superior—comes from the internal maxillary within the spheno-maxillary fissure. It descends through the posterior palatine canal in order to reach the back part of the roof of the mouth, whence it runs forward towards the teeth, supplying the gums and mucous membrane in its course, and sends a twig upwards through the foramen incisivum to inosculate with the artery of the septum in the nostril.

The *vidian branch*, a small vessel, comes off from the internal maxillary nerve or with the descending palatine, and running backwards, enters the pterygoid foramen and is distributed to the Eustachian tube, the top of the pharynx and the sheath of the vidian nerve, with which it is associated.

The *pterygo-palatine*, or pharyngea superior, runs through the pterygo-palatine canal and supplies the adjacent parts of the pharynx and Eustachian tube.

The *spheno-palatine*, or nasal artery, is the terminal branch of the internal maxillary. It enters the cavity of the nostril through the spheno-palatine foramen, and divides into two branches which lie between the mucous membrane and periosteum: it sends branches backward to the sphenoidal and ethmoidal cells; a longer branch to the back part of the septum narium, and a yet

longer branch to inosculate with the descending palatine artery where the latter comes up through the foramen incisivum. In this course the spheno-palatine artery is freely distributed upon the Schneiderian membrane, and sends branches to the antrum.

Fig. 277.

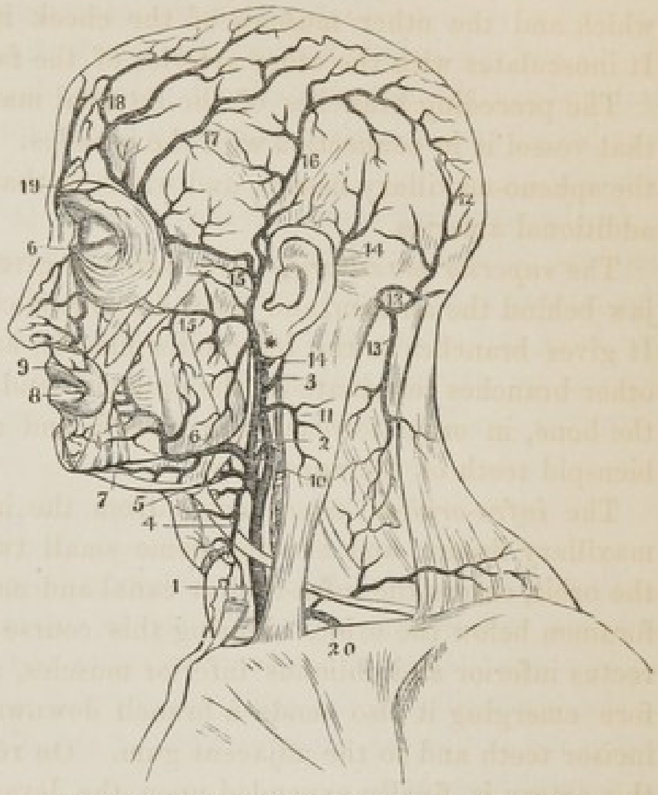


Fig. 277. 1, primitive carotid; 2, external carotid; 3, internal carotid; 4, superior thyroidal; 5, lingual; 6, facial; 7, submental; 8, inferior coronary; 9, superior coronary; the course of these coronary arteries from the facial trunk and beneath the muscles of the mouth, is marked by a dotted line; 6 (above), terminal anastomosis of the facial with the ophthalmic artery; 10, occipital artery, running under the digastric muscle to reappear from beneath the cranial attachment of the trapezius at 12; 12 (above), its occipital branches; 13, its cervical branch; 11, pharyngeal artery; 14, 14, posterior auricular artery; *, point at which the external carotid divides into the temporal and internal maxillary; 15, trunk of the temporal; 15′, transverse facial; 16, posterior temporal; 17, middle temporal; 18, anterior temporal; 19, supra-orbitar branch of the ophthalmic; 20, subclavian artery.

External carotid artery and its branches. From Quain.

INTERNAL CAROTID ARTERY.

This artery is placed at its origin a little to the outside of the external carotid, with which it often runs parallel for a short distance. Its course is vertical to the carotid canal of the temporal bone, being accompanied by the internal jugular vein, which lies exterior to the artery. At first it is covered only by the platysma myoides and the integuments; but when it reaches the level of the lower jaw, it is crossed by the stylo-hyoid and digastric muscles and by the hypoglossal nerve. Higher up and under cover of the parotid gland, the internal carotid artery is crossed by the stylo-glossus and stylo-pharyngeus muscles and the glosso-pharyngeal nerve, all of which are interposed between it and the external carotid, while in the neck it gives off no branches. Fig. 277, 3.

On entering the carotid canal, it follows the sinuous course of that passage to its termination, and then ascends through and within the cavernous sinus at the side of the sella turcica. The artery is applied against the inner wall of the sinus, but is said to be separated from the blood contained in that cavity by

a very thin membranous envelope continuous with the internal coat of the veins. It now turns directly upward, perforates the dura mater and separates into its three branches at the inner margin of the fissure of Sylvius.

While in the carotid canal it is separated from the bone by a thin lining process of dura mater and is in contact with the carotid plexus of nerves. The cavernous portion—that within the cavernous sinus—is crossed by the third, fourth and ophthalmic nerves. The cerebral portion, after penetrating the dura mater above the anterior clinoid process, derives a sheath from the arachnoid membrane, and is in close proximity to the optic nerve which lies on its inner side.

In the preceding course of the internal carotid in its cervical, carotid and cerebral portions, it gives off no branches excepting a very small vessel while in the carotid canal, which under the name of the tympanic branch, perforates the bone and enters the tympanum, and some twigs within the cavernous sinus, *arteriæ receptaculi*, that go to the parietes of that sinus and the proximate dura mater. The proper branches of the internal carotid are the following.

THE OPHTHALMIC ARTERY.

This vessel is given off from the internal carotid directly above the clinoid process, and taking a forward course enters the optic foramen beneath the optic nerve. It soon, however, curves to the outside of the nerve, and again to the inner side of the orbit crosses the nerve in an oblique direction, and makes its exit at the inner canthus of the eye. In this spiral course it sends off several branches.

The *lachrymal artery* arises just within the orbit and takes its course along the roof of the orbit beneath the periosteum, and above the abductor muscle. It is distributed upon the lachrymal gland. It sends twigs to the eyelids and conjunctiva, and others into the cranium through the sphenoidal fissure.

The *central artery of the retina* is also given off from the ophthalmic just within the orbit. It penetrates the centre of the optic nerve and thus reaches the retina, to be spread upon its internal surface. Here it terminates in the adult; but in the fœtus it can be traced through the vitreous humor to the capsule of the lens.

The *supra-orbitar artery* runs along the roof of the orbit above the muscles, and reaching the supra-orbitar notch, ascends on the forehead and is spent upon the periosteum and muscles of the forehead. At the notch it sends a branch inwards to the diploë. Fig. 277, 19.

The ciliary arteries.—These vessels are divided into the short ciliary, the long ciliary and the anterior ciliary arteries. The *short ciliary* are ten or twelve in number, which first enclose the optic nerve, then pierce the sclerotic coat and enter the eye close to the nerve itself. They run forward and supply the choroid coat and ciliary processes. The *long ciliary arteries* are two in number. They also perforate the sclerotica and run along on opposite sides of

the eyeball, between the choroid coat and the sclerotica to the ciliary ligament, where they divide. They form an annular artery around the circumference of the iris by anastomosing with each other, and from this circle straight branches are sent forward to the iris, which form a second circle around the pupil of the eye. The *anterior ciliary arteries* are derived from the muscular branches, and in part from the lachrymal and infra-orbitar. They penetrate the sclerotic coat a line or more behind the cornea, and terminate in the great circle of the iris. All these ciliary arteries anastomose within the ball of the eye, forming a beautiful and complicated vascular network. *See the Eye.*

The muscular branches.—These are generally two in number, one of which is superior, the other inferior, but the former is often deficient. When present it goes to the muscles of the upper region of the orbit,—the levator palpebræ, levator oculi and obliquus superior. The inferior branch supplies the rectus inferior and exterior, the obliquus inferior, the lachrymal sac and the lower eyelid.

The anterior and posterior ethmoidal arteries.—The anterior ethmoidal comes from the ophthalmic opposite the anterior orbitar foramen, through which it passes together with the nasal branch of the ophthalmic nerve. It first gives branches to the ethmoidal cells and frontal sinuses, and then enters the cavity of the cranium to be distributed upon the contiguous parts of the dura mater. It also sends branches downward through the cribriform plate to the nasal cavity and Schneiderian membrane. The *posterior ethmoidal artery* passes between the levator palpebræ and rectus externus muscles, above the superior oblique, and enters the cranium through the posterior ethmoidal foramen. Its distribution is similar to that of the anterior ethmoidal artery.

The *palpebral arteries,* superior and inferior, come from the ophthalmic near the trochlea of the superior oblique muscle. They are distributed to both eyelids, the orbicularis muscle, the tarsal cartilages, the caruncula lachrymalis and lachrymal sac.

The *nasal branch* comes from the ophthalmic artery in the inner canthus of the eye, and passes over the upper part of the lachrymal sac to the nose, along which it passes to anastomose with the facial artery. It sends twigs to the lachrymar sac. Fig. 277.

The *frontal branch* is near the nasal. It turns upward to the forehead where it is distributed, by three branches, to the eyebrows, the forehead and the pericranium, and anastomoses with the supra-orbitar artery. Fig. 277, 19.

The internal carotid artery, after sending off the ophthalmic in the manner just described, separates into three large vessels that pass in different directions into the brain. We proceed to notice these branches.

THE ANTERIOR CEREBRAL ARTERY.

The *anterior cerebral artery*—anterior cerebri—is given off at the fissure of Sylvius, either from the carotid or from the middle artery of the brain, and runs forwards in the median line of the skull and nearly parallel with its fellow of the opposite side. Fig. 278, 10. It gives twigs to the olfactory and optic

nerves, and as it approaches the cribriform plate a short branch is sent transversely from one to the other: this is the *communicating artery*, which completes the circle of Willis in front. Fig. 278, 11. This arrangement takes place just in front of the pituitary gland. From its centre the communicating artery sends down a small vessel to the third ventricle, and to the anterior part of the septum lucidum and fornix. After this communication each cerebral artery curves round the anterior face of the corpus callosum in the fissure between the hemispheres, and there dividing into two branches takes a backward course: one of these branches, the *arteria callosa*, goes to the corpus callosum, to which it is distributed; the other branch runs on the flat surface of the brain between the hemispheres, and forming an arch within the pia mater, is subsequently spent upon the contiguous brain. These arteries finally anastomose with the posterior cerebral artery.

THE MIDDLE CEREBRAL ARTERY.

The *middle cerebral artery*—media cerebri—comes from the internal carotid at the side of the sella turcica, and runs directly into and along the fossa Sylvii between the anterior and middle lobes of the brain, and appears to be the continued trunk of the carotid. In this course it divides into several branches which are distributed to the anterior and middle cerebral lobes, but especially to the latter and to the pia mater, and at last inosculates with the branches of the anterior and posterior arteries of the cerebrum. A small branch winds into the anterior cornu of the lateral ventricle, and forms the plexus of vessels that covers the floor of that cavity. These, one on each side, are the *choroid arteries.* There is also a series of arteries, variable in number and very delicate, that inosculate beautifully with each other over the crura cerebri and basis of the brain, forming in the pia mater a plexus or web of vessels.* Fig. 278, 9.

The *posterior communicating artery* runs backward and a little inward from the middle cerebral, about half an inch in length, and terminates in the posterior cerebral artery. Fig. 278, 8. In this course the two vessels surround the corpora albicantia, the infundibulum and the optic commissure, sending twigs to these parts and to the crura cerebri and choroid plexus. The irregular circuit of vessels thus formed, which varies in size and shape in different individuals, is the *circle of Willis;* a beautiful arrangement by which a complete anastomosis is established between the arteries of the anterior and posterior portions of the brain. Fig. 278.

THE SUBCLAVIAN ARTERIES.

We have seen that the right subclavian arises from the arteria innominata, the left from the arch of the aorta; whence it happens that the former is the shorter of the two. It is also a little larger, and nearer the parietes of the chest.

* Anatomy of the Human Body. By John and Charles Bell, ii. 107.

The origin of the *right subclavian* is opposite the sterno-clavicular articulation. Its *first section* differs in its course from the artery of the opposite side. It curves upward and outward from the carotid, crosses the neck, ascends above the clavicle and ends at the inner margin of the scalenus anticus muscle. Besides the sterno-clavicular articulation, it has in front the platysma myoides muscle, the clavicular origin of the sterno-mastoid, and the sterno-hyoid and sterno-thyroid muscles: the internal jugular and vertebral veins and the pneumogastric and phrenic nerves are also in front of the artery. Behind it is the recurrent laryngeal nerve, and on its inside the pleura separating it from the lung. Fig. 276, 4.

The *first section of the left subclavian* ascends from the arch of the aorta to the margin of the first rib, behind the insertion of the anterior scalenus muscle. Its general relations are much the same as those of the opposite vessel. It has in front the vena innominata, and the pneumogastric and phrenic nerves, which are parallel to it, and the subclavian vein crosses it at right angles. It lies close to the vertebral column, and has behind it the thoracic duct and longus colli muscle. Fig. 276, 5.

The *second and third sections* of the subclavian arteries are analogous on the two sides of the body.

The *second section* is that part which lies between the scaleni muscles and upon the first rib, the latter having a superficial furrow that marks its passage. The anterior and middle scaleni form by their junction a pointed arch over the artery; and the anterior scalenus separates it from the subclavian vein and phrenic nerve. Behind it is the brachial plexus of nerves. At this part of its course the artery can be distinctly felt and readily compressed by the finger.

The *third section* of the subclavian extends from the inner margin of the scalenus muscle to the outside of the clavicle. It here occupies a triangular space bounded in front by the scalenus anticus and sterno-mastoid muscles, above by the omo-hyoideus and below by the clavicle. The subclavian vein lies in front of the artery and between the latter and the clavicle; it does not run between the scaleni muscles, but in front of them. Fig. 276, 14. The external jugular vein is over the artery; and the brachial plexus of nerves is placed above and to the outer side of this portion of the subclavian.* Fig. 276, 12.

The subclavian artery throughout its course, is in apposition with the pleura except where it rests upon the first rib. Its whole length from its origin to its termination is about three inches on the left side and one inch less on the right side. It gives off the following branches: viz. the vertebral, the thyroid axis, the subscapular, the transverse cervical, the internal mammary, the superior intercostal and the deep cervical.

THE VERTEBRAL ARTERY.

The vertebral is the first and largest branch of the subclavian artery. Fig. 276, 9. It enters the foramen of the transverse process of the sixth cervical verte-

* Wilson. Anatomy, p. 317.—Von Behr, § 553.

bra, whence it runs vertically, perforating the upper vertebra of the same series including the atlas. When, however, it reaches the vertebra dentata, it inclines outwards, in which direction it is yet further prolonged in order to reach the atlas. From the latter bone it makes a sudden curve inwards, lies horizontally in the groove in the bone, and then rises vertically into the cranium through the foramen magnum, first piercing the dura mater. The two vertebral arteries run along the basilar process of the occipital bone, and unite at the lower margin of the tuber annulare in a single trunk, the basilar artery. Fig. 278, 1, 2.

Within its canal the vertebral artery is accompanied by the vertebral vein which lies in front of it, and by filaments of the sympathetic nerve which form a beautiful network around the arterial trunk. The following are the branches of the vertebral artery.

The *lateral spinal arteries* are given off from the vertebral in the neck. They enter the intervertebral foramina, are spent upon the spinal cord and its membranes and anastomose with the other spinal arteries.

The *posterior meningeal artery* comes from the vertebral opposite the foramen magnum, one on each side. Entering the cranium, they are distributed upon the dura mater and falx cerebelli.

The *anterior spinal artery* comes from the vertebral near its termination. It unites with its fellow on the front of the medulla oblongata and below the foramen magnum, and descends along the anterior face of the spinal cord, to which it is distributed. It inosculates with other vessels from the inferior thyroid artery above, and from the lumbar, ileo-lumbar and lateral sacral arteries below, to form the anterior median artery, which extends the whole length of the spinal cord in front.

The *posterior spinal artery* curves round the medulla oblongata and thus reaches the posterior face of the cord, along which it extends as low as the second lumbar vertebræ. Near its origin it sends a small branch to the fourth ventricle, and lower down anastomoses with the intercostal and lumbar arteries.

The *inferior cerebellar artery*—profunda cerebelli—arises near the tuber annulare, curves round the upper part of the medulla oblongata in order to reach the under surface of the cerebellum, and there divides into two branches. One of these continues its backward course and gets into the fissure between the lobes of the cerebellum; the other runs outwards and is distributed on the under surface of the cerebellum, anastomosing with the superior cerebellar arteries. This artery is sometimes a branch of the basilar. Fig. 278, 2.

The BASILAR ARTERY, formed as heretofore explained, by the junction of the two vertebrals on the basilar process of the occipital bone, extends almost from the foramen magnum to the posterior clinoid process, where it bifurcates and ends in the posterior cerebral arteries. Fig. 278, 4. The basilar artery gives off the following branches.

The *transverse branches* run to the tuber annulare and proximate parts of the brain. One of its twigs is sent to the labyrinth of the ear, and another passes along the crus cerebelli to the anterior margin of the cerebellum.

The *superior cerebellar artery* comes from the basilar just behind its point of

bifurcation, and almost in apposition with the posterior cerebral vessels. Fig. 278, 5. It winds around the crus cerebri so as to enter the groove between the crus and tuber annulare in close proximity to the fourth nerve, whence it spreads to the upper surface of the cerebellum. Some of its branches anastomose with those of the inferior cerebellar arteries. Other branches go to the valvula cerebri and velum interpositum; and a small twig attends the auditory nerve into the meatus auditorius internus.

The *posterior cerebral arteries*—profundæ cerebri—the terminal branches of the basilar, are separated from the superior cerebellar arteries by the third pair of nerves, which passes through the angle formed by the proximate origins of the two vessels. They wind round the crura cerebri, and then run upwards to reach the posterior lobes of the cerebrum. Fig. 278, 6. "Immediately after its origin the posterior cerebral gives off numerous small parallel branches, which perforate the substance of the brain between its crura, at the point called from this circumstance, the posterior perforated spot—locus perforatus." The posterior cerebral is joined soon after its origin by the posterior communicating artery, to complete the *circle of Willis*, as already described. Fig. 278, 8. The posterior cerebral also gives off small branches to the velum interpositum and choroid plexus, and is then lost in the substance of the brain.

Fig. 278.

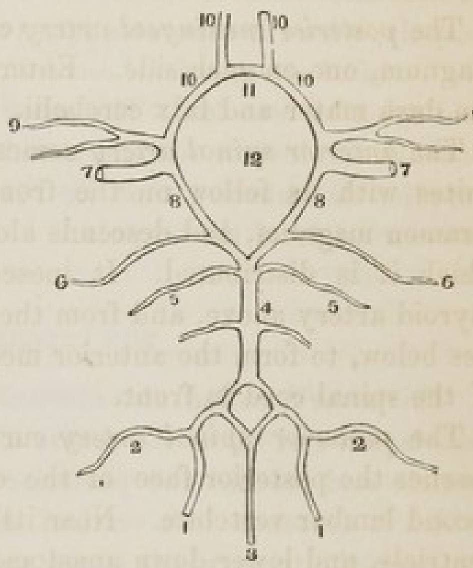


Diagram of the circle of Willis.

Fig. 278. Circle of Willis. 1, 1, vertebral arteries; 2, 2, inferior cerebellar arteries; 3, anterior spinal artery; 4, basilar artery; 5, 5, superior cerebellar arteries; 6, 6, posterior cerebral arteries; 7, internal carotid; 8, 8, posterior communicating branches; 9, 9, middle cerebral arteries; 10, 10, anterior cerebral arteries; 11, anterior communicating artery; 12, circle of Willis.

THE THYROID AXIS.

This artery, remarkable for its large size and short course (which is seldom more than a quarter of an inch), arises from the front of the subclavian near the internal margin of the scalenus anticus muscle. It separates into three large branches—the inferior thyroid, the supra-scapular and the transversalis colli. It is necessary, however, to observe, that these three arteries do not come off invariably from the thyroid axis; on the contrary, they not unfrequently arise from the subclavian itself.

The *inferior thyroid artery* ascends on the inner margin of the scalenus medius muscle, behind the carotid and in front of the longus colli muscle. It next curves inwards and downwards to reach the inferior margin of the thyroid gland which it enters and to which it is distributed, anastomosing freely with the superior thyroidal branches. It gives off a small *laryngeal branch* to the trachea on each side; and a large branch, the *ascending cervical*, that runs

up the side of the neck, and is spent upon the scaleni, longus colli and other cervical muscles. Smaller twigs enter the intervertebral foramina, and are distributed to the vertebræ, the spinal cord and its membranes.

The *supra-scapular artery* generally comes from the thyroid axis, but sometimes directly from the subclavian, and runs downward and outward to reach the superior margin of the scapula: it is at first behind the sterno-mastoid muscle, and has the brachial plexus of nerves behind it. Having arrived at the supra-scapular or cricoid notch, it enters the fossa supra-spinata and is distributed first to the supra-spinatus muscle and afterwards to the infra-spinatus. It not only supplies those muscles, but gives off many branches to the bone and periosteum.

The *transverse cervical*—transversus colli—called also the posterior scapular artery, comes from the thyroid axis, and extends to the vertebral border of the scapula. It runs transversely outward through the nerves of the brachial plexus, and then curves backward towards the posterior superior angle of the scapula, where it separates into two branches. The uppermost of these, called the *cervical* or *superficial cervical*, is spent upon the trapezius, levator scapulæ and splenius muscles. The other branch, the *posterior scapular artery*, curves beneath the levator scapula muscle, and running along the base of the scapula, supplies the muscles that lie between it and the spine, and terminates at the inferior angle of the scapula.

THE INTERNAL MAMMARY ARTERY.

This artery, called also *thoracica interna*, is given off from the front of the subclavian and takes its course along the inner margin of the scalenus anticus muscle and reaches the posterior face of the cartilages of the true ribs, along which it descends in a vertical direction. It lies exterior to the pleura, and between the triangularis sterni and intercostal muscles, about half an inch from the sternum. It finally ends, after a long and straight course, by anastomosing with the epigastric artery on the rectus abdominis muscle. The following branches come from the internal mammary.

The *superior phrenic artery* accompanies the phrenic nerve between the pleura and the pericardium, and is spent upon the diaphragm where it anastomoses with the other phrenic arteries.

The *mediastinal branches* are small and variable in number. They are distributed upon the thymus gland.

The *pericardiac branches* go to the pericardium.

The *anterior intercostal arteries* correspond in number with the intercostal spaces, and are given off from the internal mammary where it crosses these spaces. There are two to each space, either arising separately or coming from a common origin which bifurcates and sends one branch along the lower margin of the rib above, and the other along the upper margin of the rib below. They at first run between the pleura and intercostal muscles, but afterwards get between the two layers of these muscles, to which they are distributed. They also send branches to the pectoral muscles and inosculate with the aortic intercostals.

The *anterior or perforating arteries* arise from the internal mammary, pass directly through the intercostal muscles and then curving outwards, divide into cutaneous and muscular branches. They supply the pectoralis major muscle, and the mammary gland, and are lost in the adjacent integuments.

The internal mammary afterwards divides into two terminal branches, the musculo-phrenic and the superior epigastric.

The *musculo-phrenic* artery runs downwards behind the cartilages of the false ribs, and terminates at the last intercostal space. It is distributed to the diaphragm and abdominal muscles.

The *superior epigastric artery* is the continuation of the internal mammary. It passes down behind the cartilage of the seventh rib, enters the abdomen and lies behind the rectus muscle. It is distributed to the abdominal muscles and particularly to the upper part of the rectus, and finally anastomoses with the epigastric artery from the external iliac.*

THE DEEP CERVICAL ARTERY.

This vessel, the *profunda cervicis*, arises from the upper and back part of the subclavian, and not unfrequently from the superior intercostal. It is situated on the outside of the vertebral and on a level with it. It first passes upwards and backward, curves outward behind the scalenus anticus, and then dips down between the transverse process of the seventh cervical vertebra and the first rib. This tortuous arrangement, according to the observations of Cruveilhier, is remarkably constant. The artery subsequently divides into two branches, one of which ascends between the complexus and semispinalis colli muscles upon which it is chiefly spent; the other branch descends, and is distributed to the muscles of the back as far as the dorsal region.

THE SUPERIOR INTERCOSTAL ARTERY.

This branch of the subclavian comes off from the lower and back part of the latter vessel, sometimes by a common trunk with the deep cervical. It runs backwards in a tortuous course in front of the first or two first ribs, and reaches the second intercostal space where it divides into two branches. One of these goes to the first, the other to the second intercostal space; which latter branch generally anastomoses with the first aortic intercostal. They are distributed to the proximate intercostal spaces and send some terminal branches to the muscles of the back.

THE AXILLARY ARTERY.

The axillary artery is the continued trunk of the subclavian, and consequently begins where the latter ends—at the margin of the clavicle, or rather of the

* Quain and Sharpey. Anatomy, ii. 519.

subclavius muscle, it extends to the lower border of the pectoralis major, where it ends in the brachial artery, thus traversing the axillary region. It is covered in front by the pectoralis major and minor muscles; it lies on the serratus magnus; and lower down is in relation with the latissimus dorsi and teres major muscles which are behind it. At this part the coraco-brachialis muscle is in front of it: the axillary vein lies also in front of it, and the acromial and cephalic vein cross it at its upper part. Above, the axillary artery has the brachial plexus of nerves on its outer side; but beneath the pectoralis minor muscle that plexus surrounds the vessel. It is at first embraced by the external and internal roots of the median nerve; lower down it lies between the external cutaneous nerve on the outside, the median nerve in front, the internal cutaneous and ulnar nerves on its inner side and the radial and circumflex behind.*

The *axillary region* through which the artery thus pursues its course, is an acute-angular cavity of which the point presents upwards. It is bounded in front by the pectoral muscles, and behind by the latissimus dorsi, teres major and subscapularis muscles. The base or bottom of this region is formed by the serratus magnus; and its outer margin is covered by the coraco-brachialis, biceps and subscapularis muscles. This space contains, besides the axillary vessels and nerves, a quantity of lymphatic glands, areolar tissue and adipose matter.

The following are the branches of the axillary artery; but they are so extremely diversified in their origin, number and size, that no two anatomists give the same account of them.

The *thoracica acromialis*, or *acromial thoracic artery*, is a short vessel that ascends above the pectoralis minor muscle and divides into several branches. Two or three of these are distributed to the muscles on the side of the chest,—the serratus magnus and pectoral muscles,—whence their name of *thoracic branches.* Other branches run upwards to the acromion process, upon which and upon the deltoid muscle they are finally distributed. These, from their course, are designated as *acromial branches.* Fig. 279, 5.

The *superior thoracic artery* sometimes arises by a common trunk with the thoracica acromialis; in other instances it comes off independently from the axillary. It runs along the upper border of the pectoralis minor muscle, and is distributed to the mammary gland and pectoral muscles. Fig. 279, 6.

The *external mammary*,—called also *thoracica longa* and *inferior thoracic*,—is either a branch of the axillary, the subscapular or the acromial-thoracic. It runs along the inferior border of the pectoralis minor to the side of the chest, and generally terminates near the sixth intercostal space. It sends branches to the mammary gland, the lymphatic glands of the axilla and the several muscles on the side of the thorax.

The *thoracica axillaris* is a small artery of remarkably variable origin, coming either from the axillary itself or from almost any one of its upper branches, but most frequently, perhaps, from the external mammary. It is distributed to the glands of the axilla. Fig. 279, 7.

* Cruveilhier. Anatomy, p. 542.

THE SUBSCAPULAR ARTERY.

The subscapular artery, *scapularis inferior*, is one of the largest and most constant branches of the axillary. Fig. 279, 8. It arises near the anterior margin of the subscapularis muscle, below the shoulder-joint, and giving branches to the parts contained in the axilla, descends along the anterior border of the subscapularis muscle to be spent upon the teres major and minor muscles and upper part of the latissimus dorsi. In this course it sends off a branch, the *dorsalis scapulæ,* about an inch from its origin; this vessel runs between the subscapularis and latissimus dorsi muscles and afterwards between the teres major and minor, and divides into several branches which are distributed upon the muscles just named. This artery next winds round the lower border of the scapula, and reaches the dorsum of that bone beneath the infraspinatus muscle on which it terminates. This branch is the *dorsalis inferior scapulæ.*

THE ANTERIOR CIRCUMFLEX ARTERY.

The *anterior circumflex artery*—articularis anterior—arises from the axillary above the tendon of the teres major muscle, and sometimes by a common trunk with the posterior circumflex. It runs outward over the united tendons of the latissimus dorsi and teres major, and getting beneath the long head of the biceps and curving upwards on the neck of the humerus, divides into several branches. One of these is distributed to the shoulder articulation,—its capsule, synovial membrane and periosteum. Others go to the deltoid muscle and finally anastomose with branches of the posterior circumflex. Fig. 279, 11.

THE POSTERIOR CIRCUMFLEX ARTERY.

This vessel arises from the axillary a short distance below the anterior circumflex, at the lower edge of the subscapularis muscle. It passes round the neck of the humerus, between it and the long head of the triceps muscle, and terminates in the deltoid muscle and in the apparatus constituting the shoulder-joint. Fig. 279, 10.

THE BRACHIAL ARTERY.

The *brachial artery*—arteria humeralis—lies between the lower margin of the axilla above and the bend of the arm below; that is to say, from the inferior border of the tendons of the teres major and latissimus dorsi muscles to the neck of the radius. Fig. 279, 2, 3. It is covered by the fascia of the arm, and lies at the inner margin of the biceps and coraco-brachialis muscles. It rests upon the coraco-brachialis and brachialis-anticus, and in front of it is the basilic vein which

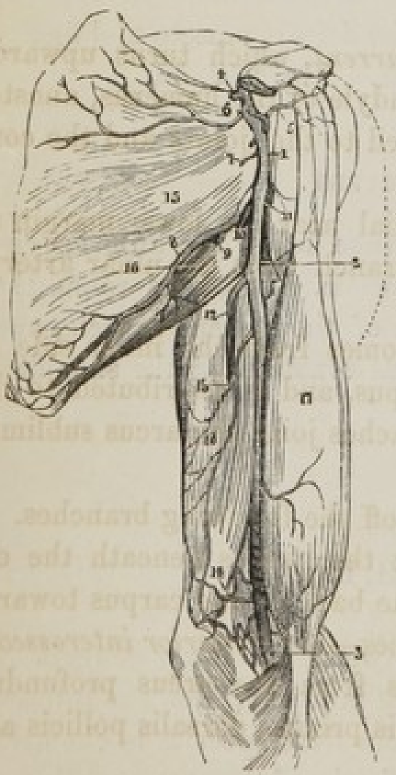
accompanies it nearly its whole length. It has also venæ comites which cross it in various directions and here and there form a plexus around it. The median nerve also lies for the most part in front of the artery; above, however, it is on its outer side; below, near the elbow on its inner side. The following are the principal and more constant branches of the brachial artery.

The *profunda superior*—spiralis—arises from the brachial below the tendon of the latissimus dorsi, soon penetrates between the second and third heads of the triceps muscle and curves round the os humeri to the back of that bone, in company with the musculo-spiral nerve. It subsequently becomes superficial between the triceps and brachialis internus, on the opposite side of the arm, and from this point runs to the external condyle, where it anastomoses with the recurrent branch of the radial artery. In this course it gives inconstant branches to the triceps, to which it is principally distributed, and to the brachialis internus and extensor muscles of the forearm. Fig. 279, 12.

The *nutritious artery* is a very slender branch of the brachial that comes from it about the middle of the arm. It enters the medullary foramen and goes to the interior of the bone, where it is distributed upon the internal periosteum. This artery is sometimes derived from one of the branches of the brachial.

The *profunda minor* arises either above or below the nutrient artery, about the middle of the arm. It takes a curved course to the inner side of the arm, and thence runs downward to the inner condyle and in the sulcus between the latter and the olecranon. It is accompanied by the ulnar nerve and anastomoses with the ulnar recurrent artery. It is chiefly spent on the lower part of the triceps muscle. The profunda minor is not unfrequently given off by the spiralis. Fig. 279, 13.

Fig. 279.



Axillary and brachial arteries. From Quain.

Fig. 279. Axillary and brachial arteries. 1, axillary artery, which ends at 2 in the brachial; 2 to 3, brachial artery; 4, 5, 6, 7, external thoracic arteries; 8, subscapular artery; 9, its dorsal branch; 10, posterior circumflex; 11, anterior circumflex; 12, profunda superior; 13, profunda inferior vel minor; 14, anastomotic artery; 15, subscapularis muscle; 16, teres major; 17, biceps flexor cubiti; 18, triceps.

The *anastomotic artery* comes from the brachial about two inches above the joint. It lies upon the brachialis internus muscle, and running inwards, gets above the internal condyle of the humerus, and divides into two branches which anastomose with the profunda inferior and the posterior ulnar recurrent arteries. Fig. 279, 14.

The brachial artery is subject to great variations of origin. Instead of bifurcating at the elbow, it not unfrequently gives off the radial at or near its upper third. Sometimes the division is much higher up; in other instances, just

above the bend of the arm. This inconstancy is not confined to the brachial artery, but is common to all its branches.

The bifurcation of the brachial artery produces the radial and ulnar arteries.

THE RADIAL ARTERY.

This vessel appears like the proper continuation of the brachial. It extends from the bend of the elbow to the wrist, around which it curves so as to get on the outside of the hand in the space between the metacarpal bones of the thumb and forefinger, and under the tendons of the extensor muscles of the thumb. Fig. 280, 4. From this point it dips between the two heads of the first dorsal interosseous muscle, and reaches the palm of the hand, which it crosses over the metacarpal bones to the ulnar side, thus forming the *arcus profundus* or deep palmar arch. The upper part of the radial artery lies between the supinator radii longus and the pronator teres muscles; its lower half is between the tendons of the supinator longus and flexor carpi radialis. The radial branch of the musculo-spiral never accompanies the radial artery to the lower end of the forearm; and there is the usual arrangement of venæ comites.

The radial artery is divided by Cruveilhier and other anatomists into three divisions:—1st, the cubital portion, or that which lies on the forearm, and extends from the origin of the vessel to the styloid process of the radius; 2d, the carpal part, extending from the styloid process to the upper part of the first interosseous space; and, 3d, the palmar portion which runs from the space just named to the terminal branches of the artery. The following vessels originate from these several divisions.

The CUBITAL PORTION gives off the *radial recurrent*, which turns upwards soon after its origin, and reaching the external condyle of the humerus, anastomoses with the profunda superior and is distributed to the joints and the contiguous muscles. Fig. 280, 5.

The *anterior carpal artery* comes from the radial near the lower margin of the pronator quadratus, and anastomoses with a branch from the ulnar artery. Fig. 280, 6.

The *radio-palmar artery*—superficialis volæ—comes from the inner side of the radial where that vessel curves over the carpus, and is distributed to the muscles of the ball of the thumb. One of its branches joins the arcus sublimus of the ulnar artery. Fig. 280, 8.

The CARPAL PORTION of the radial artery gives off the following branches.

The *posterior carpal*—dorsalis carpi—arises at the carpus beneath the extensor tendons of the thumb, whence it runs on the back of the carpus towards the ulna. It sends branches to the metacarpal spaces—the *posterior interosseous arteries*—and finally anastomoses with branches from the arcus profundus. These interosseous are three in number, the dorsalis primus, dorsalis pollicis and dorsalis indicis. Fig. 280, 7.

The PALMAR PORTION of the radial artery is divided in the following manner.

The *magna pollicis* arises at the base of the metacarpal bone of the thumb,

and runs beneath the abductor indicis. At the lower end of the flexor brevis pollicis it divides into two branches, one for each side of the thumb, at the end of which they terminate by anastomosis. Fig. 280, 10.

The *radialis indicis* arises close to the magna pollicis, runs along the metacarpal bone of the fore-finger and thence along the radial side of that finger to its end. Fig. 280, 12.

The *palmaris profunda* arises from the radial near the two preceding vessels, and dips into the palm of the hand between the flexor tendons and the metacarpal bones. It forms an arch across the palm of the hand from the radial to the ulnar side,—the *arcus profundus*, from which small branches are given to the interosseous muscles; and it sends perforating branches through the last three interosseous spaces, to anastomose with the dorsal interosseous arteries. It ends on the ulnar side of the hand by inosculating with the arcus superficialis.

THE ULNAR ARTERY.

The ulnar artery extends, as heretofore mentioned, from the bend of the arm to the palm of the hand. Fig. 280, 13. It lies at first on the brachialis anticus and flexor digitorum profundus muscles, and becomes superficial three or four inches above the wrist. It passes over the annular ligament, winds round the pisiform bone, and passes to the palm of the hand under the aponeurosis palmaris and above the flexors of the fingers. In the palm it forms the *arcus sublimis* by curving from the ulnar to the radial side of the hand; the arch beginning near the margin of the annular ligament, and terminating at the inner margin of the ball of the thumb. It presents numerous varieties of arrangement, but usually furnishes the following branches.

The *recurrens ulnaris* comes from the ulnar artery near the tubercle of the radius, and curving upwards towards the internal condyle, is spent in part upon the proximate muscles and then joins the anastomotic branch of the brachial. Fig. 280, 14.

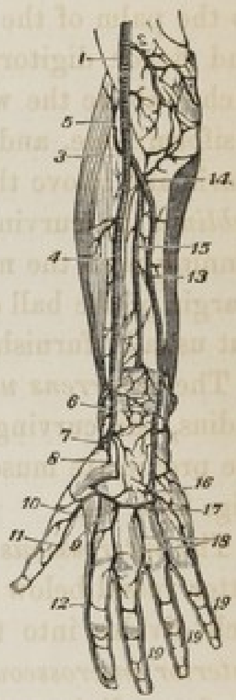
The *interosseous artery* is the largest branch of the ulnar. It arises from the latter vessel below the tubercle of the radius, and after a course of about an inch divides into two branches, the anterior and posterior interosseal. The *anterior interosseous* runs along the front of the interosseous ligament covered by the flexor digitorum and flexor longus pollicis, to which and other muscles it sends branches. Fig. 280, 15. Under the upper margin of the pronator quadratus it perforates the interosseous ligament, and having thus reached the back of the carpus, it sends off some small branches and anastomoses with the radial and posterior interosseal arteries. The *posterior interosseous* artery perforates the interosseous ligament at its upper end to reach the back of the forearm, and runs down between the ligament and the superficial extensor muscles of the arm, until it reaches the carpus and anastomoses with the carpal arteries. In this course it gives off the *recurrens interossea*, which runs upward to the sulcus between the external condyle and olecranon, where it supplies the adjacent

muscles, and then anastomoses with the profundus superior and the recurrens ulnaris.

The *dorsalis manus* comes from the ulnar just above the os pisiforme, and runs under the tendon of the flexor ulnaris to the back of the hand, whence it passes along the back of the little finger, to its end. It gives branches to the pronator quadratus and the carpal joints, and it inosculates with twigs from the radial and interosseous muscles.

The *arcus sublimis*, or superficial palmar artery. Fig. 280, 17. This is the continuation of the ulnar: it receives its present name at the lower margin of the annular ligament, where it turns obliquely outwards across the palm of the hand towards the middle of the muscles of the thumb, to inosculate with a branch of the radial artery,—the superficialis volæ,—that passes up on the inside of the thumb. The arcus sublimis sends small branches to the muscles and integuments of the palm, and a larger vessel, the *cubitalis manus profunda*, which penetrates deeply into the palm of the hand between the muscles of the little finger and anastomoses with the ulnar extremity of the arcus profundus. Fig. 280, 16. The arcus sublimis next gives off the *digital arteries*, three or four in number; these, on arriving at the heads of the first phalanges, divide into two branches, one of which runs along the side of one of the fingers to its end, and the other on the opposite side of the next finger; thus supplying all the fingers excepting the inner side of the little finger and the outside of the index finger, which, as we have already shown, are supplied from the radial artery. On the sides of the fingers each artery lies beneath the digital nerve, and gives twigs to the proximate articulations and integuments. Just before the two branches of a digital artery terminate, they converge, anastomose and send twigs to the end of the finger. The whole arrangement of the arcus sublimis is liable to many variations.

Fig. 280.



Arteries of the forearm and hand.

Fig. 280. Arteries of the forearm and hand. 1, brachial artery; 2, profunda minor; 3, bifurcation of the brachial into radial and ulnar; 4, radial; 5, recurrens radialis; 6, anterior carpal; 7, dorsalis carpi; 8, superficialis volæ; 9, arcus profundus; 10, magna pollicis; 11, digital artery of the thumb; 12, radialis indicis; 13, ulnar artery; 14, recurrens ulnaris; 15, anterior interosseal; 16, cubitalis-manus profunda, or anastomosing artery; 17, arcus sublimis; 18, digital arteries; 19, 19, digito-ulnar arteries.

THE THORACIC AORTA.

The arch of the aorta terminates, as we have seen, at the lower margin of the third dorsal vertebra of the left side, from which point to the opening of the diaphragm, in front of the last dorsal vertebra, it bears the name of *thoracic aorta.* In this course it follows the curvatures of the spine, and gives off such

small branches that its diameter is nearly the same throughout. On its right side are the azygos vein, thoracic duct and esophagus, and behind it are placed the left lung and pericardium. The thoracic aorta gives the following branches.

The *pericardiac branches* are some very small and inconstant vessels distributed to the pericardium.

The *bronchial arteries* are generally two or three on each side. They run to the bronchial glands and tubes, and to the esophagus, and anastomose with the superior intercostal and thyroid arteries.

The *esophageal arteries* are from three or four to seven in number, long and very slender. They arise from the front of the aorta and pass at once into the esophagus, anastomosing with each other. The upper ones also inosculate with the bronchial arteries and the lower ones with branches of the phrenic.

The *intercostal arteries* are called also the inferior intercostals, to distinguish them from the superior intercostals given off from the subclavian. Their number varies, but they are generally ten on the right side and eight on the left. They arise in pairs from the posterior face of the aorta and run outward towards their respective ribs, which they meet at the junction of the transverse processes with the vertebræ. The aorta being placed to the left of the spine, the right intercostals are longer than those of the opposite side. They are covered by the pleura and crossed by the sympathetic nerve. From the tubercle of the rib each artery takes its course along the intercostal groove, at the inner and lower margin of the rib, between the two planes of intercostal muscles; and after having thus followed the groove for two-thirds of the length of the rib, it divides into several branches which anastomose with others from the internal mammary. This is the proper intercostal artery. A posterior or dorsal branch, *ramus dorsalis*, is given off from the intercostal near the head of the rib, whence it runs backward between the transverse processes of the vertebræ, and reaches the muscles of the back to which it is distributed. A branch is also given off between the vertebræ that enters the intervertebral foramen, to supply the spinal cord, its membranes and the vertebral bones.

THE ABDOMINAL AORTA.

This portion of the aorta extends from the diaphragm to the body of the fourth lumbar vertebra, where it divides into the primitive iliacs. Fig. 283, 10, and Fig. 284. On its right side are the vena cava, thoracic duct and azygos vein, and it is encircled by a network of nerves from the great sympathetic. The branches of the abdominal aorta are the following.

THE PHRENIC ARTERIES.

The *phrenic arteries* come from the front of the aorta immediately below the diaphragm, sometimes by a common trunk, but more generally by separate

origins. They run upwards and outwards to reach the diaphragm at its under surface, where each vessel divides into an internal and an external branch. The *internal branch* runs forward and anastomoses with its fellow of the opposite side, just before the foramen œsophageum: the *external branch* goes outwards towards the periphery of the diaphragm, and gives branches to the capsulæ renales. The phrenic arteries anastomose with each other, with the superior phrenics from the internal mammary and with the intercostal artery. The phrenics are occasionally branches of the cæliac axis.

THE CÆLIAC AXIS.

The cæliac artery arises from the aorta opposite the upper margin of the first lumbar vertebra. It is about half an inch in length, lies to the left of the lobulus Spigelii and above the pancreas, and divides into three large branches, the gastric, the hepatic and the splenic. Fig. 281, 6.

THE GASTRIC ARTERY.

The *gastric artery*, or superior coronary artery of the stomach, is the smallest of the three branches of the cæliac. It runs obliquely upwards to the cardiac orifice of the stomach, then turns to the right side and follows the lesser curvature to the pyloric orifice, where it anastomoses with the pyloric artery. In this course it sends small branches to the esophagus and others to the cardiac orifice, around which they form a vascular plexus. The gastric artery supplies the stomach with blood from lateral branches, one set of which is distributed to the anterior, the other to the posterior surface of the organ: these branches run between the peritoneal and muscular coats, and inosculate with the arteries of the greater curvature. Fig. 281, 7.

THE HEPATIC ARTERY.

The hepatic artery ascends from the cæliac axis along the right margin of the lesser omentum, under the stomach and duodenum and behind the biliary ducts, until it reaches the transverse fissure of the liver between the ducts and the vena portarum. Just before it reaches the fissure it divides into two branches, one of which enters the right, the other the left lobe of the liver. Fig. 281, 8. Before this bifurcation takes place it sends off the following branches.

The *pyloric artery* comes from the hepatic near the pylorus, and running along the lesser curvature of the stomach from right to left, anastomoses, as heretofore mentioned, with the superior coronary artery. It sends off lateral branches to the anterior and posterior surfaces of the stomach and the right extremity of the duodenum. Fig. 281, 9.

The *right gastro-epiploic artery*—gastrica inferior dextra—comes from the hepatic near the pylorus, and descends between the duodenum and pancreas to

the greater curvature of the stomach, along which it passes from right to left between the laminæ of the great omentum. It gives branches to both surfaces of the stomach, and other slender parallel branches to the great omentum, and then anastomoses with the left gastro-epiploic artery from the splenic. Fig. 281, 11. That part of the hepatic artery that intervenes between its origin and its junction with the stomach, is called the *gastro-duodenal artery*, Fig. 281, 10, from which arises the *pancreatico-duodenal*, distributed, as its name implies, to the pancreas and head of the duodenum. Finally the hepatic artery anastomoses with the superior mesenteric. Fig. 281, 12.

The *cystic artery* is generally a branch of the right hepatic. It runs to the neck of the gall-bladder, and there divides into two branches which are spent upon the latter structure and upon the contiguous part of the liver. Fig. 281, 13.

After entering the liver, the right and left branches of the hepatic artery are distributed to the corresponding lobes. They are the nutritious vessels of this organ, ramify in its constituent acini, and finally terminate in the lobular plexus of the portal vein in the manner described when treating of the liver (p. 328).

THE SPLENIC ARTERY.

The splenic artery is the largest branch of the cæliac axis. Immediately after its origin it reaches the upper border of the pancreas, and runs in a superficial groove the whole length of that gland, from right to left until it reaches the fissure of the spleen, which it enters by many branches. In this course it is accompanied by the splenic vein and distributes the following branches. Fig. 281, 14.

The *pancreatic arteries* are large and variable in number. One of the largest of them goes to the head of the pancreas; but the rest of the gland is supplied by many small vessels given off at right angles from the splenic. Fig. 281, 15.

The *left gastro-epiploic artery*—gastrica inferior sinistra—passes downward behind the greater end of the stomach, to which it is distributed from left to right and on both surfaces. It sends branches to the omentum majus, and inosculates with the right gastro-epiploic artery from the hepatic. Fig. 281, 7.

The *vasa brevia* are five or six short vessels that either come direct from the splenic artery, or from its subdivisions before entering the spleen. They run at an angle from their origin in a straight course to the stomach, on the greater end of which they are distributed as far as the cardiac orifice, where they anastomose with the cardiac branches of the coronary artery. Fig. 281, 16.

Before reaching the hilum or fissure of the spleen, the splenic artery divides into several branches, five to eight in number, that enter the substance of the gland, and are distributed upon its structure in the manner described in the account of that organ. Fig. 281, 5.

Fig. 281.

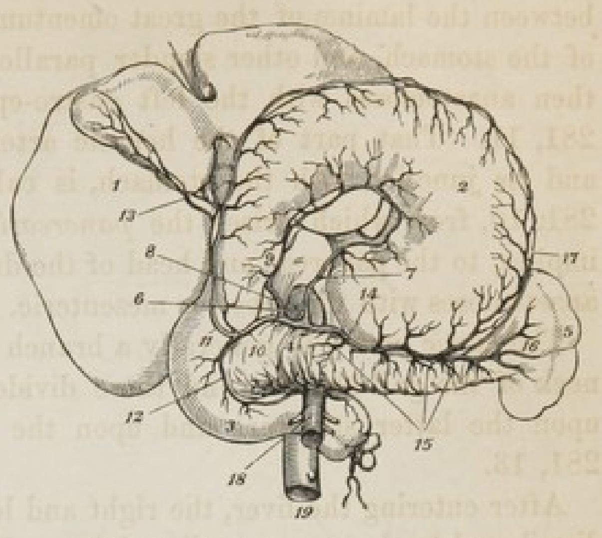


Fig. 281. The splenic and gastric branches of the cæliac axis, and the associated parts. 1, liver; 2, stomach thrown upwards to expose the duodenum; 3, 4, pancreas; 5, spleen; 6, cæliac axis; 7, coronary artery of the stomach; 8, hepatic artery; 9, its pyloric branch; 10, gastro-duodenal artery; 11, right gastro-epiploic artery; 12, pancreatico-duodenal artery; 13, cystic artery; 14, splenic artery; 15, its pancreatic branches; 16, vasa brevia; 17, left gastro-epiploic artery; 18, superior mesenteric artery; 19, aorta.

Splenic and gastric arteries. After Quain.

THE SUPERIOR MESENTERIC ARTERY.

Next below the cæliac, the aorta gives off the superior mesenteric artery, between the crura of the diaphragm and about half an inch below the cæliac. It runs forward between the pancreas and duodenum, and descends between the lamina of the mesentery, curving first to the left side and then to the right iliac fossa, opposite to which it inosculates with its own ileo-cæcal branch.* It supplies the small intestine and the right division of the large intestine, and in its course gives the following branches. Fig. 282.

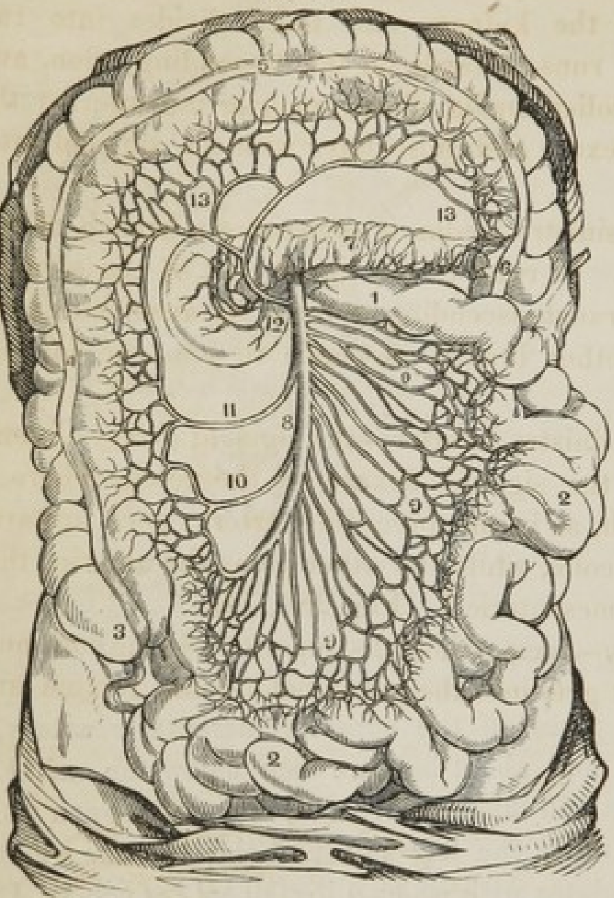
The *pancreatic* branches are several small vessels that anastomose in the gland, with the arteries from the splenic and hepatic arteries. Fig. 282, 12.

The *arteries of the small intestine*—vasa intestini tenuis—come from the convexity of the superior mesenteric artery. They are from fifteen to twenty in number, run between the laminæ of the mesentery and are distributed to the jejunum and ileum. They run parallel for a short distance, and then divide into branches that form a series of arches by inter-anastomosis. On these a second series of arches is formed, and so in succession for four or five series, growing smaller and smaller as they approach the intestine upon which they are distributed. The branches given off by the ultimate arches enter the intestine on its mesenteric margin and send a branch to each side, which branches embrace the tube and inosculate with each other. By this beautiful system of anastomosis, all parts of the mesenteric artery communicate freely. Fig. 282, 9, 9.

After the superior mesenteric has thus given off branches to the small intestine, it furnishes three large branches, the *colic arteries*, to the great intestine. The colic arteries are three in number,—the ileo-colica, colica-dextra and colica-media.

* Quain and Sharpey's Anatomy, p. 560.

Fig. 282.



Superior mesenteric artery. After Tiedemann.

Fig. 282 gives a view of the superior mesenteric artery and its branches, together with some of the associated parts. 1, duodenum; 2, jejunum and ileum; 3, cæcum; 4, right ascending colon; 5, transverse arch of the colon; 6, left descending colon; 7, pancreas; 8, superior mesenteric artery; 9, 9, 9, arteries of the small intestine, twelve or fourteen in number; 10, ileo-colic artery; 11, right colic artery, colica dextra; 12, inferior pancreatico-duodenal artery; 13, 13, colica media.

The *ileo-colic artery*, ileo-colica, runs downwards on the right side to the vicinity of the ileo-cæcal valve, whence it sends branches to the lower part of the ileum, head of the colon and the appendicula vermiformis. It anastomoses on the left side with the branches of the small intestine, and on the right with those of the colica dextra. Fig. 282, 10.

The *right colic artery*—colica dextra—comes from the middle of the upper arch of the superior mesenteric, and forms anastomosing arches which go to the ascending colon through the laminæ of the mesocolon. It inosculates by means of two principal branches with the ileo-colica and the colica media. Fig. 282, 11.

The *colica media* comes from the upper part of the arch of the superior mesenteric artery, runs forward and upward between the laminæ of the transverse mesocolon, and divides into two branches that form arches with each other. It is distributed by one branch to the right portion of the transverse colon, by another to the left, anastomosing with the colica dextra and with the colica sinistra of the inferior mesenteric. Fig. 282, 13, 13, and Fig. 283, 8.

The arteries that follow in the order of succession after the superior mesenteric, are the capsular, the renal and the spermatic branches of the aorta; but we defer a description of them in order to consider the second great intestinal vessel.

THE INFERIOR MESENTERIC ARTERY.

This artery comes from the aorta between its bifurcation and the exit of the renal vessels, whence it runs downwards, inclining to the left side and between the laminæ of the mesocolon. Fig. 283. It gives the following branches.

The *left colic artery*—colica sinistra superior—passes to the left side behind the peritoneum and in front of the kidney, and there divides into two branches. One of these branches runs upwards on the descending colon, and anastomoses with branches of the colica media of the superior mesenteric: the other branch goes to the sigmoid flexure and inosculates with the sigmoid arteries. Fig. 283, 11.

The *middle colic artery*, colica sinistra media, is sometimes a branch of the left colic and sometimes deficient. It runs to the upper part of the sigmoid flexure and there bifurcates; one branch ascending to form, by anastomosis, an arch with the left colic, while the other branch descends to join the inferior colic artery. Fig. 283, 15.

The *inferior colic artery*—colica sinistra inferior—the *sigmoid artery* of some anatomists, passes downwards to the sigmoid flexure of the colon, where it divides into branches, one of which, as in the preceding artery, goes upwards and anastomoses with the middle colic, while the other joins the arteries that go to the rectum from the inferior mesenteric.* Fig. 283, 14.

The *superior hemorrhoidal artery*—hæmorrhoidalis superior—is the continuation of the inferior mesenteric. It gets into the pelvis behind the rectum and between the laminæ of the mesorectum, first crossing the ureter and common iliac artery of the left side. In this course it divides into two branches that enter the intestine from behind, and embrace it on all sides almost to the anus. The branches of the superior hemorrhoidal anastomose in the pelvis with the middle and inferior hemorrhoidal, and with the lateral sacral arteries. Fig. 283, 13, and Fig. 284, 8.

Fig. 283.

The inferior mesenteric artery. After Tiedemann.

Fig. 283. View of the distribution of the inferior mesenteric artery, its connections with the superior mesenteric, &c. 1, transverse colon; 2, descending colon; 3, sigmoid flexure; 4, rectum; 5, small intestine; 6, pancreas; 7, superior mesenteric artery; 8, colica media of the superior mesenteric; 9, arteries of the small intestine from the superior mesenteric; 10, aorta; 11, colica sinistra superior; 12, trunk of the inferior mesenteric artery; 13, superior hemorrhoidal; 14, sigmoidal or inferior colic artery; 15, middle colic artery.

* Horner. Anatomy and Histology, ii. p. 261.

THE CAPSULAR ARTERIES.

The *capsular* or *supra-renal arteries* come from the aorta opposite the superior mesenteric, and are distributed on the renal capsules. They are sometimes derived from the cæliac, in other instances from the emulgent artery. They anastomose with the capsular branches of the emulgent, and are larger in proportion in the fœtus than in the adult.

THE EMULGENT ARTERIES.

The *emulgent* or *renal* arteries come from each side of the aorta about half an inch below the superior mesenteric. They run at right angles from the parent trunk, the left being a little higher than the right on account of the encroachment of the liver towards the right lumbar region. They are remarkable for their large size, shortness and straight course. They rest upon the bodies of the vertebræ, are covered in front by the peritoneum and surrounded by cellular membrane and fat. The renal artery gives no branches excepting some small twigs to the supra-renal capsules; after which it enters the kidney at its fissure, and there divides into numerous branches that pursue a nearly straight course between the pyramids of the medullary structure; but on reaching the cortical substance of the kidney these vessels become extremely tortuous, and finally terminate in the tufts known as the corpuscles of Malpighi, already described with the kidney itself.

THE SPERMATIC ARTERIES.

The spermatics come from the front of the aorta a short distance below the emulgents. They are long slender vessels, two in number, distributed to the testes in the male and to the ovaries in the female. They run obliquely downward in company with the ureters, behind the peritoneum and in front of the psoas muscle, until they reach the margin of the pelvis, where the artery gets to the inner side of that muscle and has the external iliac artery behind it. It now enters the internal abdominal ring to become a part of the spermatic cord, with which it traverses the inguinal canal and emerges at the external ring. From this point it descends directly to the testicle; but before reaching this organ it divides into several branches, two of which go to the epididymis, while the others perforate the upper and back part of the tunica albuginea and are distributed upon the testicle. In this long course the spermatic arteries give no branches excepting some small and inconstant twigs to the contiguous lymphatic glands, ureter and peritoneum, and a few others to the parts that surround it in its passage from the abdominal ring to the testicle.

The ovarian arteries of the female arise like the spermatics of the male, but

their destination is different. Instead of entering the abdominal ring they take a course inwards from the margin of the pelvis, get between the laminæ of the broad ligaments and pursue a tortuous course to the ovaries, to which they send branches that can sometimes be traced to the Graafian vesicle. Other branches go to the round ligament and the Fallopian tubes; and the terminal branches, reaching the uterus, anastomose with the hypogastric artery and with each other.

THE LUMBAR ARTERIES.

The *lumbar arteries*, lumbares, three, four or five in number, arise from the back of the aorta, run outwards over the bodies of the vertebræ, and are superficial until they penetrate under the psoas muscle. At the space between the transverse processes each lumbar artery divides into two branches: one of these, called the *abdominal*, passes behind the quadratus lumborum and is spent upon the abdominal muscles. The posterior or *dorsal* branch passes through the intervertebral foramen, and while there sends a branch, the *spinal artery*, into the spinal canal. This spinal artery follows the nerves to the dura mater, the cauda equina and the contiguous vertebræ, upon which it is spent. The *dorsal* branch afterwards runs to the muscles of the back, among which it is finally lost. The lumbar arteries anastomose with the intercostals, the internal mammary, the epigastric, the ileo-lumbar and the circumflexa ilii.

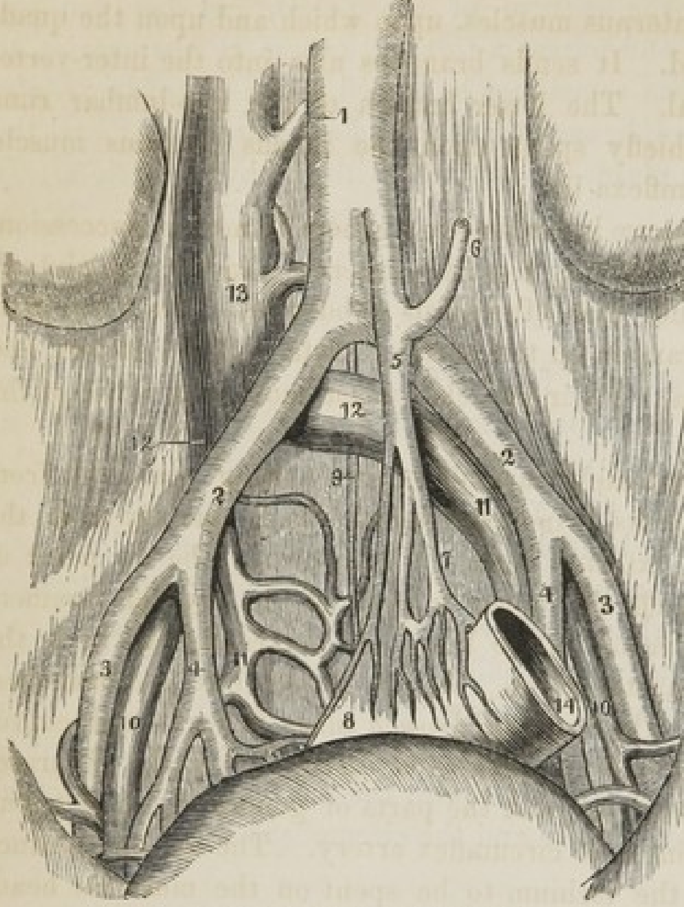
THE MIDDLE SACRAL ARTERY.

The *middle sacral artery*—sacra media—arises from the posterior part of the aorta at its bifurcation, whence it curves downwards over the anterior face of the sacrum to the end of the os coccygis to anastomose in small arches with the lateral sacral arteries. It is distributed upon the rectum; and small branches, entering the sacral foramina, terminate on the cauda equina. Fig. 284, 9.

THE PRIMITIVE ILIAC ARTERIES.

When the aorta has reached the body of the fourth lumbar vertebra, it bifurcates and forms two large trunks that run downwards and outwards, diverging from each other. These are the *common* or *primitive iliac arteries*. They terminate by bifurcation over the sacro-iliac symphysis after a course of about two inches and a half, the right vessel being a little larger than the left. The right common iliac is covered in front by the peritoneum, and behind it are the two common iliac veins. The left common iliac is crossed by the rectum and superior hemorrhoidal artery. The ureters pass in front of the iliacs at the point of bifurcation, where those arteries divide into the internal and external iliacs. The primitive iliacs give off no branches. Fig. 284, 2, 2. We proceed to examine the course and branches of the internal iliac artery.

Fig. 284.



Aorta, vena cava and iliac vessels.

Fig. 284 represents the aorta, vena cava and iliac vessels in their relative position. 1, aorta; 2, 2, primitive iliacs; 3, 3, external iliacs; 4, 4, internal iliacs; 5, inferior mesenteric artery; 6, colica sinistra superior; 7, colica media; 8, superior hemorrhoidal artery; 9, middle sacral artery; 10, external iliac vein; 11, internal iliac vein; 12, 12, primitive iliac veins; 13, vena cava ascendens; 14, rectum.

THE INTERNAL ILIAC ARTERY.

The internal iliac or hypogastric artery extends from its origin at the front and upper border of the sacro-iliac symphysis to the lower part of that articulation, and opposite the superior margin of the great sacro-sciatic notch, where it divides into two terminal trunks,—the gluteal and the ischiatic. It is from an inch to an inch and a half in length. It rests upon the sacral plexus of nerves, having behind it the internal iliac vein, and in front, the ureter, which separates it from the peritoneum. At its origin it is placed at the inner margin of the psoas muscle; below, it lies upon the upper part of the pyriformis. Fig. 284, 4, 4. In the fœtal state, as will be more fully explained hereafter, the hypogastric artery curves from its origin to the lower and lateral region of the bladder, whence it makes another curve to the umbilicus and bears the name of the *umbilical artery*. Soon after birth the umbilical artery ceases its functions, and a ligamentous cord alone remains in after life. The branches of the internal iliac in the adult are the following; but it is necessary to premise that no division of the arterial system is more liable to variation of origin than the one now to be considered. I have followed the order of succession laid down by Dr. Horner, as most in accordance with my own observations.

The *ileo-lumbar artery* comes either from the hypogastric or from its gluteal

branch, passes upwards and backwards behind the psoas magnus muscle, and divides into a superior and an inferior branch. The former proceeds upwards between the psoas and iliacus internus muscles, upon which and upon the quadratus lumborum it is distributed. It sends branches also into the inter-vertebral foramina and spinal canal. The lower branch of the ileo-lumbar runs downward and outwards, is chiefly spent upon the iliacus internus muscle and anastomoses with the circumflexa ilii.

The *lateral sacral arteries*—sacræ laterales—are generally next in succession. They arise like the ileo-lumbar, variably from the internal iliac or the gluteal, and sometimes by a single trunk that afterwards subdivides. They are four or five in number, enter the foramina on the anterior surface of the sacrum and are spent upon the cauda equina. Their branches anastomose with those of the sacra media.

The *obturator artery* is of extremely variable origin, arising generally from the hypogastric or from one of its principal trunks, but frequently from the epigastric,* or even from the external iliac. Whatever may be its point of origin, it passes forwards to reach the upper margin of the thyroid foramen, through which it curves in a channel in the bone and makes its exit from the pelvis, accompanied by the obturator nerve. It now divides into two branches, an internal and an external. The *internal branch* turns inwards and curves around the margin of the thyroid foramen to be distributed to the obturator muscles, the pectinæus, the adductors and the parts of generation, and terminates by anastomosis with the internal circumflex artery. The external branch descends to the tuberosity of the ischium to be spent on the muscular heads in that region, and sends off a branch that enters the hip-joint through the condyloid notch, and ramifies along the round ligament as far as the head of the femur.† The anterior and posterior branches of the obturator artery anastomose with each other.

The *middle hemorrhoidal artery* lies between the superior hemorrhoidal branch of the inferior mesenteric, and the inferior hemorrhoidals from the pubic. It arises equally from the internal iliac, the ischiatic, the pubic and the vesical. It runs down on the front of the rectum and is distributed to that intestine, the proximate surface of the bladder, the vesiculæ seminales and the prostate gland. In the female it sends branches to the vagina, and anastomoses, in both sexes, with the other hemorrhoidal arteries.

The *vesical arteries*—vesicales—are chiefly two, the superior and the inferior. The *superior vesical* comes from, or consists of, the portion of the fœtal umbilical artery that remains pervious after birth. It runs to the lateral parietes of the bladder, to which it is distributed. One of its numerous branches is the *deferent artery*, a slender vessel that reaches the vas deferens, and accompanies that duct in its course to the back of the testicle, where it anastomoses

* Cloquet, who examined this point in upwards of two hundred instances, states that the proportion in which the obturator arises from the external iliac, compared with that from the epigastric, may be stated as three to one.—Quain. *Vessels of the Human Body*, p. 57.

† Quain and Sharpey's Anatomy, p. 574.

with the spermatic artery.* Other ramifications are spent upon the contiguous part of the ureter. The *inferior vesical artery* runs to the base of the bladder, the prostate gland, the vesiculæ seminales and the commencement of the urethra.

The *uterine artery* arises from the internal iliac or from one of its branches, either above or below the vesical arteries. Its course is first directed to the upper end of the vagina, to which it sends branches, and then getting between the laminæ of the broad ligament, reaches the uterus, runs upwards upon its sides, and divides and subdivides in its substance in a very tortuous manner. In the gravid uterus these vessels attain a remarkable size, and the bulk of the organ is largely due to them.

The proper *vaginal artery* is a distinct branch from the uterine, and generally comes from the umbilical either above or below the uterine artery. It descends directly to the sides of the vagina, where it divides into numerous branches that enter its structure and also supply the neck of the bladder and the urethra. It finally anastomoses with its fellow of the opposite side.

After giving off the preceding branches, the internal iliac divides low down in the pelvis into two large trunks, the *gluteal* and the *ischiatic* arteries.

THE GLUTEAL ARTERY.

The *gluteal artery*, or posterior iliac, is the largest branch of the internal iliac, of which it appears to be the continuation. It escapes from the pelvis at the upper part of the sciatic notch, between the gluteus medius and pyriformis muscles, and runs upon the dorsum of the ilium beneath the gluteus magnus muscle. It here divides into two principal trunks, one of which is superficial, the other deep-seated.

The *superficial branch* passes horizontally forward between the gluteus medius and maximus muscles, and is chiefly distributed upon the latter muscle and its integuments. The *deep branch* dips into the gluteus medius and minimus muscles, upon which it is expended. It also sends ramuscles to the os ilium and to the hip-joint.

THE ISCHIATIC ARTERY.

The *ischiatic* or *sciatic artery*, descends between the levator ani and pyriformis muscles and in front of the sacral plexus of nerves. Having reached the lower margin of the great sciatic notch, it escapes from the pelvis beneath the pyriformis muscle, and passing downwards into the space between the trochanter major and the tuberosity of the ischium, separates into two branches. One of these, the *coccygeal* artery, perforates the great sacro-sciatic ligament and gets to the dorsum of the os coccygis, to which, and the proximate integuments, it is distributed. The other branch, called the *comes nervi ischiadici*, divides

* Quain and Sharpey, *ut suprà*.

into several long, slender branches, which accompany the great sciatic nerve to the lower part of the thigh.

THE INTERNAL PUDIC ARTERY.

This vessel is given off either from the internal iliac, of which it is regarded as the terminal branch, or from the ischiatic artery. It descends in front of the sacral plexus and the pyriformis muscle, and emerges from the pelvis between the anterior sacro-sciatic ligament and the pyriformis muscle, crosses the spine of the ischium, and returns into the pelvis between the two sacro-sciatic ligaments. It then curves along the ischium and ascends the rami of the ischium and pubis until it approaches the symphysis between the two laminæ of the triangular ligament, where it separates into two or three branches, to be distributed upon the genital organs. Fig. 285, 1. In this long and tortuous course the artery is accompanied by the pudic vein and the internal pudic nerve, and gives off a series of important branches in the following order.

The *inferior hemorrhoidal artery*—hæmorrhoidea inferior vel externa—is formed of several vessels that run inwardly to be distributed to the muscular structure of the anus and the adjacent perineum. This artery arises from the internal pudic behind the tuberosity of the ischium, and after that artery has returned within the pelvis.

The *superficial perineal artery*—arteria perinæi—comes from the pudic in front of the inferior hemorrhoidal, and curving upwards to the rami of the pubis, and piercing the perineal fascia, runs obliquely forward across the transversus perinæi and between the accelerator urinæ and erector penis muscles, and along the perineum for two or three inches. It gives small branches to the perineal muscles and terminates on the scrotum. Fig. 285, 3, 4.

The *transversalis perinæi* comes from the superficial perineal at right angles, runs directly across the perineum parallel with the transverse muscle, and terminates on the sphincter ani. This vessel sometimes comes from the pudic artery. Fig. 285, 7.

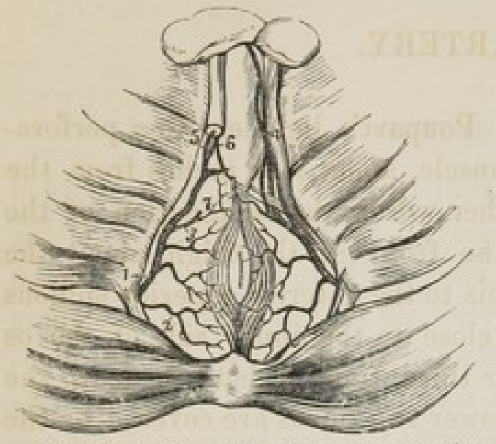
The *bulbar artery* is given off from the pudic between the layers of the triangular ligament, and enters the corpus spongiosum at its posterior margin. It is distributed to the bulb of the urethra and to Cowper's glands. The bulbar artery is sometimes a branch of the perineal. Fig. 202, 7.

The *cavernous artery*—profunda penis—is one of the terminal branches of the internal pudic. Sometimes, however, it comes from the obturator. It enters the corpus cavernosum at its crus and ramifies throughout its erectile tissue. Fig. 285, 5.

The *dorsal artery of the penis*—dorsalis penis—after its origin from the internal pudic, passes between the crura penis and the symphysis pubis, penetrates the suspensory ligament and reaches the dorsum of the penis, along which it runs in the sulcus formed by the apposition of the corpora cavernosa. It is distributed to the integuments and fibrous structure of the penis, and terminates in the glans and prepuce. Fig. 285, 6.

55

Fig. 285.



Branches of the pudic artery. After Quain.

The internal pudic artery is smaller in the female than in the male: the superficial perineal artery is distributed to the labia externa; the bulbar branch supplies the meatus urinarius and the cavernous branch goes to the clitoris. The dorsalis penis of the male is represented by the *dorsalis clitoridis* of the female.

Fig. 285. Branches of the pudic artery. 1, pudic artery; 2, inferior hemorrhoidal; 3, 4, superficial perineal; 5, cavernous artery; 6, dorsalis penis; 7, transversus perinæi.

THE EXTERNAL ILIAC ARTERY.

The *external iliac artery,*—iliaca externa,—extends from the upper margin of the sacro-iliac symphysis to the lower border of Poupart's ligament, at which point it becomes the femoral artery. It takes a straight course between its origin and termination, obliquely outward and downwards, being covered in front by the peritoneum, and lying at the inner margin of the psoas muscle, from which it is separated by the iliac fascia. The iliac vein is behind the artery until near the crural arch, where the vein takes the inner side: the anterior crural nerve is on its outside. It is almost surrounded at its lower part by lymphatic vessels and glands, and just before its termination is crossed by the circumflex iliac vein. Fig. 283, 3, 3. At its upper part it is crossed obliquely by the ureter. The external iliac gives no branches until it approaches the crural arch, at which place it sends off the *epigastric* and *circumflex iliac arteries.*

The *epigastric artery* arises just above the crural arch, and runs between the peritoneum and fascia transversalis obliquely upwards and inwards to the rectus abdominis muscle. In this course the artery lies at the inside of the internal abdominal ring and behind the spermatic cord, and having reached the rectus, is placed between that muscle and the peritoneum. It is distributed to the rectus, and having ascended above the umbilicus, anastomoses with the internal mammary artery. Fig. 286, 9.

The epigastric gives a small artery to the spermatic cord called the *cremasteric.*

The *circumflexa ilii* comes from the outer side of the external iliac, nearly opposite the epigastric artery. It runs upward and outwards behind the crural arch, and then curving along the crista of the ilium, gives branches to the iliacus internus muscle and ends by anastomosing with the ileo-lumbar artery. When opposite the anterior superior spinous process, it gives off a large branch that ascends between the internal oblique and transversalis muscles, and anastomoses with the inferior intercostal and lumbar arteries. Fig. 286, 10.

THE FEMORAL ARTERY.

The *femoral* or *crural artery* extends from Poupart's ligament to a perforation in the tendon of the adductor magnus muscle, about four inches from the knee-joint. The origin of this vessel, in other words the termination of the external iliac in the femoral artery, is on the front of the thigh, about the middle of a line drawn from the symphysis pubis to the anterior superior spinous process of the ilium; while its lower end lies close to the inner side of the os femoris. The artery is superficial in its upper third, lying directly beneath the integuments and the inguinal glands; but the lower two-thirds are covered by the sartorius muscle. Behind it, above, is the psoas muscle, which separates it from the pelvis; and as the artery descends, it lies in front of the pectineus and adductor longus muscles. On its outside, the artery is successively in contact with the psoas and iliacus internus muscles and with the vastus internus. Fig. 286, 1, 2.

The femoral artery and vein are enclosed in a common sheath derived chiefly from the fascia lata of the thigh and the contiguous cellular tissue. "Near Poupart's ligament, this sheath is much larger than the vessels it contains, and is continuous with the fascia transversalis and iliac fascia. If the sheath be opened at this point, the artery will be seen to be situated in contact with the outer wall of the sheath. The vein lies next the artery, being separated from it by a fibrous septum; and between the vein and the inner wall of the sheath, and divided from the vein by another thin fibrous septum, is a triangular interval into which the sac is protruded in femoral hernia. This space is occupied, in the normal state of the parts, by loose areolar tissue, and by lymphatic vessels which pierce the inner wall of the sheath to make their way to a gland situated in the femoral ring."* The femoral vein, as heretofore remarked, lies on the inner side of the artery above; but it soon curves so as to get behind it, and lower down is a little to the outside of the artery. The crural nerve is on the outer side of the artery, but is separated from it by intervening fibrous tissue; but the internal saphenous nerve, a branch of the femoral, runs upon the sheath of the femoral vessels at the outer side of the artery.

The following are the branches of the femoral artery.

The *subcutaneous artery*—arteria ad cutem abdominis—comes from the front of the femoral just below the crural arch. It runs upwards in the fascia superficialis abdominis and is spent in the integuments near the umbilicus. It gives branches to the inguinal glands, and anastomoses with the internal mammary artery.

The *external pudic arteries* are two in number, and arise by separate origins or from a common trunk. The *superior branch*—pudenda externa superior—runs to the mons veneris, penis and scrotum of the male, and to the external

* Wilson's Anatomy. Dr. Goddard's edition, p. 346.

organs of the female. The *lower branch*—pudenda externa inferior—runs transversely inwards, and is distributed upon the scrotum in the one sex and on the external labia in the other. The external pudics of the two sides of the body anastomose freely with each other. Fig. 286, 4, 4.

The *superficial circumflex iliac artery* is a small vessel given off from the femoral just below Poupart's ligament, penetrates the fascia lata, and running outwards in the direction of the spine of the ilium, is distributed to the psoas magnus and iliacus internus muscles.

The PROFUNDA FEMORIS, or deep femoral artery, arises from the femoral about an inch and a half below Poupart's ligament, and running downwards and backwards, gets behind the adductor longus muscle, and into the posterior part of the thigh, where it is distributed to the flexor muscles. Fig. 286, 5.

The profunda gives off the following branches.

1. The *external circumflex* is sometimes a branch of the femoral. It runs outwards under the sartorius and head of the rectus, and over the tendinous origin of the vastus internus, to be distributed to the muscles of the thigh by the ramifications of two principal branches. The *superior* branch is distributed to the gluteus minimus and tensor vaginæ femoris muscles, to the hip-joint and the trochanter major, and anastomoses with the gluteal and ischiatic arteries. The *inferior* branch curves round the great trochanter to reach the triceps, vastus externus and cruralis muscles, to which it is chiefly distributed. On the outer surface of the great trochanter it anastomoses with branches of the internal circumflex; and as it approaches the knee, it forms connections with the articular arteries. Fig. 286, 7.

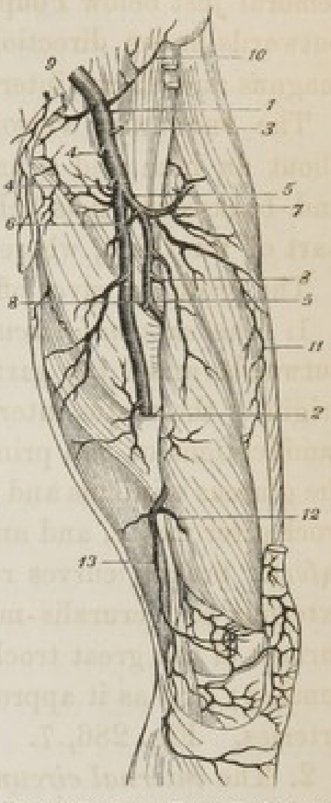
2. The *internal circumflex artery* is smaller than the external, but comes from the profunda near it, though in some cases it arises from the femoral trunk. It runs backwards between the psoas and pectineus muscles and gets to the inside of the thigh, where under the neck of the os femoris it divides into two branches. One of these is distributed above to the capsular ligament, and the obturator externus, adductor brevis and adductor magnus muscles. The branch of the internal circumflex that goes to the joint is called the *articular* artery: it enters the acetabulum through the cotyloid notch, and can be traced upon the round ligament. The *inferior* branch of the internal circumflex runs downwards to be spent upon the gracilis, biceps, semitendinosus and semimembranosus muscles, and upon the sciatic nerve. It anastomoses with the external circumflex, and by its various branches with the ischiatic, gluteal and obturator arteries. Fig. 286, 6.

3. The *perforating arteries*. These are three or four in number, and derive their name from the fact of their passing through the adductor brevis and adductor magnus muscles. The *first perforating artery* arises from the profunda below the trochanter minor, makes its way through the adductor brevis and adductor magnus muscles, and is distributed upon them and upon the other flexor muscles of the thigh. The *second perforating artery* runs through the adductor magnus and is also distributed upon the flexor muscles, after which it inosculates with

the other perforating arteries. Fig. 286, 8, 8. The *arteria nutritia* which enters the foramen of the os femoris, is a branch of this vessel. The *third perforating artery* goes through the adductor magnus below the origin of the short head of the biceps, is spent upon the flexor muscles, and anastomoses with the other perforating arteries and with branches of the profunda. There is sometimes a fourth artery of this series that penetrates the adductor magnus, and is spent upon that and the contiguous muscles.

After giving off the preceding branches the profunda femoris is distributed to the muscles of the thigh posteriorly, and anastomoses with branches of the popliteal artery. In its course, however, the profunda supplies *muscular branches* of variable size and number to the contiguous parts.

Fig. 286.



Femoral artery. From Tiedemann.

Fig. 286. Arteries of the thigh. 1 to 2, femoral artery; 3, superficial epigastric, cut off; 4, 4, external pudics, cut off; 5, 5, profunda femoris; 6, internal circumflex; 7, external circumflex; 8, 8, perforating arteries; 9, epigastric; 10, circumflexa ilii; 11, muscular branch; 12, superior internal articular artery; 13, one of its branches. The popliteal artery begins where the femoral terminates, at 2.

The ANASTOMOTIC ARTERY—anastomotica magna—is the last branch of the femoral artery, and comes from it just as it penetrates the adductor magnus, or while the parent artery is in the tendinous canal formed by that muscle and the vastus internus. It follows the tendon of the adductor to the inner condyle, where it anastomoses with the superior internal articular artery and with the recurrent tibial. It is distributed to the muscular fasciculi behind the knee-joint.

THE POPLITEAL ARTERY.

The popliteal artery begins where the femoral ends at the perforation of the adductor magnus, from which point it extends to the opening in the upper margin of the interosseous ligament below the head of the tibia, on a line with the lower border of the popliteus muscle. Here it divides into two branches, the *anterior and posterior tibial arteries.* Fig. 287, 1, 2. It runs from its origin at the inner side of the os femoris to the notch between the condyles, where it lies intermediately between the tendons of the biceps muscle on the outside, and of the semitendinosus and semimembranosus on the inside, having behind it the posterior ligament of the knee-joint and the popliteus muscle. Lying deeply in the popliteal space, it is covered behind by the fascia and integuments of this part, but soon sinks between the heads of the gastrocnemius muscle. In this course it is accompanied by the popliteal vein, which lies behind it and a little to its outer

side. The sciatic nerve lies at first on the outer side of the artery, but is more superficial; subsequently it crosses the vessel and is found at its inner margin. Excepting some inconstant muscular arteries, the popliteal gives no branches but the articular arteries, five in number, (which encircle the joint in all directions,) and the sural arteries.

The *upper articular arteries* are two in number, the external and internal. The *superior external articular artery* arises above and winds around the external condyle, beneath the lower end of the biceps muscle, and ramifies on the exterior of the joint. It anastomoses with the superior internal articular artery, and with the descending branches of the external circumflex. Fig. 287, 5.

The *superior internal articular artery*, on coming from the popliteal perforates the tendons of the adductor magnus and vastus internus, supplies those muscles and ramifies upon the inner part of the knee-joint. It also anastomoses with the upper external articular artery. Fig. 287, 4.

The *middle articular artery*—azygos—articularis media—is a small vessel given from the popliteal opposite the bend of the joint, whence it runs inwards to be distributed to the capsular and crucial ligaments, and to other parts connected with the articulation. Fig. 287, 7.

The *inferior external articular artery* arises from the popliteal below the external condyle, and passes inwards between the popliteus and proximate head of the gastrocnemius muscles, and above the head of the fibula. It is distributed to the parts connected with the external side of the knee-joint, and anastomoses with the lower articular artery of the opposite side, with the upper articular arteries and with the recurrent tibial. Fig. 287, 16.

The *inferior internal articular artery* passes between the bone and the lateral ligament of the joint, and is spent upon the inner region of the knee-joint, the head of the tibia and the patella. Fig. 287, 6.

The *gastrocnemial* or sural arteries—gemellæ—are two in number, one for each head of the gastrocnemius. They arise from the popliteal just before it passes under the head of the soleus muscle, and are spent in slender branches upon the gastrocnemius, popliteal and plantar muscles. Fig. 287, 8.

THE ANTERIOR TIBIAL ARTERY.

This vessel is the continuation of the popliteal trunk. It extends from the opening in the interosseous ligament to the bend of the ankle. It passes down close to the interosseous ligament, between the tibialis anticus and extensor communis muscles, superiorly, and between the former muscle and the extensor pollicis lower down. It is thus very deeply situated above, but more superficial below, for its pulsations can be felt beneath the finger about six inches above the ankle-joint.* In front of the latter it is covered by the annular ligament and crossed by the tendon of the extensor proprius pollicis. It is accom-

* Anatomy. By John and Charles Bell, ii. p. 214.

panied by the anterior tibial nerve, but the relative position of the two is extremely variable. The branches of the anterior tibial are numerous, but only two of them are sufficiently constant to merit particular names.

The *recurrent tibial*—tibialis recurrens—arises from the tibial directly after the latter has passed through the interosseous ligament, whence it turns upwards beneath the tibialis anticus muscle, and is distributed to the contiguous muscles and the lower part of the knee-joint. It anastomoses with the inferior articular branches of the popliteal artery.

The *malleolar arteries* are two in number, one for each ankle.

The *internal malleolar*—malleolaris interna—artery comes from the tibial about an inch above the ankle, and curving over the inner ankle, in many branches, is distributed to the joint and to the parts above it along the tibia, and below it as far as the os calcis. Fig. 287, 15.

The *external malleolar artery*—malleolaris externa—comes from the anterior tibial in front of the ankle-joint, and is spent upon the outer ankle and the proximate parts of the leg and foot. Fig. 287, 13.

THE DORSAL ARTERY OF THE FOOT.

This vessel—*dorsalis pedis*—is the continuation of the anterior tibial from the bend of the ankle to the bases of the first and second metatarsal bones, where it divides into two branches. The dorsal artery in this course gives off some inconstant twigs to the contiguous parts, and several permanent branches in the following order.

The *tarsal artery* runs obliquely forwards and outwards upon the tarsus and under the extensor brevis digitorum, to be distributed to the parts on the dorsum of the foot. It anastomoses with the external malleolar and plantar arteries.

The *metatarsal artery* arises a little below the tarsal and runs towards the outer margin of the foot, beneath the extensor brevis muscle, until it reaches the base of the little toe. It gives off three branches called the interosseous arteries, which run along the three outer interosseous spaces upon the muscles of that name until they reach the phalanges, where they bifurcate, and send a small branch on each side of the corresponding toes. The *first interosseous* branch, the *dorsalis pollicis*, comes from the dorsalis pedis in the first metatarsal space, and sends a ramuscle along the outer side of the great toe and the inner side of the second toe.

The dorsal artery of the foot, after giving off the preceding branches, penetrates into the sole of the foot at the posterior end of the first metatarsal space, and anastomoses with the external plantar artery. Fig. 287, 14.

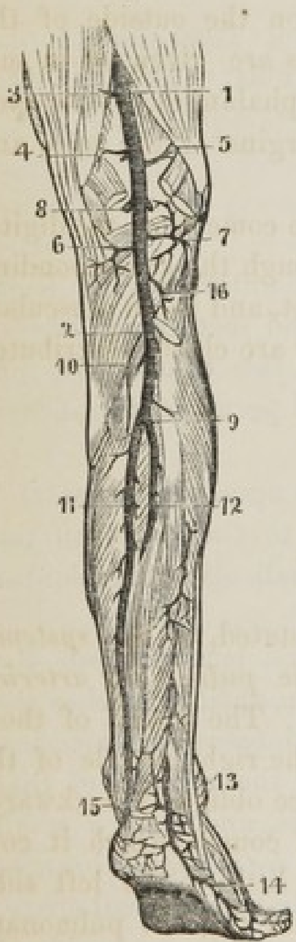
THE POSTERIOR TIBIAL ARTERY.

The *posterior tibial*—tibialis postica—extends from the lower edge of the popliteus muscle, where it is continuous with the popliteal artery, to the sinu-

osity of the os calcis, where it divides into the two plantar arteries. Its whole course is upon the back of the leg. It lies upon the tibialis posticus and flexor longus digitorum muscles, and beneath the gastrocnemius and soleus in the upper two-thirds of its length. Its lower third lies directly upon the tibia, behind the ankle-joint and at the inner margin of the tendo-achillis. The tendons of the tibialis posticus and flexor longus digitorum muscles are interposed between the artery and the malleolus internus, and the tendon of the flexor longus pollicis is at its outer margin. Fig. 287, 2, 9, 11. It gives off one large and several small branches.

The PERONEAL or FIBULAR ARTERY arises from the posterior tibial about an inch below the lower edge of the popliteus muscle, passes down near the internal edge of the fibula, and over the outer ankle to the side of the os calcis. Fig. 287, 12. This artery is deeply placed above beneath the soleus and gastrocnemius muscles; but below it lies beneath the fascia and integuments only. It gives numerous small and inconstant branches to the muscles on each side, and generally furnishes a small vessel, the *nutritia tibiæ*, that enters the foramen on the upper and posterior surface of the bone.

Fig. 287.



Arteries of the leg and foot.

Fig. 287. Arteries of the thigh, leg and foot. 1, 2, popliteal artery; 3, anastomotic artery, the last branch of the femoral; 4, superior internal articular artery; 5, superior external articular artery; 6, inferior internal articular; 7, azygos artery; 8, sural or gastrocnemial arteries; 2, point at which the popliteal divides into the anterior and posterior tibial arteries; 9, point at which the posterior tibial gives off the peroneal artery; being called thus far the tibio-peroneal artery; 10, nutritious artery of the tibia; 11, continued trunk of the posterior tibial artery; 12, peroneal artery; 13, external malleolar artery; 14, external plantar artery; 15, internal malleolar artery; 16, inferior external articular artery.

The *anterior peroneal artery* arises from the peroneal two or three inches above the external ankle, and perforating the interosseous ligament, gets to the front of the leg and runs down on the front of the fibula. It lies deeply beneath the muscles until it approaches the outer ankle, where it becomes superficial, is distributed over the ankle-joint and the outside of the foot and inosculates with the tarsal arteries.

After giving off the anterior peroneal artery, the peroneal trunk continues its course down the back of the leg at the inner margin of the fibula, and passes behind the ankle-joint to the external side of the foot, where it is finally distributed.

The PLANTAR ARTERIES.—These are two terminal vessels derived from the posterior tibial while this artery is in the hollow of the os calcis.

The *internal plantar artery* runs forwards along the inner margin of the

foot, between the aponeurosis plantaris and the abductor pollicis muscle until it reaches the inner side of the great toe. It is a small vessel, gives twigs in its course to the contiguous parts, and ends by inosculation with the digital arteries.

The *external plantar* is much the largest artery of the two, and is the continuation of the trunk of the posterior tibial artery. Fig. 287, 14. Its course is outwards and forwards between the flexor brevis digitorum and the flexor accessorius, until it reaches the metatarsal bone of the little toe; from this point it curves inwards, across all the metatarsal bones to reach the space between the first and second toes, where it lies between the bones and the tendons of the extensor longus digitorum. This curvature is the *arcus plantaris*, which at its inner end anastomoses with the dorsalis pedis from the anterior tibial. The plantar arch furnishes the *digital arteries* in the following order.

The *digital artery of the little toe* arises at the head of the metatarsal bone, gives twigs to the contiguous muscles and then runs on the outside of the little toe to its extremity. The other four digital arteries are given off in succession: they run along the interosseous muscles to the phalanges, where each one bifurcates and sends a branch to the contiguous margins of the toes, and finally inosculates with the other digital branches.

The *perforating arteries* are four in number. They are come from the digital arteries near their point of bifurcation, pass upwards through the corresponding interosseous spaces until they reach the dorsum of the foot, and there inosculate with the digital branches of the metatarsal artery. They are chiefly distributed to the interosseous muscles.

THE PULMONARY ARTERY.

The arteries hitherto described belong, as we have stated, to the *systemic* circulation; and it remains for us briefly to notice the *pulmonary arteries*, which have a totally different destination and function. The trunk of these vessels arises from the left side and anterior margin of the right auricle of the heart, in front of the origin of the aorta, and runs thence obliquely backwards to the lower margin of the arch of that artery. In this course, which it continues for an inch and a half or two inches, it inclines a little to the left side, and finally divides into two great branches, the right and the left pulmonary arteries, which are distributed to the corresponding lungs. Figs. 270, 271. Before the main trunk passes under the arch of the aorta at the point where the pulmonary artery bifurcates, a ligament unites the two vessels together: this short cord is the remains of the *ductus arteriosus* of the fœtus, now become impervious.

The *right pulmonary artery* is about two inches long, and at its origin lies behind the arch of the aorta. At the root of the lungs it divides into three branches, one for each lobe.

The *left pulmonary artery* is much shorter than its fellow, being seldom more

than inch long. It is connected behind with the left bronchus, and covered in front by the serous coat of the pericardium, excepting near the lungs, where the pulmonary veins are placed in front of the arterial branches.*

As each branch of the artery runs upwards and backwards to its respective lung, it meets and joins the two pulmonary veins and corresponding branch of the trachea; these parts are connected together by the mediastinal pleura, and thus assist to form the root of the lungs.

The pulmonary artery conveys the venous blood from the right ventricle of the heart to the lungs; thus performing the function of a vein but possessing the structure of an artery. From this anomaly has arisen the name of *vena arteriosa*, which expresses the peculiar character of the vessel.

The functions of the pulmonary artery will be adverted to in another place. It is sufficient here to remark, that its numberless ramifications convey the venous blood to the air cells of the lungs, where by contact with the atmosphere it becomes decarbonized, or in other words, assumes the fluid arterial character: it is then taken up by the pulmonary veins and conveyed to the left side of the heart, to be thence thrown into the systemic or general circulation through the aorta.

CAPILLARY VESSELS.

The *capillary* or *peripheral vessels* constitute a most delicate network between the arteries and veins, into which the former terminate and the latter arise. This transition of vessels is so gradual that no line of demarcation can be drawn between them. They inosculate most freely with each other to produce the retiform arrangement for which they are so remarkable, but even this is varied in almost every tissue. The existence of these minute vessels is vividly demonstrated by the microscope, and in a yet more permanent manner by injections; especially by those made with mercury, which pass freely from the arterial to the venous trunks through the intermediate capillary system.

The diameter of these vessels is estimated at the $\frac{1}{3000}$th of an inch, and such is their vast number that no part of the surface of the body, nor any internal vascular organ, can be touched with the most delicately pointed instrument without wounding the capillary tubes and causing the flow of blood. They are for the most part remarkable for their equal calibre, although occasional exceptions are noticed; but their arrangement is so varied in accordance with the diversified tissues to which they are distributed, that the practiced eye of the distinguished anatomist Berres, can determine the organic relations of parts by a simple inspection of their injected capillaries; a fact in harmony with the proposition, that the form of the capillary network is determined by the elements of the tissues to which it is distributed.

Fig. 288.

Linear capillaries of muscular fibre. From Berres.

* Cruveilhier, p. 665.

Thus in the *muscles of animal life* they run for the most part parallel to the muscular fibres, occupying the minute interspaces between them, as seen in Fig. 288. The parallel vessels are connected by a much smaller number that pursue a transverse or oblique course, and serve to keep up a perfect anastomosis. This arrangement constitutes the *plexus linearis* of Berres, and a similar distribution occurs in the capillaries of the nervous trunks.

Fig. 289.

Rectangular linear capillaries. From Berres.

The arrangement of the capillaries in the *muscles of organic life* presents also the parallel form, but is crossed by other vessels in a proximately rectangular direction; whence the name of *rectangular linear plexus*. An example of this kind is given in Fig. 289, taken from the muscular coat of the small intestine of a child. This is the *plexus pectinatus* of Berres.

A different and much more complex disposition of the capillaries is seen at the ends of the fingers and toes, under the nails, on the Schneiderian membrane, on the surface of the tongue and in the mucous membrane of the mouth. The peripheral vessels in these parts are curved and tortuous, and resemble an irregular aggregation of loops or nooses, as seen in Fig. 290.

Fig. 290.

Loop-like capillaries. From Berres.

Another and yet more complicated arrangement of capillary vessels is seen in the *palm-formed* plexus of the mucous membrane of various parts of the body. It is delineated in Fig. 291, from the tongue of a child. The same form is found, more or less modified, in the generative and uropoietic organs.

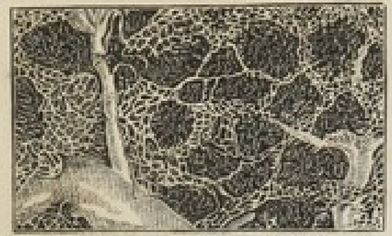
In glandular structures, the capillaries form a network around the secreting follicles, as seen in a portion of the parotid gland, Fig. 292; and a similar arrangement is common to the follicular crypts of the mucous membrane of the intestine.

Fig. 291.

Palm-formed capillaries. From Berres.

It would be easy to multiply examples of the remarkable diversity of plan in the capillary system; but those now given will serve to illustrate the more usual features of this intricate organization. It will be observed, however, that certain *islets* or interspaces exist between the capillary tubes to which no capillaries are distributed. On this subject Dr. Carpenter observes, that "there are many living parts possessing most important functions in the human body, which are not in any direct relation with blood-vessels, and which yet derive their whole nutriment and the materials of their functional operations, from the blood. This is the case, for example, with the whole of the epithelial and epidermic cells, and also with the articular cartilages and the substance of the teeth. Even in bone, the islets between the Haversian canals, which are completely unpenetrated by vessels, are of considerable size. Such islets must everywhere exist between the meshes of the capillary network; so

Fig. 292.



Capillaries of the parotid gland.

that the question of the vascularity or non-vascularity of a tissue is one of *degree* only; the ultimate fibres of muscle or nerve, and the cells and fibres of other tissues, being as completely non-vascular as the entire substance of a tooth or of an articular cartilage; the latter being nourished, like the former, by imbibition from the surrounding vessels."*

THE VEINS.

The blood that has been distributed through the system by the arteries, is brought back in an effete state to the heart by the *veins;* vessels that bear some strong analogies to the arteries, but on the other hand differ from them in several important particulars.

The veins are larger and more numerous than the arteries; and the collective capacity of the former is greater than that of the latter vessels. The larger arteries are usually accompanied by a single venous trunk; but the smaller ones have two or more which are called *venæ comites*, and are enclosed in the same sheath. Such is the case with the humeral, radial and ulnar arteries in the upper extremities, and the tibial and peroneal in the lower limbs. So also the deep-seated veins that accompany the arteries are almost always double, though for the most part of small calibre.

Again, the cutaneous or superficial veins are very numerous in the extremities, and yet are unaccompanied by arteries; thus establishing a great disparity in the bulk of the two systems of vessels.

On the other hand the veins, in some parts of the body correspond to the arteries in number, as in the stomach, intestines, spleen, kidneys, testicles and ovaries; but in other organs there are two arteries to one vein, as in the penis, clitoris, gall-bladder and umbilical cord. Yet even under these circumstances the single veins are always larger than the several arteries whose blood they carry.† Various estimates have been made by physiologists of the relative capacity of the two systems of vessels; but the difficulty attending it may be judged of from the fact, that Borelli supposed the preponderance in favor of the veins to be as four to one; Sauvages as nine to four; Haller as sixteen to nine, and Keill as twenty-five to nine.‡

The veins commence, as we have seen, in the intermediate capillary network, from which larger plexuses are formed by the successive inosculations of vessels; and these coalesce in yet larger branches, and converge into trunks of which the vena cava presents the maximum of development.

The veins are divided into two classes by position—the superficial and the

* Elements of Physiology, § 591.

† Meckel. Anat., i. p. 121.

‡ Dunglison. Human Physiology, ii. 54.

deep-seated. The former are chiefly confined to the limbs, where they lie between the skin and the aponeurosis of the muscles; being conspicuous both by their elevation above the cutaneous surface and by the dark tint imparted to them by the contained venous blood.

The deep-seated veins lie, for the most part, in contact with the arteries and in the same sheath with them; but exceptions to this rule are seen in the sinuses of the brain, which, though in reality veins, do not accompany the arteries; nor are the hepatic, ophthalmic and azygos veins, satellites of their corresponding arteries.*

The direction of the veins is straighter than that of the arteries, for the obvious purpose of facilitating the flow of blood through them; and the venous branches and twigs are larger in proportion to the trunks than in the arterial system. The communication by anastomosis, so familiar in the arteries, is yet more abundant in the veins and even extends to the larger trunks, as seen in the great transverse vein that joins the internal jugular veins, and also in the vena azygos.

The *structure* of the veins resembles that of the arteries in having three coats. The *external coat* is composed, as in the arteries, of cellular membrane, which completely but somewhat loosely envelops the tube within.

The *middle coat* is a double layer, of which the exterior one consists of contractile fibrous tissue arranged in the annular form, while the inner layer is longitudinal and sometimes described as distinctly muscular;† but much difference of opinion exists not only as to the character of these fibres but also with respect to their relative position. Dr. Horner mentions the inner layer as circular, the outer one longitudinal; while Meckel and Bichat, as he observes, deny the existence of circular fibres altogether. Cruveilhier insists that the veins have no middle coat at all; while the accurate Gerber describes it as not composed of elastic tissue, as in the arteries, but made up of fibres of fine organic muscular or contractile tissue running in long spirals, and which, under appropriate stimuli, contract the diameter of the vein and diminish its length.‡ "Admitting this coat, with the exception of its muscular ingredient near the heart, to be of the same tissue, that is, the elastic ligamentous which prevails in the arteries, yet the filaments composing it are much more decidedly intermixed, according to my personal observations. This coat in the human subject is much thicker in the system of the ascending than of the descending cava: it is also thicker in the superficial than in the deep-seated veins. In certain parts of the body it is entirely deficient, as in the sinuses of the dura mater, and has its place supplied by this membrane. The same deficiency exists in the sinuses of the bones."§

The *internal coat* is analogous to that of the arteries, and is said to be divi-

* Cruveilhier. Anatomy, p. 574.

† Wilson. Human Anatomy. Dr. Goddard's edit., p. 359.

‡ General Anatomy, p. 296.

§ Horner. Special Anatomy and Histology, ii. p. 203.

sible into two laminæ.* In the words of Cruveilhier, it is the essential constituent of the vein, because it is found to exist unaltered in every part of the venous system.

The *valves* form a remarkable feature in the organization of the veins. They consist of semilunar folds of the internal coat, with interposed contractile fibres that project from the surface of the vessel into its cavity; two of them are generally placed opposite to each other, but in the smaller veins they are single, and in rare instances threefold. They do not exist in the great venous trunks, nor in the veins of the lungs, the liver, brain and glandular organs generally, nor in the venæ cavæ, the umbilical and cervical veins, nor those of the spine, kidney and uterus; and they are also absent in all the minute subdivisions of the venous system. The adherent border of the valve is convex and directed *from* the heart, while the free border is straight and directed *towards* that organ; whence the valves close when the current of blood sets in the former direction, but afford no obstacle when the current is directed towards the heart itself. Where the valves exist there is an obvious dilatation of the vein giving it a knotted appearance, which is more conspicuous when the vessel is injected.

The veins are themselves supplied with vessels, both arteries and veins—the *vasa vasorum*—which are readily seen in the larger trunks. Nerves have not been demonstrated in the veins, though their existence is generally conceded as an inferential conclusion.

The veins belong to three classes—the systemic, the pulmonary and the portal. The first set, or *systemic veins*, as we have heretofore explained, bring the blood from the various parts of the body and discharge it into the two venæ cavæ, by which it is poured into the heart. The *pulmonary veins* bring the arterialized blood from the lungs and convey it to the left auricle; thus, though venous in structure, performing the function of arteries. The third class of veins is that of the *portal system;* in which the veins originate by capillary beginnings in the chylopoietic viscera, then converge into larger and larger trunks, and enter the liver to branch off again into divisions and subdivisions of the minutest character; thus presenting the singular example of a venous system that is capillary at each extreme, with an intermediate central trunk formed by the convergence of subordinate branches. Finally, the veins from the substance of the heart are not directly connected with either of the preceding classes, for they enter at once into the right auricle, and are therefore independent of all the great veins.

* Mandl. Anatomy Générale, p. 189.

VEINS OF THE HEAD AND NECK.

The veins of the face and neck correspond in name and in their general course with the arteries of the same parts. The same analogy, however, does not obtain between these vessels within the cranium; and the consideration of the latter will, therefore, be considered in connection with the brain and its appendages in another section. The veins of the external parts of the head and neck unite to form two large vessels, the *facial* and *temporal* veins.

Fig. 293.

Veins of the head and neck. After Walter.

Fig. 293. Veins of the head and neck. 1, frontal vein; 2, nasal vein or nasal arch; 3, supra-orbitar vein; 4, angular vein; 5, facial vein; 6, superficial temporal veins; 7, middle temporal vein lying beneath the temporal fascia, and indicated by dotted lines; 8, masseteric plexus; 9, occipital veins; 10, external jugular; 11, internal jugular; 12, anterior jugular; 13, scapular veins; 14, subclavian vein; 15, vena innominata or brachio-cephalic vein.

THE FACIAL VEIN.

The *facial vein* follows the course of the facial artery, and is placed behind it. It commences on the side of the root of the nose by the junction of three small veins, the frontal, supra-orbital and nasal. Fig. 293, 5.

The *frontal vein* comes from the muscles and integuments on the front of the cranium and the diploic veins of this region, and runs to the root of the nose, where it communicates with the vein of the opposite side by a transverse branch called the *nasal arch.* This arrangement, however, is subject to considerable variation. Fig. 293, 1.

The *supra-orbital vein*, coming also from the frontal region, passes through the supra-orbital notch, and makes its way to the inner canthus of the eye to terminate in the frontal vein. Fig. 293, 3.

The *nasal veins* are small vessels that come from the side of the nose. They do not run directly into the frontal vein, but into the continuation of it called the *angular vein*, which is formed by the junction of the frontal and supra-orbital, and which runs downwards by the side of the nose until it dips under the zygomatic muscles, opposite the lower edge of the orbit, and there joins the facial vein. Fig. 293, 2.

The facial vein, thus formed, passes down the anterior margin of the masseter muscle, crosses the lower jaw at the side of the facial artery, whence it runs

downwards and outwards to terminate in the internal jugular vein. Beside the component veins of the facial, it receives in its course the following vessels:

The *pterygoid plexus* unites the veins from the pterygoid and zygomatic regions, and opens directly or indirectly into the facial opposite the angle of the mouth by one or more trunks. The *labial*, the *buccal*, and the *masseteric*, of which the names indicate the origins; the *ranine vein* from the under surface of the tongue; the *submental vein* from the sublingual and submaxillary glands; and the *palatine vein* from the palate and tonsil, all discharge themselves successively into the facial vein.

THE TEMPORAL VEIN.

The *temporal vein* originates on the crown of the head in a plexus of vessels formed by the frontal, temporal, auricular and occipital veins. These primary branches coalesce into two larger ones, the *middle* and *superficial temporal veins*, which in their turn form a single trunk, the proper temporal, which runs down in front of the ear and reaches from the zygoma to the angle of the jaw. In this course it receives the *auricular* veins from the ear and its appendages, the parotid branches from the parotid gland, and the *transverse facial* from the side of the face. Fig. 293, 6, 7.

The temporal is joined in the substance of the parotid gland by the *internal maxillary vein*, which corresponds in the general way to the artery of that name, and receives branches from the palate, the upper and lower jaws, the pterygoid regions and the proximate soft parts of the face. The internal maxillary forms sometimes one, sometimes two trunks, which enter the temporal vein nearly at right angles, and are collectively called the *temporo-maxillary vein*, which, on emerging below the parotid gland, ends in and becomes the external jugular vein.

THE EXTERNAL JUGULAR VEIN.

This vein, as just remarked, is usually the continued trunk of the temporal. It commences on a level with the angle of the lower jaw, passes between the platysma myoides and sterno-mastoid muscles, and runs obliquely inwards to reach the lower part of the neck, where it opens into the subclavian vein near its junction with the internal jugular and in front of the scalenus anticus muscle. In some instances it ends by two or three trunks; in others, its single trunk is formed by two or three antecedent branches. In this course the external jugular receives the following veins. Fig. 293, 10.

The *posterior jugular vein* comes from the back of the neck, between the splenius and trapezius muscles, and receiving various collateral branches, terminates at or below the middle of the neck.

The *anterior jugular vein* is extremely variable, but is generally formed by branches arising on the front of the neck, and ends either in the external or internal jugular, or in the subclavian vein. Fig. 293, 12.

The *supra-scapular* and *posterior scapular* veins open into the external jugular just before its termination, following the course of the corresponding arteries.

THE INTERNAL JUGULAR VEIN.

This great vessel commences on each side at the posterior foramen lacerum at the base of the skull, at which point it is continuous with the lateral sinus. It descends on the side of the neck, being placed above on the outside of the internal carotid artery, and afterwards on the outside of the primitive carotid, with which it runs parallel and in the same sheath, accompanied by the pneumogastric nerve. Figs. 293, 11, and 276, 11. It is crossed by the omo-hyoid muscle, and for the greater part of its course lies beneath the anterior edge of the sterno-mastoid muscle. The pneumogastric nerve lies between and behind the vein and artery; while the glosso-pharyngeal and hypo-glossal nerves pass forwards between the vessels. When the internal jugular has reached the base of the neck behind the sternal end of the clavicle, it joins the subclavian, and the two form a large trunk, the *vena innominata* or brachio-cephalic vein. Figs. 293, 15, and 276, 15, 16.

The internal jugular receives various subsidiary veins which are variable in size and termination. It anastomoses with the external jugular below the parotid gland, and is afterwards augmented, in an uncertain succession, by the facial, occipital, lingual, pharyngeal and superior thyroid veins.

The *occipital vein* runs a nearly similar course with the occipital artery, and terminates sometimes in the internal, sometimes in the external jugular. Fig. 293, 9.

The *lingual vein* comes from the tongue. A branch of it, called the ranina, is seen under that organ and is sometimes subjected to venesection.

The *pharyngeal vein* comes, as its name implies, from the pharynx, and terminates either in the internal jugular or in some one of its accessory veins.

The *superior thyroid vein* brings the blood from the thyroid gland, and empties it into the internal jugular. Fig. 276, 13.

VEINS OF THE UPPER EXTREMITY.

The veins of the upper extremity commence at the ends of the fingers and coalesce in remarkably beautiful plexuses on the hand, especially on its dorsal surface as seen in mercurial injections.* By a further convergence these veins form large trunks at the carpus, whence they ascend the arm in two series, the *superficial* and the *deep-seated*.

The *superficial veins* lie beneath the skin and over the fascia of the arm. By converging on the back of the carpus they form two trunks, one of which runs along the radial, the other on the ulnar margin of the forearm; whence the names of radial and ulnar cutaneous veins.

* Mascagni. Prodromo, tav. I.

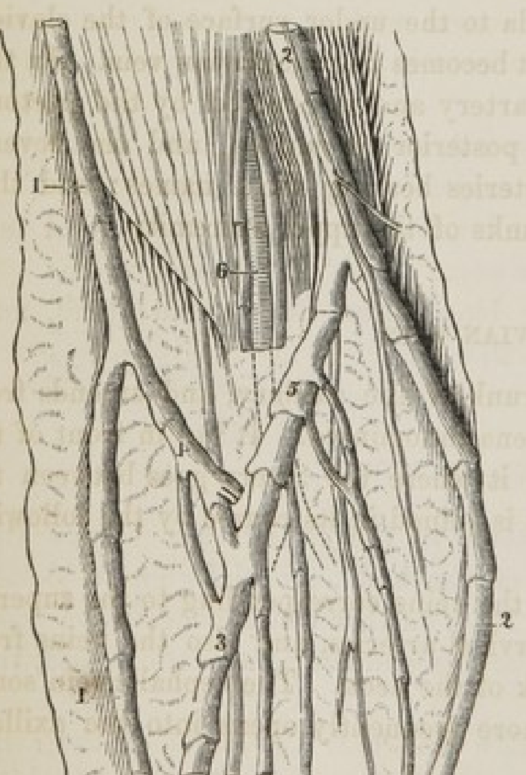
The *radial cutaneous* vein runs in the course just indicated to the bend of the arm, where it receives a branch from the median vein (median cephalic) and is now called the *cephalic vein;* which latter designation is sometimes given to the entire vessel from the wrist to the axilla. The cephalic vein continues to ascend on the arm, at the outer margin of the biceps muscle until it reaches the pectoralis major, where it sinks between that muscle and the deltoid, and empties into the axillary vein just below the clavicle. Fig. 294, 1.

The *ulnar cutaneous veins* are two in number, one anterior and the other posterior. The *anterior* trunk forms on the front of the carpus, and ascends on the forearm to the bend of the elbow. The *posterior* trunk commences at the back of the hand, and runs along the ulnar margin of the forearm until it gets a short distance below the joint, where it curves forwards on the front of the arm and joins the anterior ulnar cutaneous vein. A common trunk is thus formed, —the *basilic vein.*

The *basilic vein*—cubitalis cutanea—the common trunk of the ulnar cutaneous veins, runs upwards towards the inner side of the arm, dips beneath the fascia at the margin of the biceps muscle, and continuing along the inside of that muscle and in front of the brachial artery, joins the venæ comites and becomes the *brachial vein.* Fig. 294, 2, 2.

The *median vein* is formed of branches from the wrist, palm of the hand and lower front surface of the arm. The trunk ascends on the front of the arm until it gets within a short distance of the joint, where it divides into branches: one of these runs upwards and outwards to join the cephalic vein, and hence is called the *median cephalic,* Fig. 294, 4: the other branch runs upwards and inwards to join the basilic vein and is called the *median basilic.* Fig. 294, 5.

Fig. 294.



Veins at the bend of the elbow.

Fig. 294. Veins at the bend of the arm. 1, 1, cephalic vein; 2, 2, basilic vein; 3, median vein; 4, median cephalic; 5, median basilic; 6, brachial artery. After Fyfe.

The *deep-seated veins* of the arm and forearm are arranged as follows. The *deep ulnar veins* are the venæ comites of the ulnar artery. They originate from the digital veins of the fingers, which unite in two *palmar veins,* and these make a double curve or arch towards the inner side of the palm and wrist to form the *two deep ulnar veins.* These veins pass upwards in front of the wrist, on the inner, anterior surface of the arm beneath the fascia, and having

the ulnar artery between them. In this course they receive branches from the interosseous and other proximate veins, and uniting, though at variable points, with the deep radial veins, form the venæ comites of the brachial artery.

The *anterior* and *posterior interosseous* veins run from the wrist upwards on the front and back of the arm. They are double in each instance, and accompany the corresponding interosseous artery. These veins are united by frequent anastomoses throughout their course; just below the elbow the two sets are united by branches which pass through the interosseous membranes, and finally terminate in the venæ comites of the ulnar artery.

The *deep radial veins* arise from the digital and palmar veins, and form a continuous arch with that of the deep ulnar vein already described. The arch is double and answers to that of the radial artery, and it pursues the same course under the ball of the thumb in order to reach the artery above the carpus and in front of the radius. The two veins then accompany the radial artery and end in the venæ comites of the brachial artery.

The two *brachial veins* ascend the arm in company with the artery, being joined in their course by the profunda and anastomotic veins. When they have reached the lower boundary of the axilla they unite and form the axillary vein.

THE AXILLARY VEIN.

The *vena axillaris*, thus formed by the two brachial and by the basilic veins, extends from the lower edge of the axilla to the under surface of the clavicle and outer margin of the first rib, where it becomes the subclavian vein. In this course it lies in front of the axillary artery and is covered by the pectoral muscle. It receives the anterior and posterior circumflex, and the several thoracic veins corresponding to the arteries bearing those names; and thus returns the blood from all the venous trunks of the upper extremity.

THE SUBCLAVIAN VEIN.

The *vena subclavia* is the continued trunk of the axillary, and extends from the outer margin of the first rib to the vena innominata. It lies in front of the subclavian artery, but is separated from it where the artery goes between the anterior and middle scaleni muscles. It is joined in its course by the following vessels.

After crossing the first rib it receives the veins corresponding to the superior dorsal artery of the scapula and the cervical arteries, and also the veins from the muscles and integuments on the back of the neck. The cephalic vein sometimes joins the subclavian, though it more frequently opens into the axillary vein as heretofore stated.

The *vertebral vein* is formed by branches from the spinal marrow and its membranes, and from the bones and deep-seated muscles at the upper and back part of the neck. It curves round the foramen magnum, reaches the atlas and enters the foramen in the transverse process of the atlas vertebra: it passes

thence in company with the vertebral artery through the other foramina to the sixth cervical vertebra, from which the vein emerges to join either the subclavian vein near its termination, or the vena innominata, or as sometimes happens, the descending cava. Fig. 276, 14.

Behind the top of the sternum, the subclavian vein sometimes receives the *inferior laryngeal* and the *internal mammary* vein, which in other instances open into the vena innominata or superior cava: it is also joined by the *external jugular* in the manner heretofore described, and by the *internal jugular* to form the vena innominata. Fig. 293, 14, 15, and Fig. 276.

The *left superior intercostal vein* opens into the subclavian just before the latter terminates, or more frequently into the vena innominata itself. It is formed from branches that come from the five or six superior intercostal spaces, and is enlarged by the addition of veins from the esophagus and lungs. The right intercostal usually joins either the azygos vein or the vena innominata, but is sometimes deficient.

THE VENA INNOMINATA.

The *vena innominta*, or *brachio-cephalic vein*, is formed on each side of the base of the neck by the junction of the subclavian and internal jugular veins. This junction takes place behind the sternal end of the clavicle; but in their course to meet the vena cava, the direction and length of the venæ innominatæ of the two sides are somewhat different.

The right vein is very short, being hardly an inch in length, and takes a straight course downwards and inwards to its termination. Fig. 276, 15. The vein of the left side is twice the length of its fellow; it crosses behind the upper end of the sternum, curves downwards and inwards to meet the opposite vein, and the two empty at an angle into the superior cava. Fig. 276, 16. The right vena innominata is in relation with the arch of the aorta and passes obliquely in front of the vessels given off by that artery, whence its name of the *transverse vein.* The venæ innominatæ have no valves. They receive, in their short course, a very few constant branches, and among others the following, which however discharge almost as frequently into the subclavian or the superior cava:—the *inferior thyroid* from the thyroid gland; and the *internal mammary*, two in number on each side, which are the venæ comites of the internal mammary artery and anastomose with the epigastric veins.

THE SUPERIOR VENA CAVA.

This great vessel, called also the *vena cava descendens*, is formed by the junction of the venæ innominatæ behind the cartilage of the first rib on the right side, whence it descends for about three inches in a vertical direction to terminate in the right auricle. Figs. 276, 17, and 295, 8. It passes through the right margin of the mediastinum, with the aorta on its left. Above it is in contact with the pleura, and below is surrounded by the pericardium. The pulmonary

vessels of the right side lie immediately behind the vena cava, which is also on that side in contact with the right lung. It is destitute of valves.

The superior cava sometimes receives the vertebral, the superior intercostal and the internal mammary veins; but these more frequently discharge into other trunks, as heretofore shown. The only constant branch of the superior cava is the *vena azygos.*

THE VENA AZYGOS.

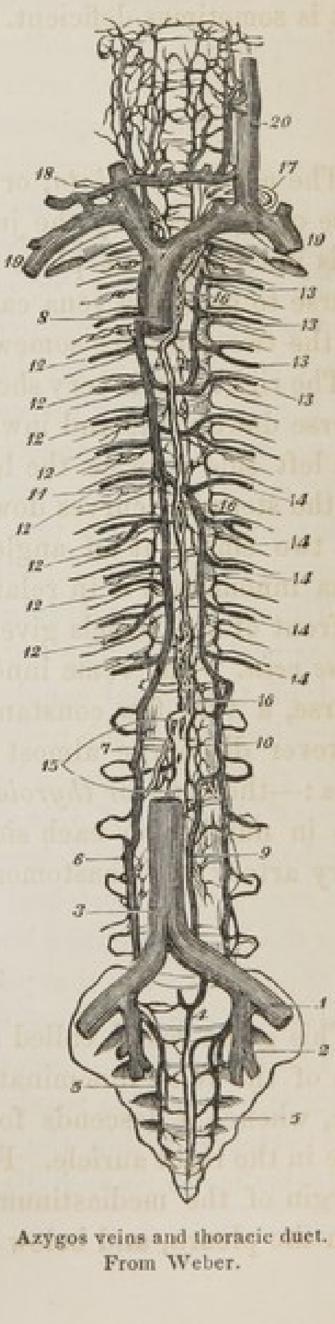
This remarkable vein commences in the abdomen from a plexus formed by the lumbar veins and a branch from the inferior cava, which unite in a single trunk. It ascends through the hiatus aorticus of the diaphragm, behind the pleura and on the right of the aorta. On reaching the third dorsal vertebra it arches across the right bronchus and opens into the superior cava about an inch above the right auricle. Its termination is guarded by a valve, and a few other but less perfect valves exist in different parts of it. Fig. 295, 6, 7, 8.

The azygos vein in this course receives the following tributary vessels.

The *azygos minor* or *vena hemiazygos*, commences in the lumbar region, on the left side, from a plexus derived from the lumbar or renal veins, with accessions from the five or six inferior intercostal veins of the same side. Fig. 295, 14, 14. It ascends into the thorax through the aortic orifice of the diaphragm, in front of the left intercostal arteries, and getting behind the aorta, opens into the great vena azygos in front of the sixth dorsal vertebra or in that vicinity. Fig. 295, 9, 10, 11.

Fig. 295. Azygos veins and thoracic duct. 1, external iliac vein; 2, internal iliac vein; 3, vena cava ascendens; 4, middle sacral vein; 5, 5, lateral sacral veins; 6, origin of the greater azygos vein in the lumbar region and from the lumbar veins; 7, its trunk; 8, its termination in the descending vena cava; 9, lumbar veins of the left side forming at 10 the lesser azygos vein, which terminates at 11, in the greater azygos; 12, 12, 12, eight or nine inferior intercostal veins of the right side, opening into the greater azygos; 13, 13, 13, superior intercostal veins, opening by a common trunk into the greater azygos vein; 14, 14, 14, five inferior intercostal veins of the left side joining the lesser azygos; 15, receptaculum chyli; 16, 16, 16, thoracic duct; 17, its termination in the angle formed between the left internal jugular and left subclavian veins; 18, right thoracic duct; 19, subclavian vein; 20, internal jugular.

Fig. 295.



Azygos veins and thoracic duct.
From Weber.

The *bronchial veins* return the blood that has been bestowed on the nutrition of the lungs. The right bronchial vein generally opens into the azygos near its termination; that of the left side ends in the superior intercostal vein.*

The *right intercostal veins* also open into the greater azygos vein. Fig. 295, 12, 12, 12.

THE VERTEBRO-SPINAL VEINS.

This series of vessels constitutes a complex anastomosis within and without the spinal canal that extends its whole length. They are sometimes called the sinuses of the vertebral column, but possess the usual character of simple veins. They collect the effete blood from the cauda equina, the medulla spinalis and its membranes and from the whole series of vertebral bones, and discharge it into the internal jugular vein. The vertebro-spinal veins belong to three principal sets in the following order.

The *dorsi-spinal veins*—dorsi spinales—embrace a series of anastomosing vessels around the spinous, transverse and oblique processes, extending from the os coccygis to the occiput. They bring the venous blood from the muscles and integuments of the spine, and terminate in part in a venous plexus within the spinal column, and partly in the lumbar, intercostal and vertebral veins.

The *medulli-spinales*, or veins of the spinal cord, run between the pia mater and arachnoid and consequently inside of the sheath formed by the dura mater. They commence at the lowest part of the sacral canal and ascend to the top of the spine, being tortuous throughout. They communicate freely with each other, and also by anastomosis with the spinal veins through lateral branches that enter the intervertebral foramina. As they approach the cranium, these veins converge into two or three small trunks that empty into the petrous sinuses, or into the inferior veins of the cerebellum.

The *meningo-rachidian veins* consist of two sets, one of which is anterior, the other posterior. The *anterior* veins are two in number, commence at the lowest end of the spinal canal, and pursue a tortuous course to its upper extremity. They lie against the posterior surface of the bodies of the vertebræ, one on each side, and are connected by such frequent anastomoses as in some places to constitute plexuses of veins. They are also joined by transverse branches from the bodies of the vertebræ (basi-vertebrals), and terminate in the sacral, lumbar, intercostal and vertebral veins. The *posterior meningo-rachidian veins* run, like the last, the entire length of the spinal canal, but on the opposite side, being in apposition with the posterior surface of the canal, and exterior to the dura mater. They terminate above in the intercostal veins.

The *basi-vertebral veins* originate in the bodies of the vertebræ, whence they emerge by a single trunk from a foramen in the centre of the posterior face of the vertebra, within the spinal canal. The veins thus formed open into the anterior meningo-rachidian trunk just described.

* Quain. Anatomy, p. 629.

The vertebro-spinal veins within the spinal canal are very unequal in size, sometimes contracting, sometimes dilating, and are retained in their position by cellular tissue that connects them with the bones on the one side and with the dura mater on the other. They are sometimes called the *sinuses* of the vertebral column.*

VEINS OF THE LOWER EXTREMITY.

The veins of the foot, like those of the hand, follow their respective deep-seated arteries, and also form superficial trunks that run with great irregularity of course beneath the skin and fascia. All these veins, in common with those of the lower extremity generally, are abundantly furnished with valves. The pedal veins form a plexus over the top of the foot, from which two large trunks take their origin; the one curving to the outer, the other to the inner ankle. These are the *saphenous veins*.

The *external* or *small saphena*—saphena externa—originates from the outside of the ankle and contiguous lateral and dorsal parts of the foot. The trunk is formed behind the external malleolus, whence it extends upwards near the tendo-achillis, covered only by the integuments. It afterwards lies upon the gastrocnemius muscle, and finally dips inwards between the heads of that muscle to join the popliteal vein.

Fig. 296.

Saphena major.

The *internal saphena*, saphena major, Fig. 296, 4, 5, forms its trunk from the dorsum, sole and malleolar surfaces of the foot, and runs upwards in front of the inner ankle, parallel with the inner edge of the tibia and accompanied by the corresponding saphenous nerve. It crosses the internal condyle of the femur, ascends on the inner surface of the thigh, and terminates in the femoral vein an inch or two inches below the crural arch by perforating the fascia lata; for which reason the perforation is called the *saphenous opening*. In this long course the great saphena receives many muscular and cutaneous branches, and is always placed immediately beneath the skin and fascia. Just before it joins the femoral vein it perforates the fascia of the thigh, and receives the internal pudic and superficial circumflex veins. Fig. 296, 2, 3. It is furnished with valves, but they are few, and variable in number.

Fig. 296. Saphena major. 1, superficial epigastric vein; 2, internal pudic vein; 3, superficial circumflex vein; 4, origin of the saphena major; 5, its termination in the femoral vein.

* For admirable illustrations of the vertebro-spinal veins, see *Breschet*, Essai sur les Veines du Rachis; and *Quain*, Vessels of the Human Body, Pl. 38, 39.

THE POPLITEAL VEIN.

The *popliteal vein* is formed by the conjunction of the deep-seated veins of the leg at the lower edge of the popliteus muscle, from which point to the opening in the adductor magnus it bears the name of popliteal vein. The vessels of the leg which enter into its composition are the venæ comites of the arteries, two in number to each artery, viz: the *anterior* and *posterior tibial* and the *peroneal* veins, with their collateral muscular branches, all remarkable for the number of their valves. The popliteal vein lies behind the artery while below and opposite the knee-joint; but above the joint it is a little to the outside of the artery. It receives the external saphenous vein and several muscular and articular branches, and is furnished with four or five valves.

THE FEMORAL VEIN.

Where the popliteal vein ends by perforating the adductor magnus, the *femoral vein* begins, and ascends the thigh in the same sheath with the femoral artery until it reaches the crural arch, where it becomes the external iliac vein. It lies at first somewhat to the outside of the artery, then gets behind it and finally, before it reaches Poupart's ligament, is placed on the inner side of that vessel. In this course it has but four or five valves, and receives the large veins of the thigh,—the profunda and its branches, the superficial veins and the great saphena.

THE EXTERNAL ILIAC VEIN.

The *external iliac* is the continuation of the femoral vein from the crural arch to the sacro-iliac junction. In this short course it receives the *circumflex* and *epigastric* veins, which enter it at a point above its origin. At its commencement under Poupart's ligament, the external iliac artery lies on its outside of the vein, but the latter gets rather behind the artery as the two vessels approach the sacro-iliac symphysis. Fig. 284, 3, 3. The internal iliac vein has no valves.

THE INTERNAL ILIAC VEIN.

This vein, the *vena hypogastrica*, is formed by the junction of the pelvic veins that accompany the branches of the hypogastric artery, and it terminates at the sacro-iliac junction by uniting with the external iliac to form the trunk of the common iliac vein. Fig. 284, 4, 4. There are two veins to each arterial branch, which unite by anastomosis at particular parts so as to form venous plexuses of large size.

The *hemorrhoidal veins* and their constituent plexuses surround the lower end of the rectum; being derived above from the *superior hemorrhoidal* veins and below from the middle and inferior hemorrhoidals, the former belonging to the infe-

rior mesenteric system, the latter to the internal iliac vein. It will be observed that a connection is thus formed between this plexus and the portal system of vessels.

The *vesical veins* are derived from the end of the penis and form two trunks on the back of that organ called the *dorsales penis*, which receive branches from the corpora cavernosa and contiguous parts; they enter the pelvis beneath the sub pubic ligament and run backwards to the side of the bladder, vesiculæ seminales and prostate, from which they receive accessory branches and by this anastomosis form the *vesical plexus*. The latter unite in two or more branches and discharge into the hypogastric vein at its lower part. This vein in the female commences on the clitoris, but is comparatively small; it receives accessions from the labia externa and anastomoses with the vaginal plexus.

The *vaginal vein* constitutes a plexus around the vagina and is particularly developed around the orifice of that canal. It communicates freely with the vesical plexus as above mentioned, and with the hemorrhoidal plexus behind.

The *uterine veins* arise in the substance of the uterus and in the broad ligaments. They are small in the unimpregnated state, but attain an enormous magnitude in the gravid uterus.

The *sacral veins* constitute a plexus on each side of the internal sacral region; they anastomose with each other, with the vertebro-spinal veins through the intervertebral foramina of the sacrum, and with the hemorrhoidal and vesical veins in front. Fig. 295, 4, 5.

The pelvic veins are freely supplied with valves, and terminate in the internal iliac at or near the origin of the corresponding arteries.

THE PRIMITIVE ILIAC VEIN.

The junction of the internal and external iliac veins over the sacro-iliac symphysis, forms a common trunk called the *primitive iliac*, which runs obliquely upwards and inwards to meet its fellow of the opposite side in front of the articulation of the fourth and fifth lumbar vertebræ, and to the right of the median line. The right vein is the shorter and more vertical of the two; the left vein, besides being much the longer, sometimes receives the middle sacral vein. The right vein is at first behind the artery, but soon gets a little to its outer side; but the left vein lies inside of the artery. The primitive iliacs have no valves. Fig. 284, 12, and Fig. 295.

THE INFERIOR VENA CAVA.

The *inferior*, or *ascending cava*, is formed by the convergence of the two primitive iliacs at the point mentioned in the last section; from whence it ascends on the front and right margin of the spinal column, to the lower border of the right auricle into which it opens. Fig. 284, 13, and Fig. 295, 3. In this course it is covered by the peritoneum, perforates the posterior margin of the liver, and then passes through the foramen quadratum in the tendinous centre of the

diaphragm. It has the aorta on its left side and the sympathetic nerve on the left. It has no valves excepting that of Eustachius at its termination in the auricle. The inferior vena cava receives the lumbar, spermatic, renal, capsular, hepatic and phrenic veins.

THE LUMBAR VEINS.

Although the middle sacral vein sometimes empties into the ascending cava, the first constant branches received by this great trunk are the *lumbar* or *vertebro-lumbar veins.* These correspond to the lumbar arteries, being three or four on each side, bringing the blood from the contiguous muscular and tegumentary structures and also from the lower and internal part of the spinal column. Each of the veins formed from these sources runs forwards and inwards, and opens into the vena cava at a right angle. Fig. 295, 6, 9.

THE SPERMATIC VEINS.

The spermatic veins commence in the interior of the testicle, in the manner adverted to when treating of that organ. "They all terminate in branches which are applied to the inner surface of the tunica albuginea, and are bound down to it by a thin layer of fibrous tissue, a disposition somewhat resembling that of the sinuses of the dura mater. The spermatic veins perforate the tunica albuginea on the inner side of the epididymis, not opposite that body. They are soon joined by the veins of the epididymis, so as to form a plexus that communicates with the dorsal veins of the penis and with the external and internal pudic veins. The spermatic veins soon unite into five or six trunks that pass upward in front of the vas deferens, and together with that canal and the spermatic artery enter into the formation of the spermatic cord."* After passing through the abdominal canal, the spermatic veins unite in a single trunk that passes up in company with the artery and the ureter, and empties, that of the right side into the vena cava, that of the left side into the renal vein. Before its termination the spermatic vein sometimes forms a plexus with other vessels from the contiguous parts.

The spermatic vein of the female is called the *ovarian vein.* It collects the blood from the ovaries, round ligaments and Fallopian tubes, and terminates like the spermatic veins of the male.

THE RENAL VEINS.

The *renal* or *emulgent* veins, one on each side, extend from the fissure of the kidney to the vena cava. The left vein is much the larger in consequence of the position of the vena cava on the right side of the spine: it crosses in front of the aorta, and takes a course obliquely downwards to meet the kidney. The vein of the right side is very short, and opens either opposite to its fellow or a

* Cruveilhier. Anatomy, p. 793.

little below it. The origin of the radicles of the renal veins have been described with the kidney, but may be recurred to in this place. The renal arteries terminate in tufts in the Malpighian bodies of the cortical substance, where, after secreting the urine, their effete blood is taken up by the efferent capillary veins. These latter vessels perforate the investing capsule of the Malpighian corpuscles and form plexuses on the outside of them, which rapidly converge into larger and larger trunks and finally into the great renal vein, of which we have described the course and termination. Fig. 232.

The *capsular veins,* called also the supra-renal, collect the blood from the capsulæ renales. They vary in number and terminate variously, but for the most part the right vein opens into the vena cava; the left one into the renal or into the phrenic vein.

THE HEPATIC VEINS.

We have explained, with the organization of the liver, the origin of the hepatic veins, and it is only necessary to advert to them here with great brevity. The radicles of these vessels are the *intralobular* veins of the hepatic lobules, which collect the effete blood from the terminal capillaries of the portal vein within the lobules and discharge it into the sublobular hepatic veins. These last converge into larger trunks that run upwards and backwards to reach the posterior margin of the liver, where they open obliquely into the vena cava. The hepatic veins do not accompany the arteries of the liver, but run towards their terminus in three sets, one of which is derived from the right lobe, a second from the left, and a third from the lobulus Spigelii. They are destitute of valves, and open into the vena cava by the three trunks just indicated immediately below the diaphragm. Fig. 297, 7.

THE PHRENIC VEINS.

The *phrenic veins* correspond to the phrenic arteries and arise from the diaphragm, one on each side. They terminate in the vena cava just above the hepatic veins.

THE CARDIAC VEINS.

These veins present the anomaly of discharging directly into the heart, and are four in number.

The *great cardiac vein*, called also the *coronary vein* of the heart, arises at the apex of that organ, and forms a trunk that runs in the sulcus between the ventricles until it reaches the base of the heart, at which point it turns into the groove between the right auricle and ventricle and opens into the right auricle. In this course it receives accessory branches from the left auricle and ventricle, together with the *posterior cardiac veins* from the posterior ventricular groove.

The *anterior cardiac veins* arise in the corresponding part of the right ventricle, and form a trunk that runs in the fissure between the right auricle and ventricle to empty into the great coronary vein just before its termination.

THE PORTAL VENOUS SYSTEM.

This remarkable system has been so fully described with the liver as to require no additional notice in this place.

THE PULMONARY VEINS.

These vessels are four in number, two for each lung. They commence in the ultimate ramifications of the pulmonary artery in the air-cells of the lung, and converge in branches of increasing size until a single trunk is formed for each lobe—or three trunks for the right lung, and two for the left; but the trunk from the middle lobe of the right lung joins that from the upper lobe of the same side, and the four mouths discharge into the four angles of the left auricle. Fig. 272, 8, 8.

In the substance of the lungs, observes Cruveilhier, the branches of the veins are behind, those of the arteries are in front and the bronchia are in the middle. The larger branches of these three kinds of vessels cross each other at acute angles, but their extreme ramifications are parallel. At the root of the lungs the veins are in front, the artery is in the middle and the bronchus behind.* The right pulmonary veins reach the auricle behind the superior vena cava; the left veins pass behind the pulmonary artery; and before their termination they perforate the pericardium. They are destitute of valves.

The pulmonary veins perform the function of arteries, whence their synonym of *arteriæ venosæ*. They communicate freely, as injections prove, with the terminal capillaries of the pulmonary arteries, and thus receive the arterialized blood in the bronchial cells, whence they convey it to the left ventricle.

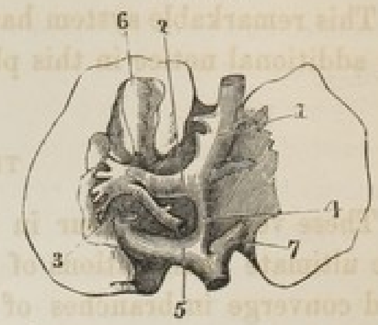
THE FŒTAL CIRCULATION.

The placenta is to the fœtus what the lungs are after birth: it arterializes the blood and qualifies it for the nourishment of the embryo. The blood thus prepared is received by the capillary sources of the *umbilical vein;* which vessel, formed by the junction of an infinitude of placental radicles, becomes a large trunk at the surface of the placenta and enters the body of the child at the umbilicus. Fig. 299, 4, 5. From this point it is attached to the margin of the suspensory ligament of the liver, follows the course of the umbilical fissure, and terminates in the left branch of the sinus of the vena portarum. Fig. 297, 2. Hence it is that the liver, a large and important organ in the fœtus, receives a very large share of arterialized blood; but another portion is distributed in a different direction by means of the ductus venosus.

* Anatomy, p. 577.

The *ductus venosus* comes from the left branch of the sinus of the vena portarum, and passing backwards opens into the ascending vena cava, or into the hepatic vein just before it discharges into the former. Fig. 297, 4, and Fig. 299, 9. By this arrangement the arterialized blood becomes mingled with the effete blood brought from the lower extremities, and the whole is thrown by the vena cava into the right auricle of the heart.

Fig. 297.

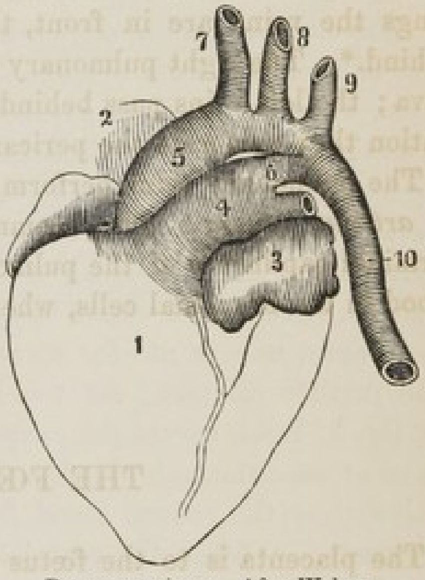


Ductus venosus. From Cruveilhier.

Fig. 297. Under surface of a fœtal liver, showing the situation of the ductus venosus and its associated vessels. 1, 2, umbilical vein; 3, vena portæ; 4, ductus venosus; 5, vena cava; 6, gall-bladder; 7, hepatic vein.

From the right auricle the blood passes through the foramen ovale in the inter-auricular septum, to the left auricle, by which means it is in a great measure restrained from entering the right ventricle and the pulmonary artery: that portion of the blood, however, that takes the latter route, does not pass except in very limited quantity through the lungs, as in the adult; but on the contrary is transmitted directly from the trunk of the pulmonary artery to the aorta by means of the *ductus arteriosus*. This is a short canal that connects the two great vessels, but its diameter is so considerable that it looks like the continued trunk of the pulmonary artery, and opens into the aorta below the arch and just beneath the origin of the left subclavian artery. Fig. 298, 6, and Fig. 299, 17.

Fig. 298.



Ductus arteriosus. After Weber.

Fig. 298. Ductus arteriosus. 1, right ventricle; 2, right auricle; 3, left auricle; 4, pulmonary artery; 5, aorta; 6, ductus arteriosus; 7, arteria innominata; 8, left primitive carotid; 9, left subclavian; 10, thoracic aorta.

The arterialized blood of the right auricle is thus mingled with the venous blood from the upper extremities and head, whence it is brought by the descending vena cava. Thus we have in the auricle, as before in the vena cava, a contact and partial blending of the effete with the decarbonized blood. Very little blood, it will be observed, can reach the lungs in this circulation; for in the first place they are dense and in a measure impervious to it,—and in the second place, the foramen ovale and the ductus arteriosus intercept the current and direct it to the left auricle, thence into the left ventricle and from this cavity into the aorta. The arterialized blood is thus distributed, but in part only as will be presently explained, to the head and upper extremities by means

of the carotid and subclavian arteries; another part, mixed with venous blood, takes the course of the descending aorta and has also a twofold destination in the following manner: one portion flows into the external iliac and femoral arteries, and is distributed to the lower limbs; a second and greater portion is conveyed through the hypogastric and umbilical arteries back to the placenta.

These *umbilical arteries* are two in number, one on each side. They may be regarded either as branches of the internal iliacs, or more properly as the continuous trunks of these arteries. From this origin they first curve downwards, then ascend on the sides of the bladder, and converge towards each other as they approach the umbilicus, where they come into contact, pass out of the abdomen, and become constituent parts of the umbilical cord. From their junction at the navel to their termination in the placenta, the two arteries wind round the umbilical vein in a very tortuous manner. The arteries anastomose near the placenta, and then enter that organ, wherein the capillary vessels become continuous with those of the umbilical vein. Fig. 299, 23, 23.

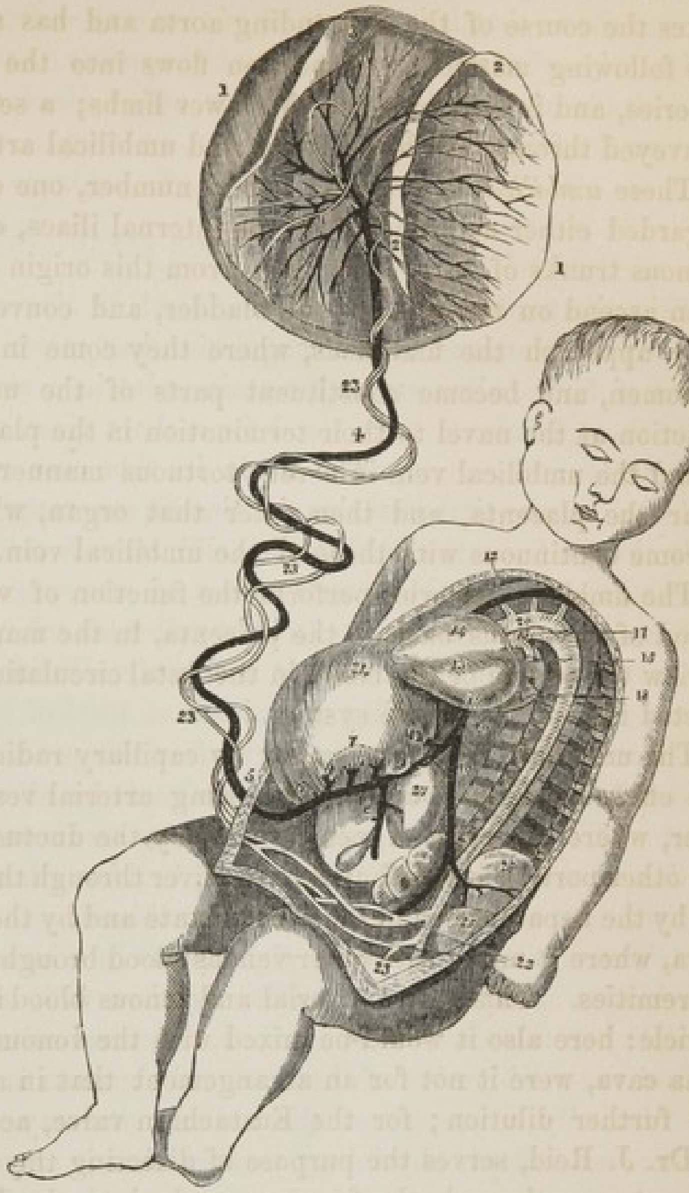
The umbilical arteries perform the function of veins by conveying the effete blood of the fœtus back to the placenta, in the manner just described. Let us review the course of the blood in the fœtal circulation in order to impress a connected idea of the whole system.

The umbilical vein, originating by capillary radicles in the placenta, receives the effete blood from the anastomosing arterial vessels and conveys it to the liver, where one portion goes directly by the ductus venosus to the vena cava: the other portion is distributed to the liver through the portal system, and is taken up by the hepatic veins in the venous state and by them poured into the ascending cava, where it mixes with other venous blood brought by that vein from the lower extremities. This mixed arterial and venous blood is next conveyed to the right auricle: here also it would be mixed with the venous blood from the descending vena cava, were it not for an arrangement that in a great measure counteracts the further dilution; for the Eustachian valve, according to the experiments of Dr. J. Reid, serves the purpose of directing the arterial blood of the inferior cava at once through the foramen ovale into the left auricle; while the same valve gives the venous blood from the superior cava a direction into the right ventricle. "When the ventricles contract, the arterial blood which the left contains is propelled into the ascending aorta, and supplies the branches that proceed to the head and upper extremities before it undergoes any admixture; whilst the venous blood contained in the right ventricle is forced through the pulmonary artery and ductus arteriosus into the descending aorta, mingling with the arterial current which that vessel previously contained, and passing thus to the trunk and lower extremities. Hence the head and superior extremities, whose development is required to be in advance of that of the lower, are supplied with blood nearly as pure as that which returns from the placenta; whilst the rest of the body receives a mixture of this with what has previously circulated through the system, and of this mixture a portion is transmitted to the placenta, to be renovated by coming into relation with the maternal fluid."*

* Carpenter. Physiology, § 944.

Fig. 299. 1, placenta; 2, amnion; 3, chorion; 4, 5, umbilical vein; 6, its passage through the liver; 7, its hepatic branches; 8, vena portarum; 9, ductus venosus; 10, ascending vena cava; 11, hepatic vein; 12, descending vena cava; 13, heart, turned upon its anterior side; 14, right ventricle; 15, pulmonary artery; 16, left pulmonary artery; 17, ductus arteriosus; 18, left pulmonary veins, opening to the left auricle; 19, left ventricle; 20, arch of the aorta; 21, descending aorta; 22, primitive iliac arteries; 23, umbilical arteries; 24, liver, turned up; 25, kidney; 26, renal capsule; 27, lobulus Spigelii.

Fig. 299.



Plan of the fœtal circulation. After Weber.*

It has been at various times supposed and asserted, that a direct vascular communication exists between the mother and the fœtus. Such, however, is not the case, as ample observation has proved; nor have any experiments to test this question been more elaborately, carefully and conclusively performed than those of Professor Horner;† who corroborates the now general sentiment of physiologists, that the only vascular communication between the two systems is on the principle of imbibition, or as he terms it interstitial circulation. For further details on this subject the reader is referred to the chapter on the uterus.

THE BLOOD.

The blood is familiar to every one as a fluid of a red color, viscid consistence, peculiar odor and slightly saline taste. When first taken from the body, the

* Reduced from the copy in Paxton's Anatomy, Fig. 95. I have also availed myself of the references connected with Dr. Henry H. Smith's enlarged and improved chart of this structure.

† Special Anatomy and Histology, ii. p. 310.

human blood presents a homogeneous appearance; but microscopic inspection at once shows that it is composed of two very different elements—a transparent and nearly colorless fluid, the *liquor sanguinis;* and disseminated through this, a multitude of small, discoidal bodies called *blood corpuscles.* These elements present the following characters.

THE LIQUOR SANGUINIS.

This, the transparent part of the blood, is also called *plasma* and *coagulable lymph.* If examined before coagulation has taken place, it is found to be composed of fibrin, albumen and certain salts in a state of mutual solution; but when these elements have stood for a short time, they separate spontaneously into *fibrin* and *serum.* The fibrin in this case retains the blood-corpuscles, and the serum that remains is the liquor sanguinis deprived of its fibrin. This change from the fluid to the solid state is called its *coagulation;* and the residual mass bears the several names of *cruor*, *crassamentum* or *clot.*

The serum.—This fluid is of a light yellowish color, viscid and transparent, with the taste and odor of blood. It is slightly alkaline, owing to the presence of a little free soda, and readily coagulates at 160° of Fahrenheit in consequence of the presence of albumen; but even after this process there is left a thin watery fluid called *serosity*, said by the chemists to be albumen in combination with an alkali. The quantity of water yielded by serum in analysis, is ninety per cent. of the whole bulk; and the residue, besides albumen, is chiefly composed of various salts of soda and of soda uncombined.

Albumen constitutes about eight parts in a hundred of serum: it is held in solution by ninety parts of water, together with some free soda to which the solubility of the albumen is ascribed. Several salts of soda are also detected in it, and the combination of these several elements is hence called the *albuminate of soda.* By a process of the animal economy albumen is convertible into fibrin; and indeed, physiology teaches that it may be transformed into any of the proteine compounds of the human body. Thus various secretions, the epidermis, hair, nails, &c., the gelatinous tissues, the capsules of the blood-globules and some other structures, are transformations of albumen.

The serum also contains a small quantity of *casein*, and a much larger proportion of fatty substance in the form of cholesterin, serolin, &c., together with extractive matters of various kinds, oxygen, azote, carbonic acid, urea and a yellow coloring matter probably derived from the bile. Albumen is more abundant in women than in men.

Fibrin.—We have observed that fibrin is an essential part of the liquor sanguinis and only separates from it by coagulation. The latter process takes place spontaneously, or by the action of heat, of acids and various other chemical agents, and is wholly due to the presence of fibrin, the red globules being passively entangled in the mass. The experiments of Lecanu corroborate the common observation of physiologists, that the strongest fibrin is the slowest to coagulate and forms the firmest clot. Coagulation becomes more rapid under

the influence of heat, as before mentioned, and when exposed to the atmosphere. Cold and motion suspend the process for a time but do not prevent it.

Fibrin may be obtained in an isolated state by beating freshly drawn blood with a rod, or by washing a mass of the crassamentum until the red globules are separated from it. It then appears in the form of shreds or fasciculi of an opaque, white color, and of a tough, elastic consistence. Its fibres cross each other in every direction, and are most distinct in the buffy-coat of inflammatory blood, in which, as we shall presently show, they have made further progress towards organization. In its purest state it contains about three-fourths its weight of water: if the latter element be removed by desiccation, the residue becomes hard and brittle, but like muscular fibre assumes the soft state again when moistened with water.

The average proportion of fibrin in the blood is about three parts in 1000; but M. Andral states that the proportion varies in the healthy condition from 25 to 35 parts.* In various diseases, however, the proportion is still more altered; M. Andral lays it down as an axiom, that fibrin will be always augmented under the influence of inflammation; whereas in typhoid fevers there is a manifest diminution of fibrin.

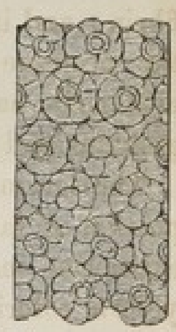
Its function is manifold in the animal economy; and its constant tendency is to assume the organized form and to exhibit vital properties. It is found not only in the blood but in the chyle, and in the fluid of the peripheral absorbent system. It is also a principal element of the colorless exudations poured forth from wounded or inflamed surfaces; for the *coagulable lymph* is the fibrinous element of the blood in a concentrated and strongly organizable state.†

Fig. 300.

Exudation corpuscle. After Gerber.

When it coagulates in the form of a hyaline mass, as we see it do in the buffy-coat of the blood, it eventually becomes granular. If it is poured out on the living tissues, for example on the pleura in pleuritis, it undergoes rapid organization and assumes the character of *exudation corpuscles*, as represented in Fig. 300; and these, when arranged upon each other, constitute *false* or *exudation membranes*, Fig. 301.‡ The recent observations of Dr. Gulliver show that clots of fibrin have a rudimentary appearance of organization. Even when coagulated out of the body fibrin contains corpuscles that appear to be organic germs; and it would therefore seem that the process of inflammation is not essential to the healing of wounds, since it is ascertained that cell-germs, or at least analogous corpuscles, are formed in the blood by the simple act of coagulation.§ It is now well ascertained that the plastic power of any

Fig. 301.



False or exudation membrane. After Gerber.

* Pathological Hæmatology. Translated from the French by Drs. J. F. Meigs and Alfred Stillé.

† Carpenter. Physiology, § 178.

‡ By tracing the metamorphosis a single step further we come to the *pus-globule*, as shown in the annexed drawing from Gerber, Fig. 302.

§ Dr. Willis, in Wagner's Physiology, p. 265.

Fig. 302.

Pus-globule.

animal fluid, that is to say, its capability of being transformed into organized tissue, is in direct proportion to the quantity of fibrin it contains.

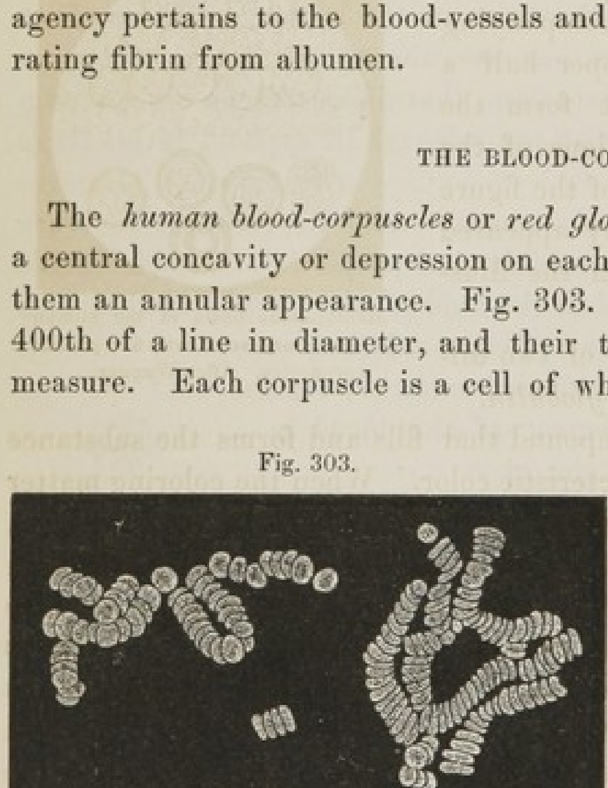
Notwithstanding the marked differences in the organic properties of fibrin and albumen, the chemists have discerned hardly any difference in their ultimate composition. We have seen that albumen is convertible into fibrin; and although the latter is regarded as albumen in which the process of organization has begun, there is no evidence to prove that simple albumen ever becomes organized.

Fibrin is first detected in the chyle, and increases in quantity as the latter fluid continues its course through the lacteals, so that the maximum of fibrin exists in that fluid where it is poured into the blood-vessels: and yet in the latter the proportion is much greater, notwithstanding the constant withdrawal of it for the purposes of nutrition; whence it is inferred that some peculiar agency pertains to the blood-vessels and exists within them, capable of elaborating fibrin from albumen.

THE BLOOD-CORPUSCLES.

The *human blood-corpuscles* or *red globules* are flattened, circular discs with a central concavity or depression on each surface, which in some aspects gives them an annular appearance. Fig. 303. They vary between the 300th and the 400th of a line in diameter, and their thickness is about one-fourth of that measure. Each corpuscle is a cell of which the envelope is elastic, homogeneous, pellucid and colorless, and the contents of a more or less deeply red color. They are, however, destitute of distinct nuclei; "the dark spot which is seen in their centre being merely an effect of refraction in consequence of the double concave form of the disc." But since the corpuscles of the lower animals are distinctly nucleated, some physiologists insist that the nucleus exists also in the blood of mammiferæ, although it has hitherto eluded positive demonstration.

Fig. 303.



Human blood-corpuscles. After Donné.

Fig. 304.

Blood corpuscle. After Gerber.

Fig. 304 shows a blood-disc from an observation of the accurate Gerber, presenting a proximate resemblance to a true cell and thus according with the remark of Valentin that a blood-globule is a *nucleus*. *a*, represents the nucleus; *b*, the central spot.

The corpuscles of the different races of men, and those of men, women and children, cannot be distinguished from each other;* but they vary in number in the two sexes and under various circumstances. For example, in 1000 parts of human blood the

* Mr. Gulliver has moreover shown, that the corpuscles of the whole family of monkeys, both of the Old and New World, are also the same as those of the human blood.

corpuscles in the male range between 110 and 116 parts, and give an average of 140 parts of the whole bulk; while in the female they rise as high as 167 parts and fall to 71, making an average of 112. Simon, however, makes the proportion between 120 and 130 parts in the 1000 of blood. The proportion is proverbially modified by disease; for the peculiar character of plethora is derived from the augmented quantity of red globules, while in anæmia and chlorosis the reverse takes place.*

There is a remarkable disposition in the blood-corpuscles to come into apposition by their flat surfaces, thus forming columns more or less curved that have been well compared to coins piled one upon another. Fig. 303.

The vesicular envelopes of the blood-discs have been supposed to be analogous in character to fibrin, being extremely delicate, transparent and highly elastic membranes. The accompanying drawing, Fig. 305, shows in its upper half a congeries of these membranes that form the colorless residue after repeated ablutions of the discs with water. In the lower part of the figure are seen five entire blood-discs as they appeared before washing, and which accord with the illustration given above from Gerber.

Fig. 305.

Membranous bases of the human blood-corpuscles, with five perfect corpuscles. After Wagner.

The contents of the capsule consist of two different substances called *hæmatin* and *globulin*.

HÆMATIN, or *hæmatosin*, is the compound that fills and forms the substance of the corpuscle and gives it its characteristic color. When the coloring matter is separated from the other constituents it appears as a dark brown substance, insoluble in water, ether, acids or alkalies, or in alcohol alone, but dissolves in alcohol with the addition of sulphuric acid or ammonia. This solution has also a dark color and possesses all the properties of the coloring matter of venous blood. It contains a considerable proportion of peroxide of iron; but Scherer has proved, contrary to the received opinion, that the coloring matter is not derived altogether from the iron, because when the latter is wholly separated from the hæmatin a deep-red coloring matter still remains.†

GLOBULIN.—This substance is obtained from the capsules of the red-corpuscles and is their component element. It is regarded by the chemists as a protein compound closely allied to albumen, from which it differs, however, in being insoluble in serum and in coagulating in a granular form unlike the residue from albumen. Henlé suggests that globulin is albumen modified by combination with the substance of the disc-envelopes. The globulin and hæmatin combined constitute the admitted contents of the globules, and is called the *cruor*.‡

* The experiments of Becquerel and Rodier prove the important fact, that repeated venesections diminish the quantity of red corpuscles and albumen of the blood; but that they exert no perceptible influence on the proportion of fibrin. Carpenter, Principles of Physiology, § 707. Andral, Hæmatology, pp. 40, 43.

† Carpenter, *ut suprà*, § 147.

‡ Quain and Sharpey, Anatomy, ii. xc. Simon's Animal Chemistry, pp. 29, 152.

The human blood corpuscles are by many physiologists, even by those who deny their nucleated character, regarded as cells capable of reproduction in the manner of the cells of other tissues. This process according to the latest microscopists, is shown in the following manner: first radiating lines are seen to pass from the centre to the periphery, dividing the disc into several segments, usually six in number: and these parts become gradually isolated from the parent corpuscle and constitute as many new and independent cells. It is in this manner that the red corpuscles are rapidly generated by a power of self-production within themselves, which is increased or retarded, however, by various circumstances to which we have already adverted.*

The blood-corpuscles vary considerably in size: they are said to be larger in the fœtus than in the adult, but they are also of different dimensions in the same individual. Their form is also subject to modification in consequence of pressure; for they become elongated and bent in the capillary vessels in order to facilitate their transit through them.

Function.—The uses of the blood-globules are yet unknown. Many ingenious conjectures have been offered, and among them the following have attracted most attention:

1. That they convert the fibrin of the blood into albumen; but the great difficulty in the way of this hypothesis is, that the red globules are absent in the invertebrate animals, in which class, however, the change in question is as manifest as in those that have red blood.

2. The chemists regard them as "carriers of oxygen to the various tissues, and of carbonic acid from these tissues to the lungs;"—thus serving as "the medium for bringing the tissues into relation with the air, the influence of which is necessary for the maintenance of their vitality."

THE WHITE CORPUSCLES.

These bodies are nearly of the same size as the red corpuscles, or about the $\frac{1}{3000}$th of an inch in diameter; but they contrast with the latter in being destitute of color, in maintaining a remarkably uniform size, and in being composed of molecules which possess a distinct motory action within the parent cell. They moreover possess a greater refracting power than the red corpuscles, have more firmness and are less liable to aggregation. This last observation is especially recognized in inflamed blood, in which the red corpuscles collect and adhere together, while the white are much more disseminated and solitary, at the same time that they exist in great number.

Professor Wagner regards these white corpuscles as identical with those of the lymph and chyle; or in other words he supposes them to be the primary form, or the free nuclei of the red corpuscles. Dr. Carpenter gives plausible reasons, which need not be detailed here, for his opinion, that these cells perform the function of converting albumen into fibrin, which they accomplish by

* Wagner, Physiology, p. 248. Carpenter, Principles of Physiology, § 148. Valentin asserts that "the blood-globules are not cells but nuclei: their nuclei are in effect nucleoli."

the simple process of cell-growth; drawing albumen from the fluid in which they float, and returning it as fibrin to supply the constant drain of that substance in the nutritive operations of the system.*

Besides the several constituents of the blood above mentioned, it contains more or less fatty matter, a small part of which can be traced in the red corpuscles and fibrin, but by far the greater part either dissolved or diffused in the serum.

There is also a certain proportion of saline substances entering into the composition of the more solid and mineral-form tissues, as bones and teeth, and some secretions, urine, perspiration, &c. All these constituents of the blood are embraced in a very large proportion of water, no less, as we have seen, than 800 parts in 1000.†

GENERAL OBSERVATIONS.

Many estimates have been made of the average quantity of blood in the human body, and of the proportion it bears to the other component parts. The whole weight of the circulating fluid, arterial and venous, was supposed by Hoffman to be twenty-eight pounds; some computations are far below and others far above this; but Dr. Dunglison observes, that "although the absolute estimate of Hoffman is below the truth, his proportion is nearly accurate. He conceives that the weight of the blood is to that of the whole body as 1 to 5. Accordingly, an individual weighing one hundred and fifty pounds will have about thirty pounds of blood; one of two hundred pounds, forty; and so on. Of this, one-third is supposed to be contained in the arteries and two-thirds in the veins. The estimate of Haller is perhaps near the truth: the arterial blood being, he conceives, to the venous as four to nine. If we assume, therefore, that the whole quantity of blood is thirty pounds, in a man weighing one hundred and fifty pounds,—which is perhaps allowing too much, nine pounds at least may be contained in the arteries, and the remainder in the veins."‡

THE ABSORBENT SYSTEM.

This important and intricate system embraces three intimately connected structures, the lacteals, the absorbent or lymphatic vessels, and the lymphatic glands. It is to be observed, however, that these two sets of vessels differ only in function and not in structure, for which reason we proceed to notice them collectively.

The lymphatics originate in minute radicles on every surface and in almost

* Physiology, p. 213.

† Besides the normal components of the blood, the following substances are detected in various diseased conditions of the system: sugar, urea, bilin, biliphæin, manganese, copper, silica and certain salts.

‡ Dunglison. Human Physiology, ii. p. 141.

every cavity and tissue of the body; not, however, by distinct open or closed extremities, but in a plexiform network of extreme tenuity. From these networks trunks are given off in various directions, frequently uniting with each other and converging into larger and larger canals which eventually pour their contents into the veins. They are extremely delicate and transparent, even more so than blood-vessels of the same calibre; they are very elastic, whence it happens that a lymphatic that is almost invisible when empty, is capable of being very greatly distended. Of the sensibility of these vessels in health little is known, but they form, when diseased, a most irritable part of the vascular system.*

The lymphatics are in various respects analogous to veins: they resemble the latter in converging from minute origins, and in being composed of two sets—a subcutaneous set that accompanies the superficial veins of the limbs—and a deep set that follows the course of the deep arteries and veins. Again, the lymphatics, like the veins, are provided with valves, which in the former, however, are infinitely the most numerous and characterize them in all their localities. The lymphatics, moreover, present this peculiarity, that in anastomosing with each other they do not form larger trunks, but continue their course of a nearly equal calibre notwithstanding a multitude of such junctions.

Structure.—The extreme tenuity of these vessels renders our knowledge of their structure in part, at least, conjectural; but if we may draw our inferences from the thoracic duct, they possess an external, an internal and a middle coat; the first, composed of interlacing fibres that cross each other in every direction; while the inner or serous coat is thin, delicate and transparent, and more readily ruptured than the external tunic. The middle coat is thin and elastic, and presents longitudinal fibres like those of the corresponding coat of the arteries and veins, and blended with them are traces of annular fibres placed on the outside.

Fig. 306. Fig. 307. Fig. 308.

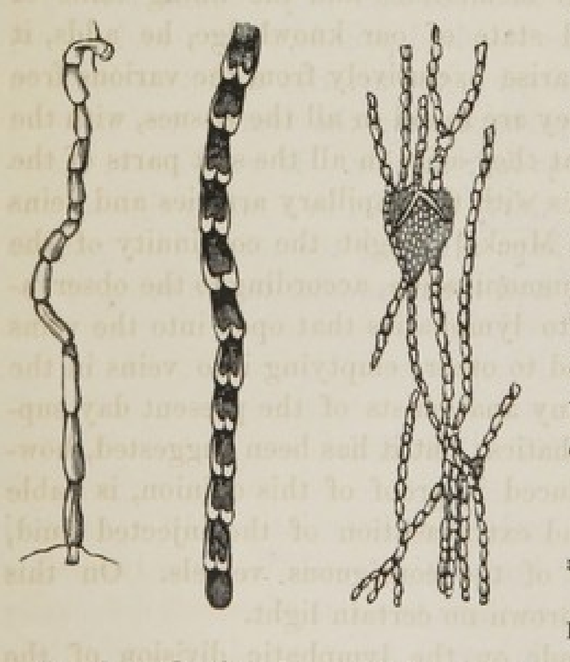


Fig. 306. Lymphatic vessel.

Fig. 307. Another lymphatic vessel showing the arrangement of the valves.

Fig. 308. Lymphatic vessels connected with a lymphatic gland.

The lymphatics have a linked or knotted appearance, Figs. 306, 307, owing to the presence within them of an infinitude of valves of a semilunar form, arranged in pairs. Their adherent margin is directed towards the sources of the vessels so as to allow of the free transit of fluid to the larger trunks, while they also prevent a reflux current. They do not everywhere exist in equal numbers;

* Mandl. Anatomie Générale, p. 211.

being for the most part fewer in the larger trunks, for example in the thoracic duct, wherein they are placed at considerable distances, even as much as two or three inches, and are variable in different subjects. On the other hand they are most numerous in the lymphatic glands, and more abundant in the upper than in the lower extremities. The valves are composed of cellular tissue covered by epithelium.

Notwithstanding the profusion with which lymphatics are distributed to some and indeed to most of the organs, they are not demonstrable in all. In some tissues, for example, their presence can only be inferred from reason and analogy. Thus they have not been seen in the interior of the brain and spinal cord, in the cartilages, tendons and ligaments, nor in the membranes of the ovum. Yet that they exist in these parts there can be no question; for it is only of recent time that Fohman detected them on the surface of the brain and in its membranes, in the plexus choroides, placenta and umbilical cord. They were long denied to the eye, but Arnold has found them there also; and they have moreover been traced into the interior of the bones. In these several tissues no lymphatics could be detected even by the critical eye of Mascagni, and we may therefore suppose that they will yet be discovered in the few remaining exceptions.

The lymphatics originate in vessels of extreme tenuity, resembling the capillaries of the arterial and vascular systems; but this origin, as Cruveilhier has observed, can only be shown upon the free surfaces, such as the mucous membrane, the skin, the serous and synovial membranes and the lining tunic of arteries and veins; so that in the actual state of our knowledge, he adds, it might be maintained that these vessels arise exclusively from the various free surfaces of the body. Since, however, they are found in all the tissues, with the exceptions above stated, we may infer that they arise in all the soft parts of the body; but the connection of their radicles with the capillary arteries and veins has been long a subject of disputation. Meckel taught the continuity of the venous and absorbent vessels; but this communication, according to the observations of Lauth, appears to be restricted to lymphatics that open into the veins in the parenchyma of certain organs, and to others emptying into veins in the interior of the lymphatic glands.* Many anatomists of the present day suppose the arteries to end directly in lymphatics; but it has been suggested, however, that the evidence of injection adduced in proof of this opinion, is liable to a twofold fallacy; viz., the escape and extravasation of the injected fluid, and its transudation through the pores of the contiguous vessels. On this point even the microscope has hitherto thrown no certain light.

The preceding remarks have been made on the lymphatic division of the absorbent system, the other vessels of this class are called *lacteals;* but, as heretofore observed, the anatomical structure is the same in both, the only difference being that they convey fluids of different character. Both, however, have the same office in degree, that of collecting the chyle or product of digestion,

* Horner. Anatomy and Histology, ii. 315.

on the one hand, and lymph, or the result of nutritive absorption, on the other, and these are mingled together in the thoracic duct, to be finally blended with the blood of the venous system. These fluids, and the means by which they reach their ultimate destination, will be duly noticed as we proceed.

LYMPHATIC GLANDS.

The *absorbent glands* form another essential part of this apparatus. They are also called by Sylvius, *conglobate glands* and by Chaussier *lymphatic ganglia*. They are small, oval, flattened bodies, varying in size from a pin's-head to an almond-kernel. In the healthy state the largest are found in the lungs, the smallest in the omentum; but they are subject to singular variations from the presence of irritation and disease. They present exteriorly a lobulated appearance, but when divided have a cavernous aspect owing to the numberless knotted convolutions of the lymphatic vessels within them, and which, in fact, constitute their structure. These vessels are often dilated into larger cells to which capillary blood-vessels are freely distributed; but the latter have no direct communication with the interior of the absorbents and the glandular cavities, being separated from them by the membranous parietes of both sets of tubes, at the same time there can be no doubt that transudation readily occurs between them. These glands are embedded in a loose areolar tissue of a reddish yellow or reddish gray color, and invested by a capsule of the same tissue that connects the lobules of the gland together and which serves also to attach them to the contiguous parts.

All the absorbent vessels enter and pass through these glands either directly or indirectly. Those that enter are called *vasa inferentia*, and those on the other hand that come from the glands are the *vasa efferentia;* the former being the smallest and in greatest number. When the vasa inferentia approach a gland they divide into several branches, some of entering its substance while others run over it. On the opposite side, the vasa efferentia come out and coalesce into trunks similar to their fellows.

The lymphatic glands contain a fluid, *succus proprius,* which has been compared to the plasma or liquor sanguinis of the blood, and contains an abundance of corpuscles resembling blood-globules in form. The former are supposed by Wagner and other eminent physiologists, to be the "free nuclei of blood-corpuscles."

Besides the intricate convolutions of lymphatic vessels, these glands are composed of comparatively large arteries and yet larger veins, all intimately connected by cellular tissue.

THE LYMPHATIC VESSELS OF THE HEAD AND NECK.

The lymphatic vessels of this series are both superficial and deep-seated. The superficial lymphatics accompany the arteries of the head and face, viz: the occipital, temporal and facial. The *occipital lymphatics* commence in the

back of the head and descend through the occipital glands behind the ear, to terminate in the superficial lymphatics of the neck. The *temporal lymphatics* originate on the front and lateral parts of the head, descend in front of the ear, and enter, in part, the glands that are connected with the parotid, and in part the zygomatic glands. A third and smaller group embraces the *facial lymphatics* which follow the course of the facial artery and its branches, and enter the submaxillary lymphatic glands. The deep lymphatics of the face come from the nostrils and their appendages and from the mouth and pharynx, and following the internal maxillary artery, enter the glands near the angle of the jaw.

The *deep lymphatics of the head* are those of the pia mater and arachnoid membrane, which make their exit from the cranium, in common with the veins, through the foramina of the base of the skull. These vessels enter the deep cervical glands, which lie along the sheath of the carotid artery and internal jugular vein even to the top of the thorax. No lymphatics, as we have already stated, have been demonstrated in the interior of the brain or dura mater.

The *cervical lymphatics* consist of the efferent vessels from the glands of the head and face, which descend the neck in company with the jugular veins, being both superficial and deep-seated. They converge into fewer trunks, and terminate as follows: those of the left side open by a single orifice into the thoracic duct near its termination; those of the right side discharge by a single trunk into the right lymphatic duct.

LYMPHATIC GLANDS OF THE HEAD AND NECK.

No lymphatic glands are now admitted to exist or at least to be demonstrated within the cranium. They are sparsely distributed on the posterior surface of the skull, behind the ear, and under the cranial end of the sterno-mastoid muscle. The submaxillary lymphatic glands lie partly on the outside of the lower jaw, and partly on and within its base. Other glands of this series lie upon, and others in the substance of the parotid gland, and between the latter gland and the masseter muscle. These are called the *parotid lymphatic glands*.

The *zygomatic glands* lie within and under the zygomatic arch.

The *cervical glands* are very numerous and of large size. They surround the internal jugular vein and sheath of the carotid artery from the base of the skull to the top of the thorax, where they become connected with the lymphatics of the chest. The superficial glands of this series commence beneath the inferior maxilla, follow the external jugular vein and are particularly numerous behind the origin of the sterno-mastoid muscle. They are connected both with the glands of the axilla and thorax. The beautiful plates of Mascagni and Cloquet should be consulted in reference to this and indeed all other parts of the lymphatic system.

LYMPHATIC VESSELS OF THE UPPER EXTREMITY.

These also are superficial and deep-seated. The former commence on the inside of the fingers, and run along the front of the forearm to the elbow-joint in company with the subcutaneous veins. They pass in part through the glands at the inner condyle of the humerus, and finally merge into the deep lymphatics of the axilla. Another set commences on the back of the fingers and hand, and making their way to the bend of the arm, terminate in part in the preceding vessels; but another part follows the course of the cephalic vein to join the subclavian glands.

The deep lymphatics accompany the deep-seated blood-vessels, anastomose more or less with the superficial series and terminate in the axillary and subclavian glands.

LYMPHATIC GLANDS OF THE UPPER EXTREMITY.

The *glands* of the upper extremity, with the exception of a few small ones in front of the elbow-joint, are seated in the axilla along the course of the axillary vessels, enveloped in adipose matter and loose cellular tissue. They receive not only the lymphatics of the arm, but those of the breast, front of the thorax and integuments of the back. These glands are variable in number, but are seldom less than ten or more than fifteen.

The lymphatics of the arm leave the glands as efferent vessels, follow and partially surround the subclavian artery, and form on each side a large trunk: that of the left side opens into the thoracic duct, that of the right side into the right lymphatic duct.

LYMPHATIC VESSELS OF THE LOWER EXTREMITY.

The *superficial lymphatics* of this series are arranged in two anastomosing groups, one of which is external, the other internal. The former are fewer in number than the latter; they commence on the outside of the foot and ankle, and follow the external saphena vein to the popliteal space, where they terminate in the lymphatic glands of that region.

The *internal* set commences on the back and inside of the foot, and ascend the leg with the saphena major; they pass behind the inner condyle of the femur, then come to the front of the thigh and enter the superficial inguinal glands. These lymphatics are extremely numerous, and receive frequent accessions in their course from all the superficial parts of the leg and thigh.

The deep lymphatics follow the corresponding veins. In this way they form in the leg the anterior and posterior tibial and the peroneal lymphatics, which meet with few glands in their ascent until they reach the popliteal space. They subsequently rise to the inguinal glands, penetrate them and form efferent vessels

that again communicate with the glands that surround the iliac vessels. The deep lymphatics of the gluteal region and posterior part of the thigh, follow the gluteal and ischiatic arteries into the pelvis and enter the absorbent glands around the internal and common iliac arteries.

THE LYMPHATIC GLANDS OF THE LOWER EXTREMITY.

The lymphatic glands of the lower extremity of the leg and thigh are the following:

The *anterior tibial gland* lies below and behind the knee-joint, in front of the interosseous ligament. It is not always present.

The *popliteal glands*, four or five in number, lie in the popliteal space, where they are embraced in cellular tissue and fat along the blood-vessels of that part.

The *inguinal glands* are superficial and deep-seated. They lie beneath the fascia lata, below the crural arch, "and are generally grouped around the entrance of the internal saphenous into the femoral vein, in a sort of depression formed between the adductor longus and pectineus on the inside, and the psoas and iliacus on the outside."* These, the superficial glands, sometimes extend some distance down the thigh along with the saphenous vein. The deep-seated glands are placed beneath the fascia lata and surround the femoral vessels. They are both smaller and less numerous than the superficial set.

The *gluteal and ischiatic glands* are placed near the great sciatic notch, above and below the pyriformis muscle and adjacent to the vessel whose name they bear.

LYMPHATIC VESSELS OF THE PELVIS AND ABDOMEN.

These, in accordance with the general arrangement, are both superficial and deep-seated. The former class extends downwards from the umbilicus to the pelvis, in the integuments of the abdomen, and terminate in the superficial inguinal glands. These are called *epigastric glands.* A corresponding deep-seated series pursues the same general direction, to open into the glands around the external iliac artery. Such are the *circumflex-iliac lymphatics.*

The *superficial absorbents of the penis* converge to the dorsum of that organ, whence they send branches to the inguinal glands; but the deep-seated vessels take the course of the internal pudic artery, and terminate in the internal iliac glands.

The *lymphatics of the scrotum* and perineum end in the inguinal glands.

The *lymphatics of the testicle* come in part from the tunica vaginalis, and in part from the interior of the gland. They form several trunks that follow the spermatic cord into the abdomen, and then end in the lumbar glands.

* Cruveilhier. Anatomy, p. 822.

The *lymphatics of the bladder*, together with those of the prostate gland and vesiculæ seminales, enter the hypogastric glands.

The *lymphatics of the rectum* pass in part into some small adjacent glands, and finally enter those in the hollow of the sacrum or higher up in the loins.

The *sacral lymphatics* come from the canal of the sacrum and from the front of that bone, and enter the lumbar and hypogastric plexus.

The *ileo-lumbar lymphatics* arise from the parts around the arteries of that name, and like the sacral lymphatics enter the lumbar and hypogastric glands.

In the female the lymphatics are as follows. Those of the *uterus*, which are very obscure in the unimpregnated state, become very large and numerous during gestation. The several trunks from the body of the organ and from the ovaries and Fallopian tubes, converge and take the course of the ovarian arteries, and enter the hypogastric and other glands on the side of the aorta and vena cava. The *lymphatics of the vagina* in part follow the round ligament of the uterus through the abdominal canal to join those of the uterus; while others are directly connected with the latter vessels. The *lymphatics of the clitoris* follow the internal pudic artery. The uterine and vaginal lymphatics all enter directly or indirectly into the hypogastric plexus, which ascends the loins in company with the hypogastric artery.

We will hereafter more fully explain, that all the lymphatics from the parietes of the pelvis, and from the gluteal, ischiatic and obturator vessels, follow the course of the internal iliac arteries, and unite with the lumbar lymphatics; and the latter, after receiving all the trunks from the lower extremities, pelvis and loins, terminate by several large trunks in the receptaculum chyli.*

The *lymphatics of the kidneys* come from the surface and from the interior of the gland, and unite at the hilum renale into several trunks that enter the lumbar glands. The supra-renal lymphatics and those of the ureter unite with those from the kidney, excepting the few that arise from the lower part of the ureter. These last anastomose with the vesical lymphatics.

The *lymphatics of the spleen* converge at its fissure and pass through the gland in the course of the splenic artery. They receive the lymphatics of the *pancreas*, and after anastomosing with each other and with the lymphatics of the liver and stomach, terminate in the thoracic duct.

The *lymphatics of the stomach* lie partly on its surface beneath the peritoneum, and partly in its substance between the muscular and mucous coats. They pursue very different courses: one set runs to the greater curvature of the stomach and enter the proximate glands; others pass to the lesser curvature; some go to the pyloric lymphatic glands and a few to those of the spleen. The trunks formed by these several sets of vessels, open directly or indirectly into the thoracic duct.

Lymphatics of the liver.—These are divisible into three sets, one from the convex surface, a second from the concave surface, and a third set from the internal structure. The lymphatics of the convex surface arise both from the

* Wilson. Anatomy, p. 382.

right and left lobes, but chiefly from the former: they converge to the suspensory ligament, and form a large trunk that passes between the fibres of the diaphragm behind the xyphoid cartilage, ascends in company with the internal mammary artery through the lymphatic glands around that vessel, and opens into the right lymphatic duct. Sometimes it terminates directly in the thoracic duct on the left side of the neck.

The concave surface of the liver is also most abundantly supplied with lymphatic vessels which terminate variously. Thus, those from the right lobe form trunks which run to the transverse fissure where they join the deep lymphatics and mostly terminate in the lumbar glands: those of the left lobe take their course between the laminæ of the small omentum to the glands of the lesser curvature of the stomach. The lymphatics of the gall-bladder, which are collected into a large and intricate plexus, terminate in the glands of the right margin of the lesser omentum.*

The deep lymphatics of the liver originate in every part of its structure, and follow the course of the portal veins within the capsule of Glisson. They anastomose freely with the several sets of superficial lymphatics and with those of the stomach, make their exit at the transverse fissure, and enter the glands of the lesser curvature of the stomach and those behind the pancreas. They subsequently open into one of the lacteal trunks, and thus indirectly into the thoracic duct.

The *lymphatics of the large intestine* are comparatively few in number. Those of the cæcum and ascending and transverse colon, pass through the mesenteric glands and become continuous with the lacteals of the mesentery. The lymphatics of the sigmoid flexure and rectum open, the former into the lumbar glands, the latter into hypogastric glands.

The *lymphatics of the small intestine* are of two kinds, one of which is called *absorbent* or *lymphatic vessels*, the other *lacteals*. The former commence in the substance of the intestine, both in its serous and mucous coats, and after forming an intricate plexus enter the mesenteric glands. The lacteals differ nothing in organization from the simple lymphatics, and are only distinguished from the latter when filled with chyle in an animal that has been killed after having been fed. Having noticed the origin of the lacteals in the chapter on the small intestine, it is only necessary here to repeat, that these vessels commence as cæcal ducts in the villi of the mucous membrane, coalesce into a retiform plexus, and subsequently into many trunks of considerable size. The latter pass through the mesenteric glands between the folds of the mesentery, and finally terminate in the thoracic duct. Fig. 213.

The *lymphatics of the stomach* arise partly from the muscular coat beneath the peritoneum, and partly from the mucous membrane. They run in various directions, some terminating in the glands of the greater curvature, others in those of the lesser curvature. A part of them also terminates in the pyloric glands, and a few in the splenic and aortic glands.

* Cloquet.

LYMPHATIC GLANDS OF THE PELVIS AND ABDOMEN.

The *sacral glands* lie behind the rectum in the hollow of the sacrum, and partly between the folds of the meso-rectum. The *hypogastric* or internal iliac glands form a continued chain in the course of the hypogastric artery, and fill up the space between it and the external iliac.

The *lumbar glands* are continuous with those of the pelvis; they ascend from the angle formed by the common iliac arteries, whence they cover the lower part of the aorta and vena cava, and extend as far as the crura of the diaphragm on each side of the lumbar vertebræ.

The *splenic glands* occupy the fissure of the spleen. The *pancreatic glands* follow the course of the splenic artery along the margin of the pancreas. Those of the *liver* are very numerous; they surround the trunk of the vena portarum and follow the course of the other hepatic vessels, being conjoined with the glands of the spleen and pancreas in forming the chain of *cœliac lymphatic glands.*

The *mesenteric glands* are large and in great number. They lie between the laminæ of the mesentery, and commence near the intestine and increase in size as they approach the base of the mesentery. They have been grouped, according to their situation, into duodenal and ileo-colic; the former being opposite the termination of the ileum, the latter in front of the duodenum.

The *meso-colic glands* are those of the great intestine. They are small and few in number, seldom being more than fifty. Those of the transverse mesocolon form a continuous chain with the mesenteric glands. Winslow, in the presence of the Academy of Sciences at Paris, exhibited chyle in the absorbents of the mesocolon; this fact, as Dr. Horner observes, explains the salutary effect of nutritious enemata.

The *gastro-epiploic glands* lie between the laminæ of the omenta where the latter meet at the curvatures of the stomach.

THE LYMPHATIC VESSELS OF THE THORAX.

These are derived from the parietes of the chest on the one hand, and from the thoracic viscera on the other. Among the former class are the intercostal, internal mammary and diaphragmatic lymphatics, to which, for the purpose of convenience, we may add the proper mammary vessels.

The *intercostal lymphatics* arise from the muscles and integuments of the thorax, accompany the intercostal arteries, and after entering the glands on the front of the vertebral column, open into the thoracic duct. In this course they anastomose freely, and receive the lymphatics of the pleura costalis and posterior part of the pericardium.

The *internal mammary lymphatics* arise from the front of the abdomen above

the umbilicus, where they anastomose with the epigastric lymphatics. They accompany the corresponding arteries to the top of the thorax and penetrate the inferior cervical glands; after which they terminate on the left side in the thoracic duct, on the right side in the left lymphatic duct.

The *lymphatics of the diaphragm* converge in part into the internal mammary and partly into the intercostals, and thus terminate indirectly in the thoracic duct.

The *absorbents of the mammary glands* are both superficial and deep-seated. The former arise from the nipple and the adjacent integuments, and run to the axilla, where they enter the lymphatic vessels of that region. The deep-seated lymphatics of the breast perforate the intercostal muscles and anastomose with the internal mammary trunks.

Lymphatics of the lungs.—The superficial series arise from the surface of the lungs beneath the pleura, where they form an intricate plexiform network that ends by converging trunks in the bronchial glands. The deep lymphatics, also very numerous, coalesce into two or three trunks which follow the trachea to the root of the neck, and terminate in the thoracic and lymphatic ducts. In this course they pass through the bronchial glands.

The *lymphatics of the heart* originate from its surface and also in its muscular structure, and follow the course of the arteries, chiefly along the right margin of the heart to its base. Here they meet at the commencement of the aorta in a trunk that ascends to the left side of the neck, to terminate in the lymphatic duct. The deep lymphatics of the left side of the heart coalesce at its base in a single trunk, which ascends by the pulmonary artery and behind the aorta to open into the thoracic duct.

The *lymphatics of the esophagus* follow the course of that tube and open into the thoracic duct near the root of the lung.

The *lymphatics of the thymus gland* terminate in the jugular vein of the corresponding side by one or by several orifices. Those of the *thyroid gland* terminate on the left side in the thoracic duct; on the right side in the right lymphatic duct.

LYMPHATIC GLANDS OF THE THORAX.

The *internal mammary glands* follow the course of the internal mammary artery, and lie at the anterior end of the intercostal spaces. They are irregular in number, varying generally from six to ten, and receive the internal mammary lymphatics. They are sometimes called the *substernal glands*.

The *intercostal glands* are placed on each side of the vertebræ near the heads of the ribs, and partly between the two layers of intercostal muscles.

The *anterior mediastinal glands* lie upon the diaphragm in front of the pericardium, and around the great vessels contiguous to the base of the heart.

The *posterior mediastinal glands* are arranged along the course of the esophagus and aorta, and form a combination of the intercostal glands. Those behind

the arch of the aorta, sometimes called the *aortic glands*, are but three or four in number. The *esophageal* set number about fifteen or twenty.

The *bronchial* or *pulmonary glands* are placed between the two bronchi at their bifurcation, whence they ascend along the air-tubes into the substance of the lungs. They are from fifteen to twenty in number and vary in size from a garden-pea to a walnut. In early life they are of a pink color; but, like the lungs they become gray in adult life, and very dark and even black in advanced years. The coloring matter of these glands is said by the chemists to be pure carbon, brought from the lungs by the bronchial lymphatic vessels, which, as heretofore mentioned, penetrate the bronchial glands.

THE THORACIC DUCT.

This vessel is formed by the convergence of the lymphatics collected on the lumbar vertebræ from the lower extremities, the lower part of the trunk of the body, the organs of generation, the intestines, stomach, spleen, pancreas and kidneys and the greater part of the liver.

These vessels are united into four or five larger trunks, and these again coalesce to form a pouch or dilatation called the *receptaculum chyli*, which generally lies upon the body of the second lumbar vertebra; sometimes, however, on the first; in other instances on the third lumbar vertebra. Fig. 295, 15. The duct, placed at first behind and between the aorta and ascending vena cava, soon inclines to the right side of the former vessel so as to be near the right crus of the diaphragm. From this point the thoracic duct assumes the form of a tube about two lines in diameter, with occasional enlargements and tortuous curves. It ascends between the crura of the diaphragm behind, and between the aorta and ascending vena cava, and enters the thorax, where it runs up in front of the spine and between the aorta and vena azygos until it reaches the level of the third or fourth dorsal vertebra. Fig. 295, 16, 16. It now curves to the left side and ascends to the root of the neck near the head of the first rib, as high as the body of the seventh cervical vertebra, being behind the internal jugular vein. It next bends downwards and forwards for about three-fourths of an inch, and opens into the angle formed by the junction of the left subclavian and left internal jugular veins. Its termination is guarded by a double valve, that prevents the venous blood from flowing into the duct. Fig. 295, 17.

We have seen that the thoracic duct receives, while yet in the abdomen, the lymphatic trunks from the lower extremities and several abdominal viscera, together with the lacteal trunks from the small intestines. Soon after it has entered the thorax it receives the common trunk of the hepatic absorbents; and still higher up, those from the thorax and the thoracic viscera. About half an inch before its termination in the veins it receives the trunks formed by the lymphatic vessels of the left side of the head and neck, the left upper limb and the contiguous parts of the thorax.

We have already adverted to the structure of this canal,—its three coats, its

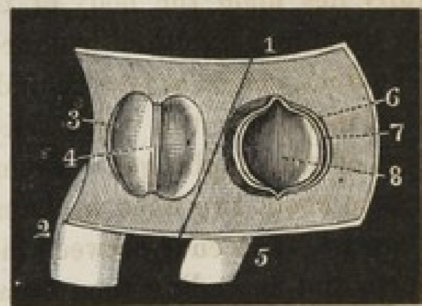
few valves and its general characteristics;* to which we have only to add that it is there transparent and elastic, and liable to many abbreviations from the single tubular form and direct course above described. Thus, it not unfrequently bifurcates opposite the seventh or eighth dorsal vertebra into two branches, which again unite into one. In other instances it gives off several branches that form a plexus in place of a single trunk; and the duct has in rare instances terminated in the vena azygos.

THE RIGHT LYMPHATIC DUCT.

This vessel, sometimes called the *right thoracic duct*, is about an inch in length, and opens into the angle formed by the junction of the right subclavian and right internal jugular veins. It is formed by the conveyance of the lymphatics of the right side of the head and neck, and of the corresponding upper limb, together with those of the right side of the thorax, right lung, and one or more branches from the liver. Fig. 295, 18.

Although the great bulk of chyle and lymph is poured in the manner just described into the internal jugular veins, yet other veins receive the absorbents by direct inosculation to a very considerable extent. How far this arrangement obtains in the human body has been a question for controversy; but it will answer the purpose of illustration to give the annexed drawing from Gerber, showing a portion of the mesenteric vein laid open with lymphatics opening into it.

Fig. 309.



Lymphatics opening into the mesenteric vein. After Gerber.

Fig. 309. 1, mesenteric vein laid open; 2, lymphatic vessel; 3, closed valves of that vessel; 4, free edges of the valves; 5, end of the lymphatic within the vein; 6, space between the valve and parietes of the vessel; 7, free edge of one of the valves; 8, cavity of the lymphatic vessel.

FUNCTION OF THE ABSORBENT SYSTEM.

It was at one time generally supposed that the lymphatics absorbed and conveyed out of the system the superfluous residue of nutrition; those materials, for example, which were thrown off in the effete state from tissues that were undergoing repair or renovation. This doctrine, which was entertained by John Hunter, is found to be inconsistent with the progress of physiological inquiry; for the lymph of the lymphatic vessels is in itself a highly nutritive fluid, and constitutes a large and important element of the healthy blood. Absorption is therefore in the present day regarded as an active agent in *nutrition;* taking from the system those particles of the organic textures capable of subserving that function, and which are partially removed by the process of secretion to be in turn employed in repairing the waste and wear of the

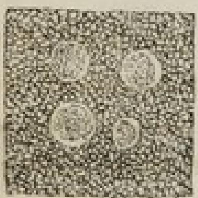
* Mandl. Manuel d'Anatomie Générale, p. 212.

body. The lymphatics and lacteals, therefore, perform an identical function, differing only in the relative nutritiveness of their respective fluids.

THE CHYLE AND LYMPH.

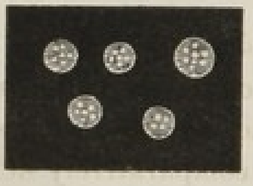
The chyle is a milky fluid elaborated during the process of digestion, and conveyed by the lacteal vessels into the thoracic duct. It has a peculiar odor, an alkaline taste, and is somewhat variable in color and consistence. The milky appearance of chyle has been generally attributed to the presence of oil-globules; but Mr. Gulliver refers it to an infinitude of particles called by him the *molecular base;* particles so minute, indeed, that their form has not been positively ascertained. They are not affected by those reagents which act on the chyle-corpuscles, are abundant in rich opaque chyle, but sparsely distributed in watery chyle. Their size relatively to the chyle-globules is seen in Fig. 310.

Fig. 310.



Molecular base of chyle, with chyle globules. From Dr. Gulliver.

Fig. 311.



Perfect chyle corpuscles. After Wagner.

Fig. 312.

Small molecules found swimming in the chyle. After Wagner.

Fig. 313.

Intermediate stage between a chyle-corpuscle and a blood corpuscle? After Wagner.

The *chyle-corpuscles* are diffused everywhere in the chyle, but particularly in that portion of the fluid obtained from the vicinity of the mesenteric glands. The average diameter of these spherules is about the $\frac{1}{1800}$th of an inch, but they are considerably varied in size. They have a granulated surface and are without regular nuclei, but often contain a number, three or four for example, of isolated molecules, which are supposed from analogy to be the germs of other corpuscles of the same nature. The chyle-corpuscles are few in the rudimentary lacteals; but they increase greatly in number as the latter approach the mesenteric glands, and the chyle drawn from the glands themselves is remarkably prolific of these bodies. A series of perfect chyle-corpuscles is seen in Fig. 311, taken from the mesenteric glands of a young woman eighteen years of age, who had committed suicide by drowning. Fig. 312 represents smaller molecules found swimming in the chyle, regarded by Prof. Wagner as elementary chyle-globules,—the molecular base of Dr. Gulliver? Fig. 313 represents several chyle-corpuscles surrounded by a very delicate envelope; an appearance that Prof. Wagner believes to be the stage of transmutation from a chyle corpuscle to a blood-corpuscle. Chyle undergoes marked changes in the short interval between its formation in the intestine and its reception into the thoracic duct; for that portion which is found between the duct and mesenteric

glands is alone capable of complete and spontaneous coagulation, so as to separate into the clot and serum. Coagulation in this instance, as in the blood, is owing to the presence of fibrin, which substance first appears in the lacteals just before these vessels enter the mesenteric glands. From this stage the fibrin continues to increase in quantity, and the albumen to diminish in proportion, until the chyle is poured into the thoracic duct. The *clot* is of a semi-solid consistence, embracing many chyle-corpuscles, each surrounded by a film of oil. This serum resembles in appearance the serum of the blood; it is a solution of albumen with some chyle corpuscles floating in it, and fatty particles upon its surface.

Coagulation is observed to take place only when the chyle-corpuscles are present; whence the function of the corpuscles is supposed to be that of converting the albumen of the chyle into fibrin—a change that takes place chiefly in the mesenteric glands.*

THE LYMPH.

This term, in its proper restricted sense, belongs only to the fluid of the lymphatic vessels. It differs from chyle in being nearly transparent, consequently wanting the milky hue, and in the absence of the oil-globules and molecular base. In fact, lymph is comparatively deficient in these elements which give to chyle its ready power of assimilation, viz: albumen, fibrin and fatty matter. It contains cells or corpuscles resembling those of the chyle in some respects, in others the blood-globules; and these bodies are most numerous in the lymph derived from the glands, or from the absorbents that have passed through the glands. Lymph is susceptible of coagulation, in which state it retains its translucent appearance.

The lymph mingles with the chyle in the thoracic duct, as already explained, and the combined fluid has a pale reddish color.

* Carpenter. Elements of Physiology, § 519.

NEUROLOGY.

DESCRIPTION OF THE NERVOUS SYSTEM.

THIS branch of anatomy describes the cerebro-spinal axis, or central portion of the nervous system, and the peripheral portion of that system as seen in the nerves. It may also include, without arbitrary arrangement, several of the organs of sense—the eye, the ear, the nose, &c., and these will accordingly be described in the present chapter, as appendages of the nervous system, in accordance with the classification of several distinguished anatomists.

GENERAL ANATOMY OF THE NERVOUS SYSTEM.

The nervous system, in all its parts, is composed of a substance called *neurine* or nervous matter, which is distributed with singular modifications of form, density and function, to almost every tissue of the animal economy. These modifications, however, are embraced in two principal varieties, the vesicular and fibrous neurine.

Vesicular neurine.—This substance is also called the cineritious or pulpy neurine, and constitutes the gray or cineritious portion of the brain and spinal cord. When examined by the microscope, it is observed to consist almost entirely of cells, having a nucleus and a nucleolus, in various stages of development, as seen in Fig. 314.

Fig. 314.

Fig. 314. Spheroidal cells of vesicular neurine, from Todd and Bowman. 1, cell; 2, nucleus; 3, nucleolus.

The envelope is finely granulated with nucleated particles, and of an extremely delicate structure. Fig. 317. The general form of these cells is spheroidal, whence they are sometimes called *ganglion globules;* but in some instances they assume other shapes, being more or less flattened and presenting remarkable tail-like prolongations, as in Fig. 315 from the convolutions of the cerebellum.

Fig. 315.

Caudate cell of vesicular neurine. After Todd and Bowman.

Fig. 316.

Caudate nerve-cell. After Todd and Bowman.

Fig. 316 is another form of caudate vesicle from the Gasserian ganglion.

These last are sometimes subdivided into filaments which are probably a medium of connection with other cells. The interior structure of the cells is of a finely granular nature, in the midst of which are pigment granules collected around the nucleus and giving it a reddish or yellowish-brown color.

These cells are contained in a matrix of a minutely granular matter of the same general character, and constitute that portion of the gangli-onic mass known as the *cineritious* or *cortical* part of the brain, of which it generally forms the exterior layer. Fig. 317. In some instances, however, as we shall hereafter show, the cineritious substance is enclosed within the medullary or fibrous portion. It is extremely vascular, the capillaries being arranged in an intricate plexiform manner, and so numerous that Ruysch supposed the cineritious substance of the spinal marrow to be entirely composed of blood-vessels.

Fig. 317.

A vesicular neurine-cell with a capsule of nucleated particles. After Todd and Bowman.

With respect to the *function* of the vesicular neurine, it will be sufficient here to remark that there are good reasons for adopting the view of Mr. Solly;—that it is the *source of power* in the nervous system, while the fibrous neurine is merely the *conductor* of it. "In short, that the cineritious portion of the nervous system stands in the same relation to the rest of the system, as the secreting portion of a gland does to the rest of that organ, though one portion would be useless without the other."*

Fibrous neurine.—This is also termed the medullary or tubular neurine. It embraces the pearly-white or medullary portion of the brain and spinal cord, and the whole of the peripheral nervous system excepting only the sympathetic nerve. When separated from its membranous connections it is white, soft and yielding, but is firmer in the nervous trunks than in the central portions of the system. In its most complete form it is distinctly tubular, the diameter of the tubes varying from the $\frac{1}{2000}$th of an inch to half as much. They are larger in the nerves than in the brain, and they diminish in the latter as they approach the vesicular neurine.

The arrangement of the fibrous neurine possesses extreme interest. Every fibre is enveloped in a very delicate, transparent, elastic membrane, similar to the sarcolemma of the fibres of voluntary muscles, and like it serves more completely to isolate the contained substance. Fig. 318, 4. This investing membrane is the *neurilemma*. It is not penetrated by blood-vessels, nor does it anastomose with other sheaths, whence it is supposed to be continuous from the origin to the termination of the nervous trunk. The neurine contained within this membrane is of two portions, readily distinguished from each other; an external portion that lines the cylinder, and an inner portion constituting its central mass. The external portion is the *white substance*—substantia alba of Schwann, and differs in chemical composition from the contained nervous matter, and is supposed to serve, like its investing membrane, for the more

* The Human Brain, p. 37.

complete isolation of the *internal cylinder*.* The latter or central substance is transparent; it is called the *axis cylinder* by Rosenthal, and is regarded by Solly and others as the active portion of the fibrous neurine.

Fig. 318.

Tubular fibre of a spinal nerve. From Todd and Bowman.

The annexed outlines, Fig. 318, which form a diagram of the fibre of a spinal nerve, convey an idea of this triple tubular arrangement. 1, represents the axis cylinder; 2, 2, the inner border of the white substance; 3, 3, the outer border of the white substance; 4, 4, the tubular membrane or neurilemma.

When the tubes have not been disturbed by manipulation they are of a perfectly cylindrical form; but the slightest pressure displaces the contained neurine and gives the whole a knotted or beaded appearance, as exhibited in the following figure.

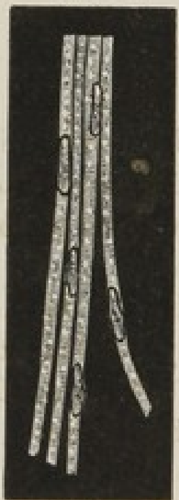
Fig. 319.

Varicose tubular neurine. After Todd and Bowman.

Fig 319. 1, 2, the natural aspect as already seen in Fig. 318; at 3, the white substance and axis cylinder are interrupted by pressure, at the same time that the tubular membrane remains entire; at 4, the fibre assumes a knotted character in consequence of mechanical displacement of the neurine. These varicose enlargements were thought by Ehrenberg to be natural and to exist during life; but later observations prove them to be altogether factitious.†

The tubes of fibrous neurine lie usually parallel to each other: they never branch like the blood-vessels, and the examples of complete anastomosis are seen only in their terminal loops in other tissues, as, for example, in the ends of the fingers. Fig. 112. Again, as Mr. Solly observes, a nerve-tube always performs one and the same office; it always conducts in the same direction, and in all instances conveys the same kind of nervous power.

Fig. 320.



Gelatinous neurine, magnified 320 diameters.

Gelatinous neurine.—This modification of nervous structure was first pointed out by Henlé. It is homogeneous in appearance, and resembles the vesicular neurine in containing numerous cell-nuclei of a round or oval shape, their long diameter being in the axis of the nerve. They are sometimes provided with nucleoli, and are disposed to split into very delicate fibrillæ.

Fig. 320 represents a fasciculus of fibres of gelatinous neurine from the solar plexus. After Todd and Bowman.

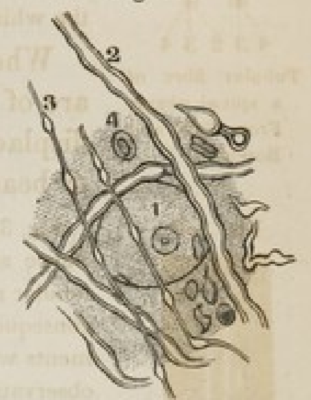
This form of neurine is destitute of the white substance of Schwann; and it would seem that the gray color of some nerves is owing to the presence of a large proportion of gelatinous neurine. The mode of connection between the gelatinous fibres and the elements of the nervous centres, is as yet unknown; they are chiefly found in the sympathetic nerves and are regarded as their distinctive element by Dr. Carpenter, who calls them *organic nervous fibres.*

* Carpenter. Elements of Physiology, § 374.

† Todd and Bowman. Physiology, p. 211.

They are smaller than the tubular fibres and have no tubular membrane; but they are closely related to the tubular neurine, since both classes of fibres appear to run continuously from one end of the nervous cord to the other, without union or anastomosis; each ultimate fibre having its peculiar office which it cannot share with another. The two sets of fasciculi, however, occasionally mix and exchange fibres; an interchange that may take place among fasciculi of the same or of different trunks.*

Fig. 321.



Blended vesicular and fibrous neurine. After Todd and Bowman.

Blended vesicular and fibrous neurine.—These two forms of nervous matter are often found in connection in the nervous centres, but the precise nature of the arrangement is not known. "No more can be said respecting it at present, than that the relation of nerve fibres to the nerve vesicles is most intimate, and that the latter are rarely met with without one or more of the former in immediate connection with them."†

Fig. 321 illustrates this relationship in a ganglion-globule, or vesicular cell, of the cerebellum. 1, globule, with its nucleus and nucleolus; 2, nerve-tube, slightly varicose, and in close contact with the cell; 3, smaller nerve-tubes. These parts all lie in a finely granular matrix, interspersed with nuclei, 4.

THE NERVES.

A nerve is a fasciculus of nerve-fibrillæ connected together by a sheath called neurilemma. The nerves act the part of intermediate agents between the brain and the other organic structures, for the purposes of function, sensation and voluntary motion.

The *neurilemma* is derived from the areolar tissue. It is of a white silvery appearance and firm texture, not only binding the fibres together, but also enveloping, as we have seen, every nervous fibril. It is regarded as continuous, at its central extremity, with the pia mater; such at least is the character of the general nervous envelope; but the particular sheaths of the finer fibres are insensibly lost. From the inner surface of the neurilemma thin layers of areolar tissue are given off, which form so many partitions between the smaller fasciculi and individual fibres of which the trunk is composed.

Fig. 322.

Nerve with its neurilemma. From Mandl.

Fig. 322. Nerve with its neurilemma, magnified 50 diameters. 1, 2, neurilemma; 3, elementary nerve-fibrils.

The nerves are supplied with *blood-vessels*, which run parallel to the fibres and are distributed upon the neurilemma and upon the processes it sends off between the nervous fibres. The capillaries are extremely small, and are arranged in linear series with transverse communications, like those of muscular fibre. Fig. 139. The blood-vessels are generally derived from contiguous

* Carpenter. Elements of Physiology, § 376.

† Todd and Bowman, p. 215.

arterial branches; but in some instances a special vessel accompanies a nervous trunk and even perforates it, as in the great sciatic and optic nerves.

ORIGIN.—Nerves are said to originate in the nervous centre to which they are on the one hand attached, and to terminate in the various textures in which their ultimate ramifications can be traced. Thus a nerve is called *cerebral* if it arises from the brain, and *spinal* if it comes from the spinal cord. "The fibres of nerves may be traced into the nervous centres, the white or fibrous part of which they contribute to form. As they enter the centre, the fibres diverge slightly, either singly or in separate bundles, and pass on to form a connection with vesicular matter in the immediate vicinity of the point of immergence, or at a more remote situation. How the fibres comport themselves with respect to the elements of vesicular matter is not known. It is certain, however, that nerve-tubes frequently adhere to the sheaths of nerve vesicles, probably to form a connection with more distant ones."* This arrangement is distinctly seen in the ganglions, and also in the spinal cord and brain.

ANASTOMOSIS.—The anastomosis of nerves differs from that of blood-vessels. Sometimes it consists in the connection, side by side, and in the same sheath, of different nerves, as seen in the arrangement of the anterior and posterior roots of the spinal nerves; the respective tubules being thereby so completely intermixed that the ramifications that pass off in the subsequent course of the nerve often contain fibres from both roots and possess the function of both. In this manner the relative position of the component filaments may be completely changed; so that those at first superficial become deep-seated, and *vice versâ*, owing to a decussation of fibres.

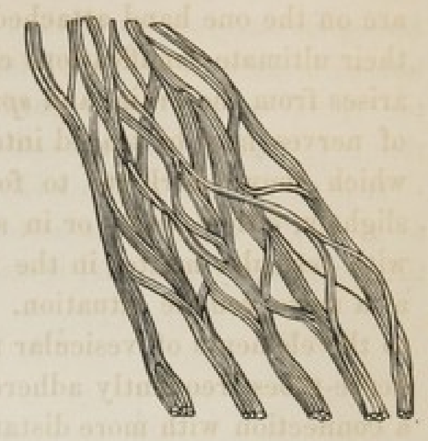
A second mode of anastomosis is that by which nervous loops or arches are formed, the convexities of which are directed towards the periphery, and give off filaments to the contiguous parts. The anastomosis between the ninth and hypoglossal nerve, and the cervical plexus, in front of the carotid artery, may be quoted as examples. Similar loops, leaving the nervous centre as a constituent of one nerve, and returning to it at some distance in company with another nerve, are found in various parts of the nervous system, and an example of this kind occurs in the commissural fibres of the optic nerves.†

PLEXUSES.—A plexus is a retiform interlacement of several nervous trunks, so that there is a more or less complete and reciprocal interchange of fibres. They do not, however, anastomose and blend into single fibres; for however complicated this arrangement may be, no single fibre ever loses its identity: it either returns upon itself, or joins some contiguous fibre or fasciculus and thus returns to the central system whence it had proceeded. The plexiform arrangement of nerves may occur in any part of their course. Thus, the roots of different nerves sometimes combine before or in connection with the formation of nervous trunks, as seen in the plexus formed between the facial and auditory nerves. In other examples the trunks alone are mingled, as in the axillary plexus, and in like manner the branches only unite, as in the facial with the trigeminal nerves. Fig. 323.

* Todd and Bowman, p. 217. † Idem., p. 219.

The *ganglionic plexus* is chiefly observed among the organic nerves, and is divided into *internal* or *cellular plexuses*, and into *external* or *ganglionic*. In the former, the nervous fasciculi enter the ganglions and there form mutual interchanges of the primary fibres enclosing ganglionic cells. Fig. 324.

Fig. 323.



The axillary plexus of nerves.

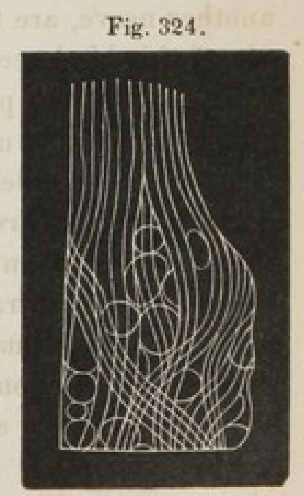
The *external ganglionic plexus* is a radiated combination of organic nerve-trunks and branches by means of ganglia, as exemplified in the solar plexus, the mesenteric plexus, the renal plexus, &c.* Fig. 325.

The *terminal plexus* is constituted of the ultimate fasciculi of nerves, and is seen throughout the peripheral system. Those of the organic nerves are but little known; those of the voluntary muscles have been already described and delineated.

GANGLIA.

A nervous ganglion is a swelling or enlargement in the course of a nerve, formed by an accumulation of ganglion globules; the latter being interspersed among the nerve fibres, constituting the essential feature of the ganglion and distinguishing it from a plexus. Fig. 324. In other words, a ganglion has been compared to a plexus with nerve-vesicles deposited in its meshes. When a nerve enters a ganglion, its fibres divide and penetrate the ganglion in different directions, and emerge again in new fasciculi arising from a recombination of fibres. In their course through the ganglion they come in contact with the vesicular neurine, and at their exit are found to be softer in structure but of larger diameter than at their entrance.† The ganglia also contain a portion of gelatinous neurine, which, as before mentioned, is more abundant in the sympathetic than in the cerebro-spinal ganglia; and lastly, the vesicular neurine is not confined to the interstices between the fibres, but is also found on the surfaces of the ganglia in immediate contact with the investing membrane. The latter is a continuation of the neurilemma of the nervous trunks, the membrane in the two positions being identical in structure and function.

Fig. 324.



Section of the ophthalmic ganglion. After Valentin.

Fig. 324 represents a thin slice from the ophthalmic ganglion, showing the nerve-fibres and interposed ganglion globules.

From the preceding description of a ganglion, it will follow that it is by no means restricted to the nodular enlargements that occur in the course of nervous trunks; and we agree with Mr. Solly in the propriety of applying

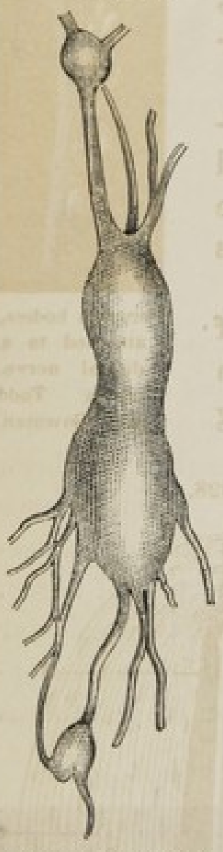
* Gerber. General Anatomy, p. 261.

† Carpenter. Elements of Physiology, § 380.

the name to any circumscribed mass of vesicular neurine, whatever may be its external form or arrangement. In this view of the question Mr. Solly regards the vesicular neurine forming the convolutions of the brain, as the *hemispherical ganglia* of that organ; and on the same principle he considers the human brain as a series of large ganglia.* So also the cineritious neurine of the spinal cord is now regarded as a connected chain of ganglia,† whose function is to regulate the sensations and voluntary motions of the limbs and body.

It is to be observed in addition that there are two kinds of ganglia, differing so greatly in appearance as to be detected at a glance. One of these belongs to the sensitive system, and is seen in connection with the posterior roots of all the spinal nerves. It is rounded, rough and more distinctly fibrous than the second variety, and bears in all respects a close resemblance to the ganglion of Gasser and the other *sensory ganglia*. But the ganglia of the sympathetic system are different; being much smoother externally, and less distinctly fibrous in theirstructure. These two kinds of ganglia are contrasted in the annexed drawings, Figs. 325, 326, from Sir Charles Bell.‡

Fig. 325.



Sympathetic ganglion.

Fig. 326.

Spinal ganglion.

Fig. 325. One of the ganglions of the sympathetic nerve.

Fig. 326. This cut delineates a ganglion of one of the spinal nerves, to show, in the first place, its resemblance to the ganglion of the trigeminus (ganglion of Gasser) in every particular; and in the second place its entire distinctness from the sympathetic ganglion. 1, posterior or sensitive root of the spinal nerve; 3, ganglion formed upon that root; 2, anterior or motor root of the nerve.

THE COMMISSURES.—The cerebro-spinal system contains certain symmetrical ganglia which are connected by processes of tubular or fibrous neurine, and which appear to arise in the one side and to terminate on the other. These connecting portions of neurine are called commissures, whose obvious function is to unite and equalize the operations of the two different parts. The corpus callosum connecting the hemispheres of the brain, is the largest of the commissures; several smaller ones are distributed through the cerebral mass, and no less than three, as we shall hereafter see, connect the opposed parietes of the third ventricle.

* The Human Brain, p. 55.

† In some of the lower animals it is divided into distinct and separate knots.

‡ The Nervous System of the Human Body, Pl. IX.

PACINIAN CORPUSCLES.

These bodies derive their name from Prof. Pacini, a distinguished Italian anatomist, who first made them known in 1830. They are of an elliptical form, generally not larger than a small grain of barley, nearly transparent, and endowed with considerable firmness. Each one is attached to its associated nerve by a pedicle of fibrous tissue derived from the neurilemma, and is embedded in areolar tissue to which it partially adheres. They are most numerous in the nerves of the hand and foot; but they are also attached to other spinal nerves and to the plexuses of the sympathetic system, but are said never to be found associated with the nerves of motion. Fig. 327.

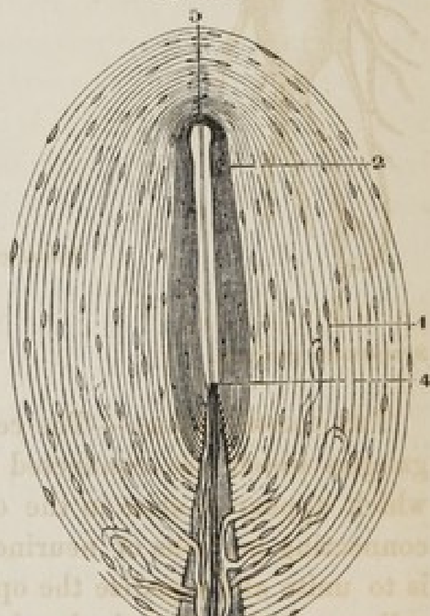
Fig. 327.

Pacinian bodies, attached to a digital nerve. From Todd and Bowman.

The structure of these singular bodies is extremely complicated. They consist of a series of membranous capsules enclosed one within the other, while a single tubular nerve traverses the pedicle or stalk, and having reached the central capsule, runs through it from end to end.

The capsules are from thirty to sixty or more in number, of which the ten or fifteen innermost ones are in contact with each other, while the others are separated by a clear space containing a fluid. A puncture down to the inner series of capsules permits the fluid to escape, and causes a collapse of the whole structure. The stalk or pedicle is of a conical form, and penetrates all the capsules without itself communicating with the intercapsular spaces. Each Pacinian corpuscle is furnished with capillary blood-vessels, and a single nerve possessing the white substance of Schwann and the double contour.

Fig. 328.



Pacinian body. From Todd and Bowman.

The annexed drawing, Fig. 328, from the mesentery of a cat, illustrates the structure of the Pacinian body. 1, the external capsules, which are kept separated and distended by a fluid; 2, the inner series of capsules lying in contact; 3, the nerve, which at 4 has penetrated all the capsules, and from that point to 5, where it terminates, is an attenuated white cord; 6, the conical stalk or pedicle, deriving its external tunic from the neurilemma; 7, a capillary artery that enters the corpuscle and ramifies upon its capsules.

On entering the innermost capsule, the nerve-tube suddenly loses its envelope of white substance and becomes pale and reduced in size, and then "stretches like an arrow along the very centre of the capsular cavity to the opposite end, where it swells into a knob or button

which fixes itself to the inner surface of the capsule." This arrangement of the nerve is one of the most constant features of these bodies, of whose function nothing certain is known.* Fig. 328.

DEVELOPMENT OF NERVOUS FIBRE.

Fig. 329.

Partially developed nerve-fibre.

According to the observations of the celebrated Professor Schwann, the nerve-fibres, like those of muscles, appear to be formed by the fusion of a number of primary cells arranged in rows, into a secondary cell. A nerve is first seen as a pale cord with longitudinal fibres, interspersed with many nuclei and enclosed in an incipient neurilemma. At a later period a secondary deposit of a fatty, white-colored substance, takes place on the inner side of the investing membrane. These points are illustrated in Fig. 329; at 1, the fibril is still pale; below, at 2, the deposition of white substance has taken place, rendering the fibril dark in that direction. The deposit goes on until the whole fibre becomes opaque and the nuclei are absorbed.

CLASSIFICATION OF NERVES.

The nerves are separated, according to their structure and function, into two classes, the cerebro-spinal and the sympathetic or ganglionic nerves. The description above given applies especially to the cerebro-spinal class; and it remains to make some remarks on the ganglionic nerves.

The *ganglionic* or *sympathetic* nerves differ from those of the cerebro-spinal axis in containing both kinds of fibrous neurine—the tubular and the gelatinous, but in very variable proportions, and also in being destitute of the white substance of Schwann. The tubular fibres are numerous in the ramifications of the solar plexus, and in the cardiac nerves; while the gelatinous neurine almost exclusively composes one of the fascicles by which the sympathetic communicates with the spinal nerves; and it also preponderates in the sympathetic cord in the neck. A remarkable feature of the sympathetic system is the frequent occurrence of ganglia in its nervous trunks, and the plexiform arrangement of the nervous fibrils around the arterial tubes. The connection of this system with the brain and spinal cord, appears to take place through the cerebro-spinal nerves, in the manner hereafter to be described. Its connections seem limited to the trunk and head, and if any exist in the extremities they can at most be very limited.†

Briefly recapitulating the foregoing descriptions, it appears that nervous masses present themselves in three different modifications, viz:—

1. *Vesicular neurine*, forming the cineritious portion of the brain and spinal cord.

* Todd and Bowman. Physiolog. Anat., p. 397. † Idem., p. 223.

2. *Fibrous* or *tubular neurine*, which constitutes the medullary matter of the brain, and of the entire series of cerebro-spinal nerves.

3. *Gelatinous neurine*, which is combined with the fibrous variety to form the nerves and ganglia of the sympathetic system.

FUNCTIONS.

The functions of the nervous system generally are for the most part involved in great obscurity; parts of it, however, are well understood, and especially the action of particular nerves, which will be noticed with the description of the nerves themselves. On the present occasion we shall merely advert to a few of the more remarkable of the collective functions.

SENSORY NERVOUS SYSTEM.—The sensory nerves have their origin, not in the brain, but in every other part of the body; and these primary filaments, collecting in larger trunks, take their course towards the spinal cord, where they become isolated in the posterior columns of that cord and pass upward with it to the brain. The impressions made upon them involve the sense of feeling; or, in other words, they are *felt*, for which reason they are termed *sensations*. In the language of Prof. Wagner, these nerves transplant, as it were, an impression which they have received at their peripheral ends to the brain, and here excite an idea or consciousness of the impression; thus constituting the immediate *instruments of sensation*. Their course *to* the brain has given them the designation of *afferent nerves;* and they are also called in reference to their function, *excitor nerves* and nerves of *common sensation*.

The latter name is used to distinguish them from a set of nerves of the same general class, but which are devoted to *special sensation*. Thus while a stimulus applied to the former causes pain, a stimulus to the latter occasions a special sensation, as of light, sound, taste, &c. Thus if the optic nerve be irritated, a flash of light is produced. A galvanic shock to the auditory nerve, causes sound. This class embraces the optic, olfactory and auditory nerves.

MOTORY NERVOUS SYSTEM.—The nerves of this class subserve the function of motion. They act from the centre to the periphery; *from* the brain through the nerves to all parts of the body. They of course originate in the encephalon, and form larger and larger trunks that enter and constitute the anterior column of the spinal cord. They pass off from the latter in the form of the anterior roots of the spinal nerves, being isolated motor nerves until they join the posterior root, when they are blended with the sensory root in the corresponding spinal nerve. The motor nerves are distributed to the muscles in general as *conductors of the will*.

EXCITO-MOTORY NERVES.—This class embraces both sensory and motor filaments, and is therefore capable of a double function. It is necessary to bear in mind, however, that the nervous filaments in these instances are not blended, but placed in apposition; a motor and sensory nerve side by side. Remarkable examples of this kind exist in the trigeminus, glosso-pharyngeal, pneumogastric and spinal accessory nerves.

These several classes of nerves have the same structural character. The eye perceives no difference between them; and when they are blended, as in a proper spinal nerve, for example, they lie in contact with each other and perform their separate functions, without our being able to distinguish the one set of fibres from the other.

The *sympathetic* or *ganglionic* nervous system differs in various respects from either of the preceding. Its functions are in a great measure isolated from those of the cerebro-spinal centre, at the same time that they appear to possess both sensory and motory powers. In conformity with this double function, they are regarded by Wagner and others as both running *to* and issuing *from* the brain. Its real functions, although manifestly of the highest importance, have in a great measure eluded physiological research; but they are supposed to serve, yet in some mysterious way, as conductors of nervous power to the digestive and generative organs; to combine and harmonize the muscular movements immediately connected with the maintenance of organic life; and to bring these into relation with certain conditions of the mind.

Reflex actions.—Physiologists are indebted to Sir Charles Bell for an exposition of the doctrine of reflected or indirect nervous action, which is accomplished in the following manner. In the first place an impression is made upon the extremity of a nerve by some external agent, precisely as when sensation is to be produced. In the second place this impression is transmitted by an afferent nervous trunk to the spinal cord; but instead of being communicated to the mind by the agency of the cord, and thus becoming a sensation, it immediately executes a *motor* impulse which is reflected back, as it were, by the efferent trunks to certain muscles, and, by their contraction, gives rise to a movement without any necessary intervention of sensation or volition. Most of those movements which are directly connected with the organic functions,—respiration, deglutition, the expulsion of the feces and urine, &c., are explained on this principle.*

This reflex action is well illustrated in the movements of the iris for the contraction and dilatation of the pupil. "Here, the stimulus of light upon the retina gives rise to a change in the condition of the optic nerve, which, being transmitted to a certain portion of the encephalon with which that nerve is connected, excites there a motor impulse; and this impulse is conveyed through a distinct nerve (a branch of the third pair) to the iris, occasioning contraction of the pupil. Every one knows that this adjustment of the size of the pupil to the amount of light, is effected without any exertion of the will on his own part and even without any consciousness that it is taking place. It is performed, too, during profound sleep; when the influence of light upon the retina excites no consciousness of its presence,—when no sensation, therefore, is produced by it."†

We shall in this place add only the following propositions: 1st. The vesicular

* Carpenter. Elements of Physiology, § 324.

† Idem. Physiologists are by no means united on the subject of reflex actions. Dr. Bennet Dowler, of New Orleans, has ably examined this question.

neurine is the source of power in the nervous system, and the medullary or tubular neurine, the medium by which that power is conveyed to all parts of the body. 2. The functional activity of the nervous system is mainly dependent on the combination with its elements of the oxygen supplied by the blood; the production of the nervous force, whatever be its nature, being the result of this change of composition.*

THE CEREBRO-SPINAL AXIS.

The cerebro-spinal axis, or the central portion of the nervous system, is constituted of the spinal cord and brain. These important parts are enclosed in three protective membranes, called by the older anatomists *meninges* (matres) from an idea that they gave origin to all the other membranes of the body.

MEMBRANES OF THE CEREBRO-SPINAL AXIS.

THE DURA MATER.

The dura mater invests the brain and spinal cord, and lines the continuous cavity in which they are contained. It is a shining, dense, opaque, fibrous structure, of which the filaments decussate each other in all directions. It adheres everywhere to the internal surface of the cranium, but this attachment is much stronger at the base of the skull and at the sutures and foramina. It is also more adherent in the growing state; whence it happens that in attempting to separate it from the infantile cranium, portions of the bone are often detached with it. In the vertebral canal, however, it does not adhere to the osseous parietes, but is separated from them by a fatty layer furnished with many veins. The dura mater consists everywhere of two laminæ united by cellular tissue and readily separated from each other. This separation is normal in the vertebral canal; yet at the inner margin of the atlas the spinal dura mater and the contiguous periosteum meet together, and adhere so closely as to exhibit within the cranium the appearance of a single membrane. The external surface of the cranial dura mater forms the internal periosteum of the skull; but the internal face of the membrane is differently arranged; for it is lined by a reflexion of the arachnoid tunic that gives it a smooth and polished character, admirably adapted to protect the brain with which it is in contact.

The cranial dura mater is as large in capacity as the cavity it lines; but the spinal portion of the membrane lies loosely in the vertebral canal. Again, the spinal portion is much larger than the contained medulla, which hence appears loose within it; and the interspace, during life, is filled with a fluid that keeps the membrane in a state of fulness and partial distension. The dura mater is larger in the cervical and lumbar sections of the canal than in the back; and in

* Carpenter. Principles of Physiology, § 292.

the sacral and part of the lumbar regions it forms a sac-like dilatation around the cauda equina.

The dura mater is freely supplied with arteries. These are chiefly derived from the external and internal carotids and from the vertebral arteries. The veins are interposed between its laminæ and are called sinuses. The dura mater seems to be destitute of sensibility in the healthy state, and yet some nervous filaments have been traced into it, derived from the sympathetic trunk, and others from the fourth and fifth pair. The nerves pass out of the cranium through corresponding foramina in the dura mater; and in the spinal region each foramen is divided by a process of the membrane, into two, corresponding to the anterior and posterior roots of the spinal nerves.

THE CRANIAL DURA MATER.

This portion of the membrane presents some interesting peculiarities of structure, of which we shall first notice its processes, or reflected portions.

Falx major or *falx cerebri.*—This process is formed by an inflection of the internal layer of the dura mater that dips down between the two hemispheres of the brain their whole length. It commences at the foramen cæcum and from the upper margin of the crista galli of the ethmoid bone, and extends backwards, in the medial line of the skull to the internal occipital protuberance, where it divides into two lateral portions to form the tentorium. In this course the falx is attached above to the frontal, parietal and occipital bones; it is about half an inch in width at its commencement, and gradually widens to its termination, where it is about two inches broad. The lower or free margin of the falx presents a deep arch with a sharp and perfectly defined margin. In some instances it is partially deficient, forming small openings or foramina which are altogether accidental.

Tentorium.—The lateral processes given off by the falx cerebri at the occipital protuberance, are placed in a nearly horizontal direction across the posterior cavity of the cranium, so as to divide the latter into two chambers, of which the lower one receives the cerebellum,—the upper one the posterior lobes of the cerebrum. This septum is the tentorium: its posterior and lateral margins are attached to the transverse ridge of the occipital bone; while it adheres to the superior angles of the petrous portion of the temporal bone. From the anterior ends of these bones it extends upwards and forwards to the anterior clinoid processes of the sphenoid bone. The opening between the free, internal margins of the tentorium, is of a conical form; it is called the foramen ovale, and is occupied by the crura cerebri and the tuber annulare.

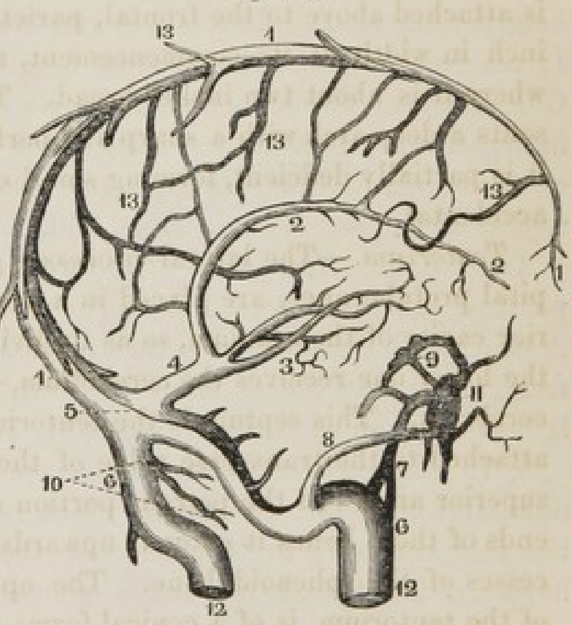
Falx cerebelli.—This is a much smaller reflection of the dura mater: it extends from the under and posterior margin of the tentorium, at the central point where the longitudinal ridges of the occiput meet, to the foramen magnum below. It is sometimes called the *falx minor*, and serves to separate the two lobes of the cerebellum.

SINUSES OF THE DURA MATER.

The sinuses of the dura mater are canals placed between its laminæ, and they constitute the terminal veins of the brain; for the venous blood of that organ having been received by the veins of the pia mater, is by them conveyed into the sinuses and thus into the internal jugular veins. The sinuses are mostly of a triangular form, are lined by a continuation of the same membrane that lines the veins, and are protected from pressure by the tension of the dura mater. There are in all fifteen sinuses.

1. *The superior longitudinal sinus* is the longest of these canals. It commences at the foramen cæcum of the frontal bone, follows the medial groove in the cranial arch to the internal occipital cross, where it branches into the two lateral sinuses. It is very small at its origin, but gradually increases in size to its termination. It is of a triangular shape with the base upwards. The veins that enter it from the pia mater open contrary to the course of the circulation, or, in other words, in the forward direction: they are furnished with valves, and their orifices are surrounded by delicate cords,—*chordæ Willisii*,—which assist in keeping them open in order to facilitate the egress of the contained blood. The veins of the pia mater are ten or twelve in number; they pass for some distance before their termination between the laminæ of the dura mater, and receive the corresponding veins from the vertical surfaces of the brain which are in contact with the falx cerebri. The dura mater itself and the cranial bones, also discharge some of their veins into the longitudinal sinus. Fig. 330, 1.

Fig. 330.



Lateral view of the sinuses of the dura mater.

The annexed diagram, Fig. 330, is reduced and slightly modified from that given in Bell's Anatomy, and conveys a good lateral view of the several sinuses. 1, superior longitudinal sinus; 2, inferior longitudinal sinus; 3, the two venæ Galeni; 4, sinus quartus; 5, torcular Herophili; 6, 6, the lateral sinuses; 7, inferior petrous sinus; 8, superior petrous sinus; 9, circular series of Ridley; 11, cavernous sinus; 10, the two occipital sinuses; 12, internal jugular veins; 13, veins of the pia mater.

The *glandulæ Pacchioni* are chiefly appendages of this sinus. They are small, white opaque bodies of a granulated appearance, sometimes isolated but more generally in clusters. They are most numerous in the upper and posterior part of the canal; but they are also found on the outside of the dura mater in this vicinity, and two of them, or rather two masses of aggregated glands, sometimes

attain the size of a small bean and are lodged in corresponding pits in parietal bone. No secretion or excretory duct has been detected in connection with these glands; and from the circumstance of their being absent in infancy, some physiologists regard them as morbid growths. But when we reflect on their almost constant presence in adult age (for in examining a great number of cases I have never found them deficient after this period of life), we may more safely infer that they are normal structures of which physiology has not yet determined the function.

2, 3. The *lateral sinuses*, two in number, are the continuous trunks of the longitudinal sinus. They commence at the centre of the occipital cross, and take a winding course outwards, downwards and forwards to terminate in the internal jugular vein at the posterior foramen lacerum. They are lodged in corresponding grooves in the cranial bones, which grooves widen and deepen as they approach the foramen lacerum, and the sinuses are of an oval form. They receive the lateral and inferior veins of the cerebrum and cerebellum. Figs. 330, 6, 6, and 331, 1.

4. The *inferior longitudinal sinus* is embraced in a fold of the inferior arched margin of the falx cerebri, and terminates behind in the sinus quartus. It receives the veins of the falx and the contiguous parts of the brain. Fig. 330, 2.

5. The *sinus quartus* or rectus, lies within the posterior margin of the tentorium where the latter is continuous with the falx: it commences at the anterior and terminates at the posterior junction of these membranes, where it joins the longitudinal sinus. It is about two inches in length and of a triangular form. It receives in front the inferior longitudinal sinus from above and the vena Galeni below, which last vessel is itself formed by two veins from the velum interpositum. Besides receiving from these sources part of the venous blood of the cerebrum, the sinus quartus also receives several veins from the upper region of the cerebellum. Fig. 330, 4.

The *torcular Herophili.*—The torcular or press of Herophilus is merely the point of junction between the large sinuses at the centre of the occipital cross. A considerable dilatation is thus formed into which the longitudinal sinus opens from above, the fourth sinus in front, the occipital sinus from below and the lateral sinus on each side. Fig. 331, 3.

6, 7. The *occipital sinuses* commence by small veins around the foramen magnum, and unite into two canals which run in the attached posterior margin of the falx cerebelli to terminate in the torcular Herophili, or, as sometimes happens, directly into the lateral sinuses. Figs. 330, 10, and 331, 4.

8, 9. The *cavernous sinuses* are situated on each side of the sella turcica, and like the other sinuses are formed by a separation of the laminæ of the dura mater. The cavity thus formed is crossed by processes of the internal face of its lining membrane, giving it a partially cavernous appearance. The carotid artery runs directly through the corresponding cavernous sinus, and has the lining membrane of the sinus reflected over it. In this remarkable course, the artery is accompanied by some filaments of the carotid plexus of nerves and by the sixth nerve. The cavernous sinuses communicate with each other by means

of the circular sinus, and with the two petrous and anterior occipital sinuses from behind. They receive the ophthalmic and the anterior and inferior cerebral veins, together with some others from the dura mater. Figs. 330, 11, and 331, 11.

10. The *circular sinus*, or sinus of Ridley, lies within the sella turcica and surrounds the pituitary gland. It receives the venous blood of the pituitary gland, and communicates on each side with the cavernous sinus. Figs. 330, 9, and 331, 8.

11, 12. The *petrous sinuses* are two in number on each side. The *superior petrous sinus* commences at the cavernous sinus within the anterior attached margin of the tentorium, runs outwards and backwards along a slight groove in the upper angle of the petrous portion of the temporal bone, and opens into the lateral sinus where the latter curves downwards to the base of the skull; thus forming a communication between the cavernous and lateral sinuses. It receives some small veins from the middle lobes of the cerebrum, and a single vein from the contiguous part of the cerebellum. Figs. 330, 8, and 331, 5.

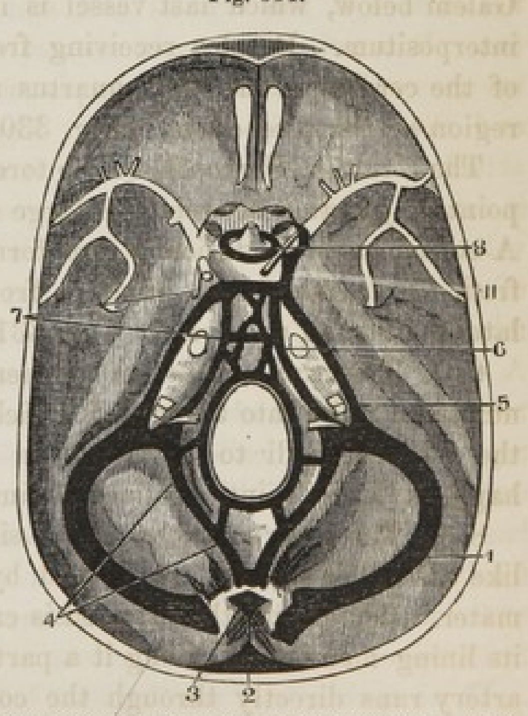
13, 14. The *inferior petrous sinus* on each side arises also from the cavernous sinus, whence it runs outwards and backwards along the lower margin of the petrous portion of the temporal bone, in a furrow formed by the latter with the occiput at the base of the cranium. It soon reaches the posterior foramen lacerum and terminates in the lateral sinus just as it merges into the internal jugular vein. Figs. 330, 7, and 331, 6.

15. The *transverse* or basilar sinus connects the two inferior petrous sinuses by passing between them across the basilar process of the occipital bone. It is occasionally double. Fig. 331, 7.

It will now be understood that these several sinuses, fifteen in number, receive the venous blood from the different portions of the brain and its investing membranes, and convey it on each side to the posterior foramen lacerum, where the internal jugular vein begins by a continuity of structure with the corresponding lateral sinus.

Fig. 331 is a basal illustration of the sinuses of the dura mater, slightly modified from Weber. 1, lateral sinus; 2, longitudinal sinus cut across, showing its angular form; 3, torcular Herophili; 4, occipital sinus; 5, superior petrous sinus; 6, inferior petrous sinus; 7 (anterior line), the carotid artery passing through the cavernous sinus; 7 (posterior line), the basilar sinus; 8, circular sinus of Ridley, surrounding the infundibulum; 11, cavernous sinus.

Fig. 331.



Basal view of the sinuses of the dura mater. After Weber.

THE SPINAL DURA MATER.

This is a continuous prolongation of the cranial dura mater that passes through the foramen magnum: it forms a long, funnel-shaped tube, larger above, and gradually diminishes until it reaches the sacral portion of the spinal canal, where it at first enlarges and then subdivides into small sheaths for the sacral nerves. The external surface is slightly attached to the vertebral parietes by filaments of cellular membrane; and between it and the bones behind, is interposed a reddish adipose tissue mingled with the veins, and which is most abundant in the sacral region.

The dura mater gives off, on each side, processes that envelope the roots of the spinal nerves for a short distance beyond the intervertebral foramina, and which are then lost in the proximate cellular tissue. The internal surface of the membrane is smooth and polished, owing to its being lined by the arachnoid tunic. The superior extremity of the spinal dura mater is attached to the margin of the occipital foramen, and its inferior end is opposite the lowest part of the lumbar region, where it expands into a pouch-like dilatation round the cauda equina.

TUNICA ARACHNOIDEA.

The arachnoid membrane is an extremely thin, transparent tissue that envelopes the brain and spinal cord, whence it is reflected over the whole internal surface of the cranial and spinal dura mater, so as to constitute a closed sac. It is not, however, in contact with the cerebro-spinal axis, for these parts are everywhere covered by the pia mater, which is thus interposed between them and the arachnoid membrane. The latter is for the most part inseparably attached to the pia mater, giving it a very smooth and glossy appearance; but it can be demonstrated where it passes over the sulci between the cerebral convolutions, and still more distinctly in three places at the base of the brain. One of these is the interval between the tuber annulare behind and the optic commissure in front, which is sometimes called the *anterior sub-arachnoidean space.* A second point of separation is seen where the arachnoid stretches across between the medulla oblongata and the inferior portion of the cerebellum, which region is hence called the *posterior sub-arachnoidean space.* A third and smaller example of this kind is seen at the tubercula quadrigemina, which locality has been called the *superior sub-arachnoidean space.* These spaces communicate freely with each other; the anterior and posterior across the crura cerebelli; the anterior and the middle around the crura cerebri; and the latter and the posterior space across the cerebellum in the course of the vermiform processes.*

These spaces, with smaller ones between the convolutions of the hemispheres, constitute a large and continuous cavity (which is prolonged into the spinal

* Wilson's Human Anatomy, Dr. Goddard's ed., p. 396. Cruveilhier. Anatomy, p. 922.

canal) filled with a serous exudation, the *sub-arachnoidean* or *cerebro-rachidian fluid.* The use of this fluid is to afford a mechanical protection to the brain and spinal cord, against the shocks to which they would otherwise be exposed. Its quantity is seldom less than two ounces, and often amounts to five; and in old age with atrophy of the brain, even to ten or twelve ounces; the proportion being comparatively small in the juvenile periods of life. It is composed of more than 98.60 parts of water, the remainder being albumen, osmazome and some salts.

As this fluid is identical with that of the ventricles, some anatomists have insisted on a direct communication between the latter and the sub-arachnoidean spaces. Magendie asserts that such an opening exists at the calamus scriptorius; but as it cannot be satisfactorily demonstrated, we may more safely adopt the explanation of Dr. Todd, that the communication is established through the hygrometric character of the pia mater, which transmits the fluid by simple endosmose and exosmose. Besides the sub-arachnoid fluid, a small quantity of serous halitus is always found interposed in the general cavity of the arachnoid membrane.

Notwithstanding the close and seemingly inseparable attachment of the arachnoid tunic to the dura mater and pia mater, it may be readily dissected from them over small surfaces by careful manipulation, and especially from the dura mater. This process is sometimes spontaneous from the effusion of serum or pus, and it is also aided by the use of the blowpipe.

The arachnoid, adds Dr. Wilson, does not enter into the ventricles of the brain, as supposed by Bichât, but is reflected inwards upon the venæ Galeni for a short distance only, and returns upon these vessels to the dura mater of the tentorium. It surrounds the nerves as they originate from the brain, and forms a sheath around them to their point of exit from the skull, whence it is reflected back upon the inner surface of the dura mater.*

SPINAL PORTION OF THE ARACHNOID MEMBRANE.

The arachnoid membrane that covers the brain is prolonged through the occipital foramen to form an envelope for the spinal cord, within the dura mater. It lines the latter as it does the cranial dura mater, only more loosely, and is then reflected upon the cord, where, however, the arrangement becomes altogether different; for it is much larger than the cord itself, around which it forms a membranous sheath, so that there exists between the two a considerable interval called the *spinal sub-arachnoid sheath.* This space therefore exists between the pia mater within and the arachnoid without; and like the analogous cavities in the cranium, is occupied by the cerebro-rachidian or sub-arachnoid fluid.

* Loco citato.—Bichât thought he had discovered that the arachnoid penetrates into the ventricles of the brain below the posterior border of the corpus callosum. He called the supposed passage the *arachnoid canal,* and others have named it the canal of Bichât; but anatomists in general do not now admit its existence. See Cruveilhier, Anatomy, p. 918.

THE PIA MATER.

The pia mater is a delicate, transparent membrane of extreme vascularity that envelopes the whole cerebro-spinal axis and is in direct contact with it. It may be called a plexus of blood-vessels, both arteries and veins, connected together by cellular tissue and constituting, in the language of Cruveilhier, the nutritious membrane of the parts invested by it.

THE CRANIAL PIA MATER.

The cranial pia mater is divided into the *external*, or that covering the brain, and the *internal*, which enters the substance of the brain and penetrates into the ventricles. The external surface, that seen on removing the dura mater, is closely covered, as we have already observed, by the arachnoid tunic, which passes from one convolution or prominence to another without dipping between them. The pia mater, on the contrary, penetrates between the hemispheres as low down as the corpus callosum, and its two surfaces adhere directly above that part of the brain. In like manner it goes to the bottom of the fissura Sylvii and enters between the convolutions of the brain, so as to separate them by a duplication of its structure. In other words, it passes down on one side of a sulcus and then curves upwards upon the other side, to be continued over the free surface of the contiguous convolution, until it thus invests the whole periphery of the brain. "It follows, therefore," observes Cruveilhier, "that this surface of the pia mater is in contact with itself to a great extent; and also that its superficies is much greater than that of the arachnoid; so that if the brain could be unfolded, as Gall supposed, its surface would be entirely covered by the pia mater. These remarks apply equally to the pia mater of the cerebellum; for every one of the numerous laminæ of that organ is covered on each side by a fold of the pia mater."*

The *internal pia mater* is more delicate than the external. It enters a fissure between the posterior margin of the fornix and the tubercular quadrigemina, and thus penetrates to the third ventricle where it forms the velum interpositum: it is also extended into the inferior cornua of the lateral ventricles, and into the fourth ventricle, as will be shown more fully when treating of those parts.

The arteries of the pia mater are the same as those of the brain, being derived from the internal carotids and vertebrals. The veins, which are large and extremely numerous, do not accompany the arteries, but terminate, as we have seen, in the sinuses, and chiefly in the longitudinal sinus. They open into this canal in the forward direction, which is contrary to the circulation in the sinus; an arrangement that tends, together with the position of the chordæ Willisii already described, to keep the mouths of these veins constantly open. Fig. 330, 13, 13.

* Anatomy, p. 922.

SPINAL PIA MATER.

The spinal pia mater is continuous with that of the cranium; but it is so differently arranged, and so intimately blended with the structure of the spinal cord, that the two will be described together in the following section of this work.

THE SPINAL CORD OR MEDULLA SPINALIS.

Since it is now a pretty generally admitted proposition in physiology, that the spinal cord is developed before the brain, and that the latter is a production from the former; and, again, since the structure and developement of the brain cannot be clearly understood without first obtaining a knowledge of the spinal cord, we proceed to examine and describe this important organ. With regard to the first of these views, however, there is yet great diversity of opinion, and perhaps the mediate proposition of Mr. Solly may be most consistent with nature; viz: that, considering the functions of the cord, the anterior columns should be described as commencing in the brain, and the posterior ones as termintaing there. There is one point at least, in connection with this inquiry, in which most physiologists agree,—that of all parts of the nervous system the spinal cord is most essential to the continuance of life.

The spinal cord is that portion of the cerebro-spinal axis contained within the vertebral canal. It commences above at the corpora olivaria, and extends in its cord-like form through the whole of the cervical and dorsal regions, and the upper part of the lumbar region, being about eighteen inches in length. In the lower part of the lumbar and the whole of the sacral regions, its place is supplied by a fasciculus of large nerves that branches from the cord and is called the *cauda equina.* The spinal cord is variable in size, being wider in the cervical region and narrow in the middle of the dorsal portion of the canal. At the lower part of the dorsal region it again enlarges, and then gradually diminishes until it becomes a rounded point opposite the second lumbar vertebra, where it terminates in a conical apex,—the *conus medullaris.*

MEMBRANES OF THE SPINAL CORD.

The dura mater.—This membrane, as heretofore remarked, is continuous with the cranial dura mater. It is adherent to the first cervical vertebra, and its pointed inferior extremity is attached to the os coccygis; but the whole cord between these terminal portions is loosely placed within the spinal canal, to which it is connected only by meshes of areolar tissue. The membrane is much larger than the cord, and has a collapsed appearance when dissected, owing to the escape of the sub-arachnoid fluid. It forms a sheath for each of the spinal nerves as far as the intervertebral foramen, where it invests the ganglion and is then

lost by degrees on the trunk of the spinal nerve. Each of these nerves passes through a separate opening in the membrane, which is smooth and glossy on its inner surface from being lined by the arachnoid tunic.

The *tunica arachnoidea* is also continuous with the cranial membrane. It lies loosely around the cord, being connected to it by filaments of cellular tissue which is most abundant in the upper part of the canal. It gives an envelope to each of the spinal nerves, and is then reflected over the whole internal surface of the dura mater. The space between the internal free surface of the arachnoid, and the external surface of the pia mater, is the *spinal sub-arachnoid space*, filled by the cerebro-rachidian fluid.

The *pia mater* of the spinal cord is a dense, fibrous membrane with little vascularity. It is in immediate contact with the cord, and sends in a process to the bottom of its anterior and posterior longitudinal fissures. From these processes many small vascular canals are given off, that anastomose freely with each other. It gives an investing sheath to each of the roots of the spinal nerves as well as to the nerves themselves; and from the end of the spinal cord is prolonged in a slender ligament—*ligamentum terminale*—that descends through the cauda equina to the inferior and internal face of the terminal pouch of the dura mater, to which it is attached.

The *ligamentum denticulatum* is a narrow band placed on each side of the spinal cord between the pia mater and the arachnoid membrane. It commences at the occipital foramen, and descends attached to the pia mater in the angle formed between the anterior and posterior fasciculi of spinal nerves. Opposite the first or second lumbar vertebra it becomes attached to and is gradually lost in the ligamentum terminale of the pia mater. The external surface of the ligamentum denticulatum is unattached to the pia mater, except by certain short, tooth-like processes, from fifteen to twenty or more in number: these processes perforate the arachnoid membrane, (which embraces the point of perforation,) and are attached to the internal face of the dura mater. The obvious use of this remarkable arrangement is to keep the three membranes in their relative position to each other and to the spinal cord.

FISSURES OF THE SPINAL CORD.

The spinal cord is divided into two equal, lateral halves by two longitudinal fissures, one in front and the other behind, which traverse its entire length.

The *anterior fissure* is wider but more superficial than the posterior, and extends to the depth of about one-third of the diameter of the cord. The pia mater dips into it, and the surfaces thus placed in apposition adhere so as to yield only with some force or slight maceration. At the bottom of the fissure is a thin layer of tubular neurine, called the *anterior commissure* of the cord. Fig. 332, 1.

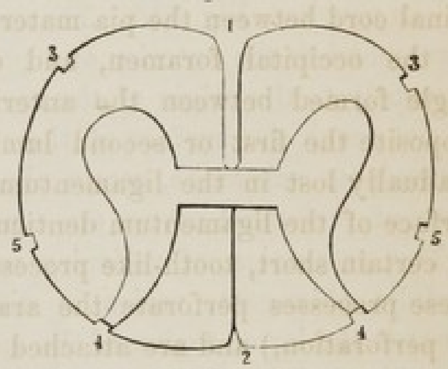
The *posterior fissure* is still more adherent than the anterior, and like it is lined throughout by the pia mater. The bottom of this fissure is destitute

of the white commissure, but presents in place of it one of cineritious neurine. Fig. 332, 2.

"Moreover, on each side of the medulla spinalis there is a lateral fissure. It is not precisely in the middle, but somewhat posterior, and penetrates inwards and forwards. In many instances it is merely a superficial depression, much less deep than either of the former. It does not run the whole length of the medulla spinalis, but terminates somewhere in the upper part of its thoracic portion by joining with its fellow, after having converged regularly towards it. The different opinions of anatomists on the existence of this fissure, may be accounted for by its being rarely found in early life, while it is obliterated or very indistinct in old age. Fig. 332, 5, 5.

"This lateral fissure should be carefully distinguished from two others, one before and another behind it, which extend the whole length of the medulla spinalis, and consist in a series of little depressions, running into each other and transmitting the filaments which form the roots of the spinal nerves. The posterior of the last named lateral fissures is deeper than the anterior, and penetrates in the same direction with the lateral fissure first-mentioned; it also, in like manner, joins its fellow, but only after having proceeded to within a few lines of the inferior end of the medulla spinalis."* Fig. 332, 3, 4.

Fig. 332.



Fissures of the spinal cord.

These subordinate fissures may in stricter language be called furrows, or sulci; and the two on each side that correspond with the origin of the spinal nerves, are the *anterior and posterior lateral sulci.*

Fig. 332 is a diagram of the fissures or sulci of the spinal cord. 1, anterior longitudinal fissure; 2, posterior longitudinal fissure; 3, antero-lateral fissure, for the corresponding roots of the spinal nerves; 4, postero-lateral fissure, for the posterior roots of the spinal nerves; 5, lateral fissure.

COLUMNS OF THE SPINAL CORD.—Anatomists consider each half of the spinal cord to be composed of two columns, one of which is the *antero-lateral*, the other the *posterior*.

The *antero-lateral column* is much the larger of the two, and includes all that portion of the cord that intervenes between the anterior longitudinal fissure and the posterior lateral sulcus. Fig. 332, 1 to 4. It therefore not only constitutes nearly all of the anterior part of the cord, but also embraces its lateral portion. The relative size of the two columns, however, varies in different parts of the cord; for in the cervical region the antero-lateral is nearly double the size of the posterior column; while in the lower part of the dorsal and contiguous part of the lumbar region, it is not more than one-fourth larger. The nerves that arise from this column of the spinal cord are subservient to motion only.

The *posterior lateral column* is the small portion of the cord that lies between

* Horner. Anatomy and Histology, ii. p. 361.

the posterior lateral sulcus and the posterior longitudinal fissure; Fig. 332, 2 to 4, and which, together with the nerves that are connected with it, is the organ of sensation. In other words, the anterior cord is *motory*, the posterior *sensitive*.

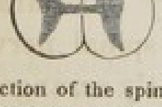
Another division of the cord is into three columns; viz.: an anterior, which is the space between the front longitudinal fissure and the anterior spinal nerves; a middle column, between the roots of the two sets of nerves; and a posterior column, which embraces that part of the cord between the posterior nerves and the posterior longitudinal fissure. This triple division, however, is only calculated to embarrass the study of these parts, without having any relation to their functions.

TRANSVERSE SECTION OF THE CORD.

A transverse section of the spinal cord shows it to be composed of tubular neurine externally, and of vesicular neurine internally, so that the latter is completely embraced within the former. The white or fibrous neurine has been compared to two cylinders, placed side by side and connected by a commissure of the same substance; while the cineritious part is formed of two crescentic portions, one in each cylinder, the two being connected by a commissure of cineritious neurine. Fig. 333. The anterior and posterior termini of these crescents, correspond to the anterior and posterior lateral sulci above described, and consequently to the origin of the roots of the spinal nerves. The anterior horns do not reach the surface of the cord; but the posterior, extending completely through its substance, attain the surface at those points where the posterior roots of the spinal nerves are connected with the cord. Fig. 333.

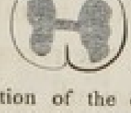
The proportion of vesicular neurine which is continuous with that of the medulla oblongata, varies in different parts of the cord; thus it increases towards the lower region of the spine, where it constitutes the bulk of the cord; and this obvious diminution of the fibrous neurine is owing to its having been gradually distributed to the spinal nerves, each nerve from the cervical downwards taking with it a few filaments. This variation in the proportion of the two kinds of neurine is seen in Figs. 333 and 334; the former being taken from the cord opposite the fourth cervical vertebra; the latter from opposite the eleventh dorsal vertebra.

Fig. 333.



Section of the spinal cord opposite the fourth cervical vertebra.

Fig. 334.



Section of the cord opposite the eleventh dorsal vertebra.

"This cineritious neurine," says Mr. Solly, "must be regarded as constituting a *chain of ganglia*, and not as one continuous ganglion; each set of spinal nerves having its own individual nervous centre, corresponding to its osseous centre or vertebra.—The anatomical continuity of this gray matter, and its physiological or functional separation into distinct ganglia or centres, is another fact of importance to show that we must not look for anatomical lines of separation in order to establish distinction of function."*

* The Human Brain, p. 174.

According to Rolando there are two kinds of cineritious neurine in the cord, one forming the anterior, the other the posterior half of the crescent, interjoined by serrated processes. This arrangement is denied by the majority of anatomists; and so also is the supposed existence of any canal in the centre of the cineritious cord, or in either of its columns.

The tubular or medullary neurine of the cord is composed of longitudinal fibres that extend its whole length. These fibres are not collected into simple fasciculi, but are arranged in laminæ of unequal breadth, one border being thick and corresponding with the surface of the cord, while the other is thin, and is in contact with the vesicular neurine of the interior of the cord.* Rolando describes them as being laterally continuous and convoluted upon each other, with enclosed laminæ of vesicular neurine.

ORIGIN OF THE SPINAL NERVES.

Without attempting to embarrass the present description by an inquiry into the foregoing and other mooted points, we proceed in the next place to describe the nerves given off from the spinal cord.

These nerves are arranged in pairs, each nerve being connected with the cord by two sets of filaments, one of which is anterior, the other posterior, whence they are called the anterior and posterior roots of the spinal nerves; and they are further classed into cervical, dorsal, lumbar and sacral, according to their place of origin. The *anterior roots* arise from the anterior lateral sulcus, and consequently from the antero-lateral column: they are smaller but more numeous than those of the posterior cord, and are connected together by loose cellular tissue. The *posterior roots* come from the posterior column of the cord at the posterior lateral sulcus, and converge to meet the anterior fasciculi. In this way an angle is formed, the base of which is the spinal cord between the two sets of roots, while the apex is the point of junction. The opposite fasciculi are connected by cellular tissue, and the ligamentum denticulatum separates them, or rather runs between them, the whole length of the cord.

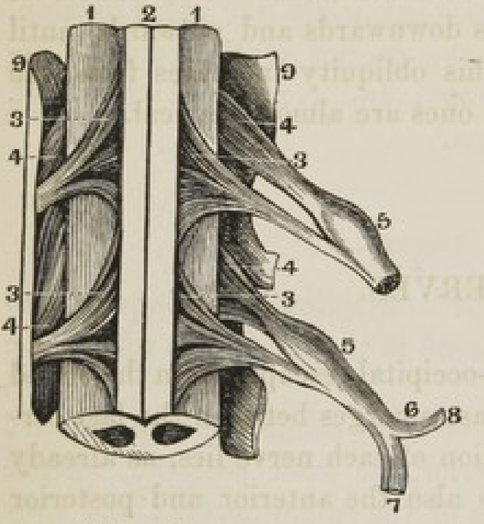
Just before these fasciculi escape from the dura mater, each set is collected into a single nerve-like trunk that perforates that membrane by a separate orifice, and then the two join together to form their respective spinal nerve. In accomplishing this object, however, the two fasciculi are differently arranged; for the anterior one continues its course to the point of junction as a single nerve trunk, Fig. 335, 3; but the posterior fasciculus, immediately after it has perforated the dura mater, forms a ganglion, which is lodged in the intervertebral foramen. Fig. 335, 5. From each ganglion the nerve is again continued a short distance, when it merges into the posterior branch, and the two coalesce into the spinal nerve, as just mentioned. The anterior nerve, though in contact with the ganglion in front, does not send any fibres into it. Fig. 335.

These roots or fasciculi of the spinal nerves, not only differ in arrangement

* Wilson. Anatomy, p. 417.

but in function: thus the anterior roots are *nerves of motion*—motor nerves,—the conductors of the will to the voluntary muscles; they are the instruments of volition, and are also called *efferent nerves*, because they convey *to* the muscles and *from* the nervous centre, the motor impulses that originate in that centre. The posterior roots, on the other hand, are *nerves of sensation*—sensory nerves; they convey sensations or impressions *towards* the nervous centres through the medium of the spinal cord, whence the synonym of *afferent nerves*.* Hence it has been remarked by Mr. Solly, that, strictly speaking, the anterior filaments alone arise from the cord, while the posterior filaments terminate there.†

Fig. 335.



Origin of the spinal nerves.

Fig. 335. Origin of the spinal nerves. 1, 1, lateral columns, marked off in front at 2, the anterior fissure; 3, anterior roots; 4, posterior roots; 5, ganglion formed by the posterior roots; 6, spinal nerve, formed by the junction of the anterior and posterior root; 7, anterior branch of spinal nerve; 8, posterior branch.

The precise nature of the connection of these nerves with the cord itself, has not been ascertained; and the most that has been written on the subject consists of ingenious conjecture. The probabilities are as follow: the roots of the anterior fasciculi extend, some upwards along the cord, others horizontally towards its centre; and the latter appear to mingle with the vesicular neurine of the anterior horn; but it is uncertain whether the upward fibres pass into the cineritious substance, or simply merge into the longitudinal fibres of the cord and accompany these into the brain. This double connection of the filaments with the cineritious and tubular portions of the cord, is corroborated by the experiments of Mr. Grainger.

The posterior roots, on the other hand, appear to originate in the posterior horns of cineritious neurine, and from the posterior part of the antero-lateral columns.

Functions of the roots of the spinal nerves.—We may repeat that numerous experiments have confirmed the physiological proposition that the anterior roots are *motor*, and preside over voluntary motion; and that the posterior roots are *sensory*, and convey sensation through the medium of the cord to the seat of consciousness,—the cerebral hemispheres.

Thus, irritation of any kind applied to the anterior roots always produces muscular contraction, and a section of them ends in paralysis of motion. On the other hand, no muscular action follows irritation of the posterior roots, which, when divided, cause paralysis of sensation. "The latter effect is evinced by

* They are not unfrequently called *excitor nerves*. We have constantly to lament the numerous synonyms for different parts of the nervous system.

† The Human Brain, p. 172.

the utter insensibility to pain shown on pinching a toe; whilst in the limb in which the posterior root is entire, such an irritation is acutely felt. If the anterior roots of the nerves to the lower extremity be cut on one side, and the posterior roots on the other, voluntary power without sensation will remain in the latter, and sensation without voluntary power in the former."*

Classification.—The thirty-one spinal nerves thus formed are classed in the following manner: there are eight cervical nerves, among which is included the suboccipital nerve; twelve dorsal, five lumbar and six sacral. The course of these nerves after they leave the spinal cord, is downwards and outwards until they escape from the vertebral canal; and this obliquity increases from the higher to the lower nerves, so that the inferior ones are almost vertical.

THE CERVICAL NERVES.

Of the eight cervical nerves the first, or sub-occipital, escapes from the spinal canal between the occiput and the atlas; the last emerges between the last cervical and the first dorsal vertebræ. The ganglion of each nerve lies, as already observed, in the intervertebral foramen; where also the anterior and posterior roots conjoin to form the single trunk of the spinal nerve, and this immediately again divides into two branches, an anterior and a posterior. Fig. 335, 7, 8.

THE FIRST CERVICAL NERVE.—This, the suboccipital nerve, is the smallest of the spinal series. It mostly arises by a single root composed of a number of filaments from the anterior column of the spinal cord. It emerges from the vertebral canal in company with the vertebral artery, and while in the canal formed by the occiput and atlas forms a small, elongated ganglion, and then divides into an anterior and posterior branch.

The *anterior branch* lies at first in the groove of the atlas and beneath the vertebral artery; it directly afterwards curves downwards in front of the transverse process of the first vertebra, and forms a loop by anastomosis with the second cervical nerve. It is distributed to the recti muscles on the upper front of the vertebral column, and sends branches to the occipito-atlantal articulation. Other branches join the hypoglossal and pneumogastric nerves, and filaments are also sent to the superior cervical ganglion of the sympathetic.

The *posterior branch* is larger than the anterior. It takes a backward course, and is distributed upon the recti and obliqui muscles and on the complexus.

THE SECOND CERVICAL NERVE.—This nerve escapes from the spinal canal between the atlas and axis and divides into two branches.

The *anterior branch* passes forwards and outwards beneath the inferior oblique muscle of the neck, and supplies the rectus capitis anticus major and the sterno-mastoid muscles. It also forms looped anastomoses with the suboccipital and

* Todd and Bowman. Physiolog. Anat. p. 306.

third cervical nerves, and with the pneumogastric and hypoglossal nerves. It sends a filament besides to the first cervical ganglion of the sympathetic.

The *posterior branch* is of considerable size. It sends a branch to join the third cervical, and is distributed to the integuments of the back of the neck and head and to the splenius, complexus and occipito-frontalis muscles.

The THIRD CERVICAL NERVE runs obliquely upwards and outwards between the muscles and transverse processes, and through the second intervertebral foramen, where it divides into two branches.

The *anterior branch* gives some filaments to the muscles on the front of the vertebræ, and then anastomoses in the looped form with the second and fourth spinal nerves, and with the first cervical ganglion of the sympathetic. It sends branches to the levator scapulæ and splenius colli; a branch to the integuments and muscles of the ear (auricularis magnus) and a twig to join the facial nerve. Another branch runs to the angle of the jaw and communicates with the facial nerve, and is finally distributed on the contiguous muscles of the neck. A third branch is joined by one from the accessory and is distributed to the integuments over the mastoid process, the external ear and the adjacent parts. Finally, a filament runs downwards and forms the superior origin of the phrenic nerve.

The *posterior branch* passes under the spinous process of the second vertebra, and terminates in the skin on the back of the neck. In its course it sends branches to the trachelo-mastoid, transversalis colli, complexus, splenius and trapezius muscles.

The FOURTH CERVICAL NERVE makes its exit through the third intervertebral foramen between the third and fourth cervical vertebræ, and divides as follows.

The *anterior branch* sends twigs to the rectus major, longus colli, scaleni and levator scapulæ muscles, and a loop to the third and fifth cervical nerves. It sends large branches (nervi supra-claviculares) downwards and outwards across the inferior triangle of the neck to the vicinity of the acromion and clavicle, to be distributed upon the integuments over these parts and upon the subclavius and trapezius muscles. It also anastomoses with the superior cervical ganglion of the sympathetic and the descendens noni. It moreover forms the principal part of the *phrenic nerve*, in the manner to be presently described.

The *posterior branch*, which is small in comparison, anastomoses with the third and fifth cervical nerves and is distributed upon the complexus, multifidus spinæ and splenius muscles, and is then lost upon the integuments.

THE CERVICAL PLEXUS.

The cervical plexus is formed by the communicating loops of the anterior branches of the four superior cervical nerves above described. It lies upon the scalenus medius and levator scapulæ muscles, and is covered by the sterno-mastoid muscle and the internal jugular vein, opposite the first four cervical

vertebræ. The branches of this plexus are classed into two sets, one of which is superficial, the other deep-seated; the former being distributed to the cervical fascia and integuments, the latter chiefly to the muscular branches.

SUPERFICIAL BRANCHES.

The superficial branches of the cervical plexus are further divided according to their direction into ascending and descending branches; the former embrace the *superficial cervical*, *great auricular* and *small occipital nerves;* while the descending branches are the *acromial* and the *clavicular nerves.*

The *superficial cervical nerve* is derived from twigs of the second and third cervicals, runs forward over the middle of the sterno-mastoid muscle, perforates the cervical fascia and divides into an ascending and descending branch. The ascending branch passes to the integuments of the chin and lower part of the face, and to the platysma myoides muscle. The descending branch goes to the skin of the neck as low down as the clavicle.

The *great auricular nerve*, auricularis magnus, winds round the outer margin of the sterno-mastoid muscle, and ascends upon that muscle and beneath the platysma myoides to the lobe of the ear. It sends an anterior branch to the parotid gland and filaments to the external ear. The posterior branch, called the *mastoid branch*, goes to the integument behind the ear, and anastomoses with the fascial nerve.

The *small occipital nerve*, occipitalis minor, comes from the second cervical, and runs directly upwards to the head, along the posterior margin of the sterno-mastoid muscle. It is chiefly distributed to the posterior belly of the occipito-frontalis muscle, and to the small muscles of the external ear.

The descending branches, though usually designated as the acromial and clavicular nerves, are variable in number, and arise from the third and fourth cervical nerves, and descend in the space between the sterno-mastoid and trapezius muscles.

The *acromial nerve* is the posterior branch; it runs over the acromion process and across the proximate portion of the trapezius muscle, and is distributed upon the skin of the upper and back part of the shoulder.

Th *clavicular nerves* ramify in the integuments between the inner half of the clavicle and the sternum. Other branches, crossing the clavicle, are distributed to the deltoid and pectoralis major muscles.

DEEP-SEATED BRANCHES.

The deep-seated branches of the cervical plexus, are *the connecting* and the *muscular nerves*, and the *phrenic nerve.*

The *connecting* or *communicating branches* are composed of filaments that pass between the loops of the first and second cervical nerves, and the pneumogastric, hypoglossal and sympathetic nerves. This connection takes place near the base of the cranium, and in front of the atlas vertebra.

The *muscular branches* proceed from the third and fourth cervical nerves close to the spine, and are chiefly distributed to the trapezius, levator scapulæ and rhomboidei muscles. Two separate twigs join the descendens noni, and form a small plexus from which the muscles below the os hyoides are supplied.

The phrenic nerve.—The *phrenic* or diaphragmatic nerve is one of the most interesting branches of the cervical plexus. It arises from the anterior fasciculi of the third and fourth cervical nerves, and receives accessory fibres from the fifth and sixth, and even from the second and seventh nerves. It is connected with the superior cervical ganglion of the sympathetic, and sometimes with the hypoglossal and pneumogastric nerves.* It descends downwards and inwards in front of the scalenus anticus muscle to the thorax, which it enters between the subclavian artery and vein, and traverses the anterior mediastinum to reach the pericardium. In this place it lies in the middle mediastinum and adheres to the pericardium in front of the root of the lung, being between that membrane and the corresponding part of the pleura. From this point it takes its course to the diaphragm, the left nerve passing round the apex of the heart, and being consequently longer than the right. It gives off no branches except some filaments to the pericardium, until it approaches the diaphragm, where it divides into two or more branches: these anastomose, penetrate the diaphragm, and then diverge from each other to be distributed upon the abdominal surface of that muscle. Other branches are spent upon the internal structure of the diaphragm and upon its thoracic surface; while some filaments, passing into the abdomen with the vena cava, join the solar plexus and the pneumogastric nerve.

The phrenic nerve is called the *internal respiratory nerve* by Sir Charles Bell.

THE FIFTH, SIXTH, SEVENTH AND EIGHTH CERVICAL NERVES.

The *anterior divisions* of these nerves are seen on the side of the neck between the scalenus anticus and medius muscles. They constitute large trunks, each of which has a connecting filament with the sympathetic, and they all combine, together with the first dorsal nerve, to form the brachial plexus, next to be described.

The *posterior branches* are small: they pass to the back of the neck between the transversalis colli and complexus muscles, to which they give filaments, and are ultimately distributed on the trapezius and splenius capitis, and upon the overlying integuments of the neck.

THE BRACHIAL OR AXILLARY PLEXUS.

This great plexus, formed as already stated, by the combined anterior trunks of the four inferior cervical and first dorsal nerves, extends in an oblique direc-

* Von Behr. Handbook of Anatomy, § 654.

tion from the lower and lateral region of the neck to the head of the humerus, or, in other words, from the scaleni muscles to the axilla, where it gives off branches to the upper extremity. In this course the nerves converge from their origin; but as they approach and after they enter the axilla they become interlaced and expanded in a remarkable manner, and completely surround the axillary artery from the clavicle to the head of the humerus. The brachial communicates with the cervical plexus through the medium of a filament that descends from the fourth to the fifth nerve; it is also connected with the sympathetic nerve, and with the inferior originating branch of the phrenic nerve. The nerves given off from the brachial plexus are the following; premising, however, that before the plexus is formed, its component nerves send off branches to the muscles of the shoulder and lateral parietes of the chest, and a filament, already alluded to, that runs from the fifth cervical trunk to join the phrenic nerve on the anterior scalenus muscle.

1. The *short thoracic nerves* are divided into two sets, one anterior, the other posterior, which arise from the middle of the plexus on a level with the clavicle. The *anterior branches* run forwards between the subclavian muscle and vein, give some filaments to the deltoid muscle and are then distributed upon the pectoralis major. The *posterior branch* runs forward beneath the axillary artery, and unites with the communicating branch from the anterior fasciculus to form a loop from which branches are distributed to both pectoral muscles.

2. The *long thoracic nerve*, called also the posterior thoracic, is the *external respiratory* nerve of Bell. It is formed in the scalenus medius muscle by two roots, one from the fourth, the other from the fifth cervical nerves: after emerging from that muscle, it runs behind the brachial plexus and the axillary vessels to reach the serratus magnus muscle, upon which it is extensively and exclusively distributed.

3. The *supra-scapular nerve* arises from the fifth cervical above the clavicle, and curves obliquely outwards beneath the trapezius to the dorsal surface of the scapula, passes through the notch of that bone, and sends a branch to the upper and another to the lower part of the supra-spinatus muscle. It then descends to the infra-spinatus muscle on which it is finally distributed.

4. The *subscapular nerves*, though variable in number and origin, are generally three, and come from the central part of the plexus. One of them runs between the subscapularis and serratus major anticus muscle, and is distributed on the upper end of the latissimus dorsi. A second branch goes to the subscapularis muscle; and the third is spent on the subscapularis, teres major and teres minor muscles.

In addition to the preceding branches, which it will be seen are distributed to the muscles contiguous to the shoulder, the cervical plexus gives off a series called *descending branches*, which pass down upon the upper extremity and are disposed in the following manner.*

* These nerves are variously described in Anatomical works. The order employed by Dr. Erasmus Wilson (Human Anat., Dr. Goddard's edit.) is adopted in this place.

1. The *musculo-cutaneous* or external cutaneous nerve, comes from the cervical plexus in common with the outer branch of the median, penetrates the coraco-brachialis muscle, and runs between the biceps and brachialis anticus muscles to the outside of the elbow, where it lies directly beneath the skin and divides into two branches. In this course, and before it reaches the bend of the arm, it sends branches to the coraco-brachialis and short head of the biceps; and still lower down it sends filaments to the biceps and brachialis anticus, and to the parts contiguous to the elbow-joint. The preceding are called the *muscular branches* of this nerve; the *cutaneous branches* are as follow.

Opposite the outside of the elbow-joint the musculo-cutaneous nerve passes behind the median cephalic vein, and is expended on the forearm in two principal branches, one of which is anterior, the other posterior. The *anterior branch* descends along the radial side of the forearm; near the wrist it lies in front of the radial artery, distributes twigs to the ball of the thumb and then accompanies the artery to the back of the wrist, where it anastomoses with the radial nerve and is lost in the integuments. The *posterior branch* runs in the outward direction, gets on the back of the forearm, and is distributed upon the integuments as far as the wrist, where it anastomoses with a branch of the radial nerve.

2. The *internal cutaneous nerve* is one of the smaller branches of the cervical plexus. It arises in common with the ulnar nerve on the inner side of the axillary artery, and becomes cutaneous about the middle of the arm. It runs along the inner side of the arm in company with the basilic vein, giving off cutaneous branches in its course, and then penetrates the fascia to divide into two principal branches. One of these, the *external branch*, crosses before the median basilic vein at the elbow-joint, and passing downwards in front of the forearm and towards its inner margin, terminates at the wrist. The *internal branch* runs down the forearm at the inner side of the basilic vein, and getting on the back of the limb, terminates about half way to the wrist.

3. The *small internal cutaneous nerve* is called also the *nerve of Wrisberg*, and is the smallest of the branches of the brachial plexus. It arises in common with the internal cutaneous and ulnar nerves, and forms a long slender cord which, in the axilla, is at first concealed by the axillary vein; it then winds to the inner side of that vessel, and anastomoses with the intercosto-humeral nerve. It next passes on the inner side of the brachial vessels to the middle of the arm, penetrates the fascia, and becomes subcutaneous as far as the fossa between the olecranon and the internal condyle of the humerus, where it divides into small twigs to be distributed over the posterior part of the integuments of the joint. In the axillary region it communicates, though in a variable manner, with the external branch of the first intercosto-humeral nerve.

4. The MEDIAN NERVE commences by two heads between which is the axillary artery: these soon unite in front of the artery, and then accompanies it nearly to the elbow-joint, at which point the nerve gets to the inner side of that vessel. In all this course it sends off but a few inconstant filaments; but immediately below the joint it crosses the brachialis anticus muscle, perforates the pronator

teres, and then runs between the flexor sublimis digitorum and the flexor longus pollicis and under the anterior annular ligament, to the palm of the hand. The median nerve supplies nearly all the muscles of the forearm, flexors and pronators, and sends off a branch called the *anterior interosseous nerve*, which is given off just below the elbow-joint, and runs down the forearm in front of the interosseous ligament to terminate in the pronator quadratus muscle. It gives filaments to the several deep-seated muscles in its course. Small terminal branches are distributed to the integuments of the palm of the hand and to the ball of the thumb, and digital branches to the fingers: these last lie on the inner side of the digital arteries, extend to the ends of the fingers, and in their course send twigs to the dorsal surfaces of the fingers.

5. The *ulnar nerve* is given off from the most inferior part of the brachial plexus, or, more strictly speaking, from the eighth cervical and the first dorsal nerve, runs along the internal face of the triceps muscle and reaches the inner condyle of the humerus, between which and the olecranon it passes downwards to the forearm. While in this groove it gives some filaments to the contiguous side of the joint, and then takes its course between the heads of the flexor profundus digitorum and the flexor carpi ulnaris: it is subsequently continued upon the belly of the former, and on the inner side of the ulnar artery until it reaches the wrist, whence it passes over the annular ligament to the hand. Above the elbow this nerve gives some twigs to the triceps and to the proximate integuments, and is so superficial in a part of its course as to be felt beneath the skin a little above the elbow. In the forearm it gives the following branches: some *muscular filaments* to the flexor carpi ulnaris and flexor digitorum profundus, and others called *cutaneous branches* are distributed to the skin and communicate with the internal cutaneous nerve. The *dorsal nerve* comes from the ulnar about two inches above the wrist, and taking a spiral course to the inner side of the arm beneath the flexor carpi ulnaris, divides into two branches which are spent on the ulnar side of the integuments on the back of the hand, and on the ulnar side of the little finger. On the back of the hand a branch of this nerve joins a twig of the radial nerve, and from the cord thus formed, filaments are sent to the proximate sides of the ring and middle fingers. These digital nerves, moreover, anastomose with recurrent filaments from the anterior digital branches of the median nerve.

6. The MUSCULO-SPIRAL NERVE is the largest trunk given off from the brachial plexus. It arises from the upper and posterior part of the plexus, and winds round the arm between the first and third heads of the triceps so as to get on the outside of the humerus, where it appears between the brachialis internus and triceps muscles. In this position it sends branches to the three heads of the triceps and the contiguous integuments; after which it runs to the bend of the elbow, and there divides into the posterior interosseous and radial nerves. In this course the musculo-spiral nerve gives off the following branches beside those just mentioned.

The *internal cutaneous nerve* winds to the back of the arm beneath the intercosto-humeral nerve, supplies the integuments and ends near the olecranon.

Other branches are distributed to the heads of the supinator longus and extensor carpi radialis longior, and to the brachialis anticus; and filaments are also sent along the posterior face of the arm and forearm as far as the wrist, where they anastomose with a branch of the median nerve.

The terminal trunks of the musculo-spiral nerve, the radial and posterior interosseous, are given off at the bend of the elbow and distributed as follows.

The *radial nerve* runs along the radial border of the forearm, gets under the tendon of the supinator radii longus, and near the wrist becomes subcutaneous. At this point, (two or three inches above the carpus,) it divides into two branches, one of which, the *external*, is distributed to the radial side of the hand and thumb, and anastomoses with a branch of the musculo-cutaneous nerve. The *internal* branch of the radial nerve goes to the ulnar side of the thumb, the contiguous border of the index finger, and the adjoining borders of the index and middle fingers. These constitute the *dorsal digital nerves*.

The *posterior interosseous nerve*, separating from the radial at the elbow, perforates the supinator brevis muscle to reach the back of the forearm, on the muscles of which it is distributed; viz., to the extensor carpi radialis brevior, the supinator brevis and the whole series of superficial and deep-seated extensors excepting the anconeus. This nerve subsequently reaches the back of the carpus where it forms a gangliform enlargement and sends filaments to the contiguous articulation.

7. The *circumflex* or *axillary nerve* comes from the brachial plexus at its posterior part, by a common trunk with the musculo-spiral nerve. It lies at its origin behind the axillary artery, but it soon turns backwards and divides into two branches. One of these runs up to the deltoid muscle and is distributed to it and to a part of the overlying integument. Another branch takes the opposite direction and supplies the teres minor, teres major and the back of the deltoid, together with the integuments over the lower part of the latter muscle.

THE DORSAL NERVES.

The dorsal nerves are twelve in number on each side. The first of these nerves makes its exit through the intervertebral foramen between the first and second dorsal vertebræ, and the last pair comes out between the last dorsal and first lumbar vertebræ. These nerves, as we have heretofore explained, and in common with all the spinal nerves, are formed by an anterior and posterior fasciculus from the spinal cord: these first coalesce, but immediately afterwards divide again so as to form an anterior and a posterior branch.

The ANTERIOR BRANCHES are also called *intercostal nerves* because they run in the intercostal spaces. They are distributed to the parietes of the thorax and abdomen, and are connected to the sympathetic nerve by filaments that lie in the intercostal spaces near the vertebræ. Each of these nerves runs for-

wards to the groove in the inner and lower margin of the corresponding rib, and accompanies the intercostal vessels for some distance. It then leaves the rib and enters between the two layers of intercostal muscles as far as the costal cartilages, where it becomes superficial and is lost upon the pectoral muscle and the contiguous integuments. Such is the termination of the upper half of the intercostal series of nerves; but the lower five or six have their final distribution on the superior parts of the abdominal muscles and their integuments. Beside these branches, others are given off from the trunk of the nerve in its course through the muscles, to the adjacent parts, to the mammary gland and the integuments.

The *intercosto-humeral nerves* are two in number, named from their position, first and second.

The *first intercosto-humeral nerve* comes from a cutaneous branch of the second intercostal nerve about midway of its course. It at once perforates the external intercostal muscle and divides into two branches. One of these runs internally, and is lost on the skin of the inner side of the arm. The other branch is external, makes its way to the axilla and there anastomoses with a filament from the nerve of Wrisberg. It subsequently becomes subcutaneous, and supplies the skin on the inner face of the arm almost to the elbow.

The *second intercosto-humeral nerve* is much the smaller of the two. It is a branch of the third intercostal nerve and comes out of the third intercostal space between the digitations of the serratus magnus muscle to be distributed upon the integuments of the shoulder.

The remaining intercostal nerves have a nearly similar distribution; but the last five of the series send each a filament to the diaphragm, and, as already observed, to the upper portions of the abdominal muscles. The last dorsal nerve does not run in contact with the proximate rib, but within the abdominal muscles. It passes between the internal oblique and transversalis, first crossing the quadratus lumborum and piercing the lumbar fascia. It inosculates with the eleventh intercostal nerve.

The *dorsal branches* of the dorsal nerves pass directly backwards between the transverse processes of the vertebræ, and divide into an anterior or muscular and a posterior or musculo-cutaneous branch. "The *muscular branch* enters the substance of the muscles in the direction of a line corresponding with the interval of separation between the longissimus dorsi and sacro-lumbalis, and is distributed to the muscles of the back, its terminal fibres reaching to the integument. The *musculo-cutaneous branch* passes inwards, crossing the semi-spinalis dorsi, to the spinous processes of the dorsal vertebræ, giving off muscular branches in its course. It then pierces the aponeurosis of origin of the trapezius and latissimus dorsi, and divides into branches which are inclined outwards beneath the integument to which they are distributed."*

* Wilson. Human Anatomy. Dr. Goddard's edit., p. 447.

THE LUMBAR NERVES.

The lumbar nerves are five in number on each side. The first one of the set emerges from between the first and second lumbar vertebræ; the last from between the fifth lumbar vertebra and the sacrum. They all communicate, near their origin, with the lumbar ganglia of the sympathetic, emerge behind the psoas magnus and divide into two branches, an anterior and a posterior. The anterior branch also divides into two other branches, one of which ascends to anastomose with the nerve above, and the other runs downward to join the nerve below: this intertexture constitutes the *lumbar plexus* now to be described. It is necessary, however, to premise that the lumbar and sciatic plexuses are by some anatomists included in the collective designation of the *crural plexus*. The posterior branches of the lumbar nerves will be noticed hereafter.

THE LUMBAR PLEXUS.

This plexus is formed by connecting trunks from the *anterior branches* of the four upper lumbar nerves and of the last dorsal nerve. It lies behind and in the substance of the psoas magnus muscle, and between that muscle, the quadratus lumborum and the transverse processes of the lumbar vertebræ. It is narrow above and broad below, and gives off the following nervous trunks.

THE MUSCULO-CUTANEOUS NERVES.

1. The SUPERIOR MUSCULO-CUTANEOUS NERVE is also called the *ilio-hypogastric* and *ilio-scrotal*, from the parts to which it is supplied. It comes from the first lumbar nerve, runs across the quadratus lumborum muscle to the crista of the ilium, and perforates the transversalis abdominis to get between that muscle and the internal oblique, where it divides into two branches, abdominal and scrotal.

The *abdominal* or *hypogastric branch* pursues its course to the rectus muscle to which it sends filaments, and then perforating the two oblique muscles becomes subcutaneous. It is finally distributed upon the skin over the mons veneris and groin.

The *scrotal branch* runs forwards to the external abdominal ring, first communicating, opposite the anterior superior spinous process of the ilium, with the ilio-inguinal nerve; it then pierces the cremaster muscle and accompanies the spermatic cord in the male and the round ligament in the female, to be distributed to the skin of the scrotum and labia externa.*

* Wilson. Loco citat.

2. The INFERIOR MUSCULO-CUTANEOUS,* or *ilio-inguinal* nerve, arises, like the former, from the first lumbar nerve, and runs outwards over the quadratus lumborum and iliacus muscles to perforate the transversalis abdominis and then anastomoses with the ilio-hypogastric nerve. It furnishes some filaments to the internal oblique muscles, but is chiefly distributed to the skin of the scrotum and pudenda.

THE GENITO-CRURAL NERVE.

This nerve is derived from the second lumbar trunk. It first perforates the psoas magnus muscle in the downward direction, and then reaches the anterior face of that muscle near Poupart's ligament, where it divides into two branches.

The *genital* or *internal branch*, called also the external spermatic, crosses the external iliac artery to which it sends filaments, and then perforates the fascia transversalis to reach the inguinal canal at the internal ring. It descends through the canal along with the spermatic cord, anastomoses with the inferior pudendal nerve, and is distributed upon the cremaster muscle. In the female it takes the same course to the external abdominal ring, but is afterwards spent upon the labia pudendi. A filament is given off from the genital nerve at the internal ring that is lost upon the integuments of the groin.

The *crural* or *external branch* passes downwards upon the psoas muscle and at the outside of the external iliac artery to Poupart's ligament, under which it gets to the thigh beneath the fascia lata. It then penetrates the fascia, gets beneath the skin and is distributed to the integuments of the upper half of the thigh.

THE EXTERNAL CUTANEOUS NERVE.

The *external cutaneous*, or *inguino-cutaneous nerve*, is an offset from the second and third lumbar trunk. It perforates the psoas muscle, runs across the iliacus internus and reaches the thigh by passing under Poupart's ligament. It then emerges through the fascia lata opposite the notch below the anterior superior spinous process of the ilium, and having thus become subcutaneous on the thigh, divides into an anterior and a posterior branch.

The *anterior branch* runs for some distance within the substance of the fascia lata, but becomes subcutaneous some three or four inches below Poupart's ligament, from which point it is distributed to the outside of the skin of the thigh as far as the knee, and sends filaments to the knee-joint.

The *posterior branch* runs across the tensor vaginæ femoris muscle, and gets on the outer side of the thigh, where it divides into several branches which are distributed to the integuments from the ilium half way to the knee. One of its superior branches inosculates with the anterior branch of the external cutaneous nerve.

* Called also the *middle musculo-cutaneous*, by Bichat.

THE CRURAL NERVE.

The crural nerve is derived from the second third and fourth lumbar nerves, and is the largest branch of the lumbar plexus. It lies at first in the substance of the psoas muscle, from which it escapes at its outer and lower margin, and makes its appearance on the thigh beneath Poupart's ligament, where it lies on the outside of the femoral artery. While yet within the pelvis, this nerve gives branches to the iliacus internus and psoas muscles, and on emerging from the crural arch divides into several large branches.

1. The *middle cutaneous nerve* is given off from the crural within the abdomen, descends beneath Poupart's ligament and divides about two inches below that ligament into two branches, to be distributed to the integuments of the thigh on its anterior and inner surface as far as the knee.

2. The *internal cutaneous*, or *short saphenous nerve*, arises from the crural trunk above Poupart's ligament, and passing under the arch and on the front of the thigh, separates into several branches for the muscles and integuments on the inner and outer sides of the limb. One of its branches runs on the outside of the knee and anastomoses with a twig from the saphenous nerve; another branch takes its course on the inside of the knee and is lost upon the contiguous integuments.

3. The *arterial branch* is a small nerve that penetrates the sheath of the femoral vessels: it divides into several twigs that surround the artery for some distance, and are also extended in like manner to the profunda femoris.

4. The *long saphenous nerve*, *saphenus internus*, is a large branch given off from the crural. It runs inwards to the sheath of the femoral vessels which it penetrates, and then accompanies those vessels to the opening in the adductor magnus muscle. From this point it takes a separate course, passes beneath the sartorius and gets on the inside of the knee, whence it descends in a nearly vertical direction in company with the internal saphenous vein. Having reached the foot it passes in front of the inner ankle, and is distributed upon the skin of the inside of the foot as far as the great toe. In this long course the saphenous gives off many small branches to the integuments and muscles, none of which deserve special notice.

THE OBTURATOR NERVE.

The obturator nerve arises from the lumbar plexus by two cords, one from the third, another from the fourth lumbar nerve. It takes a course obliquely downwards in the substance of the psoas muscle, from which it escapes at the brim of the pelvis, and makes its way out of the pelvic cavity with the thyroid vessels at the upper margin of the thyroid foramen. It then divides into two principal branches, one anterior the other posterior.

The *anterior branch* is distributed to the head of the adductor longus and adductor brevis muscles, and to the gracilis: it then curves downwards on the

inner and middle region of the thigh, giving off inconstant cutaneous and muscular branches, and some filaments that surround the femoral artery.

The *posterior branch* gives twigs to the obturator externus muscle, the adductor brevis and the posterior part of the knee-joint.

THE SACRAL NERVES.

The sacral nerves are six in number, and come from the pelvis through the sacral foramina. The *posterior branches* are very small, and directly distributed to the gluteus maximus muscle and to the integuments on the back of the sacrum.

The *anterior branches* are much larger than the posterior, but diminish in size as they descend. The first anastomoses with the lumbo-sacral nerve; the sixth or coccygeal is the least of them all, and goes out of the pelvis at the end of the spinal canal in company with the fifth sacral nerve. They all anastomose with the sympathetic ganglia. A combination of the sacral nerves forms the

SACRAL OR SCIATIC PLEXUS.*

The sacral plexus is arranged in the following manner. Its upper cord is derived from the *lumbo-sacral nerve*, which is itself constituted of a junction of the anterior branch of the fifth and another from the fourth lumbar nerves. This is joined by roots from the first, second, third and fourth sacral nerves; and the large, triangular and flattened plexus thus formed lies along the sacrum its whole length, its angular and inferior extremity pointing to the great sciatic notch. It is placed before the pyriformis muscle, at the side of the rectum and behind the pelvic fascia, by which it is separated from the viscera of the pelvis. The sacral plexus gives off the following nerves.

Muscular branches of small size are distributed within the pelvis to the levator ani and obturator muscles and to the contiguous parts. On the exterior of the pelvis other filaments are sent to the pyramidalis, gemelli and the quadratus femoris muscles.

The *gluteal nerve*, a branch of the lumbo-sacral, emerges from the pelvis through the upper part of the sciatic notch in company with the gluteal artery, and divides into two branches. One of these runs upwards over the ilium, and is distributed to the gluteus medius and gluteus minimus muscles. Another or inferior branch takes a downward course, and besides sending filaments to the two muscles just named, furnishes others to the gluteus magnus, pyriformis and tensor vaginæ femoris.

* Plexus ischiadicus.

THE PUDIC NERVE.

The pudic or pudendal nerve is the first considerable branch given off from the sacral plexus. It comes from the lower part of the plexus, accompanies the internal pudic artery in its course out of the pelvis between the sacro-sciatic ligaments, and then divides into a superior and an inferior branch.

The *superior branch*, called from its destination *dorsalis penis*, attends the pudic artery, penetrates the suspensory ligament of the penis, and having reached the back of that organ, runs forward to terminate at the glans, distributing filaments to the corpora cavernosa and integuments. In the female this nerve is much smaller and is spent upon the clitoris.

The *inferior branch* or *perineal nerve*, runs to the perineum in company with the internal pudic artery, and is distributed to the scrotum and the integuments on the under surface of the penis. Some other filaments are spent upon the muscles of the perineum—the sphincter ani, transversus perinæi and accelerator urinæ muscles.

THE SMALL SCIATIC NERVE.

This nerve, the *ischiadicus minor*, is given off from the lower part of the sacral plexus and escapes from the pelvis at the great sciatic notch, and below the pyriformis muscle. It then divides into muscular and cutaneous branches; the former are called, from their destination, *inferior gluteal nerves*, and are spent upon the gluteus maximus muscle at its lower part.

The *cutaneous branches* are distributed as follows.

The *perineal cutaneous nerve*—pudendalis longus inferior—curves round the tuberosity of the ischium and ascends to the scrotum, to which and to the inferior integument of the penis it is finally distributed.

The *posterior cutaneous branch* crosses the tuberosity of the ischium, and having reached the lower margin of the gluteus maximus muscle, runs down the posterior face of the thigh and leg to the middle of the calf. In this course it distributes cutaneous branches to the posterior and lateral surfaces of the thigh.

THE GREAT SCIATIC NERVE.

The great sciatic nerve, *nervus ischiadicus*, is the largest of the body. It is derived from the lower or apicial end of the sacral plexus, and issues from the pelvis through the great sciatic notch and beneath the pyriformis muscle. It runs downwards over the small rotator muscles of the thigh, and beneath the lower edge of the gluteus magnus muscle. It is there lodged in the space between the trochanter major and tuberosity of the ischium, whence it descends on the posterior border of the thigh about half way to the knee, at which point

it divides into two branches, the *popliteal* and *peroneal*. In this course the sciatic nerve gives off branches to the hip-joint and to the muscles of the thigh —the adductor magnus, semi-membranosus, semi-tendinosus and biceps.

THE POPLITEAL NERVE.

The popliteal nerve traverses the popliteal region, for the most part close to the popliteal artery and exterior to it until it reaches the angle between the heads of the gastrocnemius muscle, where, at the lower margin of the popliteus muscle, it becomes the posterior tibial nerve. In this course the popliteal nerve gives off the following branches.

Muscular branches are distributed to the gastrocnemius, popliteus, soleus and plantaris; and *articular branches*, generally three in number, penetrate the ligament of the joint behind and are distributed to the internal parts of this articulation.

The *external saphenous nerve*—communicans tibialis—follows the course of the short saphenous vein. It descends on the leg beneath the fascia and upon the gastrocnemius muscle, until it reaches a point about equidistant between the knee and foot. It then emerges through the fascia, receives a branch (communicans peronei) from the external popliteal nerve, and runs along the outer margin of the tendo-achillis to the foot. It is distributed to the outside of the foot and little toe, and anastomoses, on the dorsum of the foot, with the musculo-cutaneous nerve.*

THE POSTERIOR TIBIAL NERVE.

The posterior tibial is the continued trunk of the popliteal nerve. It extends from the lower margin of the popliteus muscle to the foot, to which it passes between the inner ankle and the heel, where it divides into the *internal and external plantar nerves*. In this course the posterior tibial gives off branches to the following muscles: the tibialis posticus, flexor longus digitorum, and flexor longus pollicis. It also distributes cutaneous branches to the heel and sole of the foot.

The *internal plantar nerve* crosses the posterior tibial vessels, and lies in the sole of the foot between the abductor pollicis and flexor brevis digitorum muscles, and separates at the posterior margin of the metatarsus into four *digital branches*. The first of these digital nerves goes to the inner side of the great toe; the fourth is distributed to the proximate sides of the third and fourth toes. The intermediate branches run to the corresponding toes. The fifth or little toe has no digital nerve from this source. The digital nerves send filaments to the contiguous joints and integuments.

The *external plantar nerve* accompanies the external plantar artery to the outside of the foot, between the flexor brevis digitorum and flexor accessorius.

* Quain and Sharpey. Anatomy, 5th edition.

It sends filaments to these muscles, to the adductor pollicis, and to the integuments of the sole and outside of the foot. It then divides into digital branches, two of which are distributed to the little toe and one to the outer margin of the fourth toe.

THE PERONEAL NERVE.

The *peroneal* or *external popliteal nerve*, comes from the great sciatic about half way down the thigh, and descends parallel to the tendon of the biceps muscle to the head of the fibula, where it separates into two branches, the *anterior tibial* and *musculo-cutaneous.* Before this bifurcation the peroneal nerve gives off filaments to the outside of the capsular ligament of the knee-joint, and several cutaneous branches which are spent upon the back and external surface of the leg. One of these is the *peroneal communicating branch* (communicans peronei) which joins about the middle of the back of the leg with the short saphenous nerve.

The ANTERIOR TIBIAL or interosseous nerve, after its origin between the peroneus longus muscle and the head of the fibula, runs to the front of the interosseous ligament, and joins the anterior tibial vessels, which it accompanies to the foot. Having reached the front of the ankle it separates into an external and internal branch. In this course it gives filaments to the integuments and contiguous muscles—the tibialis anticus, extensor longus digitorum and extensor proprius pollicis.

The *external branch* runs across the foot to its outer margin, beneath the extensor brevis digitorum, and is distributed to that muscle, the integuments and the joints of the foot.

The *internal branch* accompanies the dorsal artery of the foot to the first interosseous space, whence twigs are given off to the integuments on the back of the two inner toes.

The MUSCULO-CUTANEOUS NERVE arises from the peroneal at the head of the fibula, and passes down deeply-seated between the peronei and extensor longus digitorum, to which it gives branches, until it gets two or three inches above the ankle, in front of the leg. Here it perforates the fascia, becomes superficial and divides into an external and an internal branch.

The *external branch* runs obliquely across the foot to its outer margin, giving branches to the corresponding ankle, and is finally distributed to the lateral integuments of the toes.

The *internal branch* crosses the foot to its inner border and sends filaments to the inner side of the great toe, and to the contiguous sides of the second and third toes.

THE SYMPATHETIC.

The *sympathetic*, *intercostal*, or *ganglionic nerve*, embraces a series of ganglia extending from the base of the cranium, on the side of the vertebral column, to the lower end of the sacrum, where the ends of the opposite sides are connected in the *ganglion coccygeum* in front of the os coccygis. It is the connecting medium between all the other nerves of the body, and distributes branches to all the internal organs. It anastomoses with the cranial and spinal nerves directly as they emerge from their respective cavities; excepting, however, the fourth and sixth nerves, which it joins in the cavernous sinus, and the optic, olfactory and auditory nerves, with which it communicates at their ultimate expansions. Its branches accompany the arteries in their distribution to the several organs, and form plexuses around them; these plexuses take the names of the corresponding arteries, whence the names—splenic plexus, hepatic plexus, mesenteric plexus, and several others: and since the sympathetic nerve gives branches, as just observed, to all the internal organs of the head, neck and trunk, and is to some of them the exclusive source of nervous distribution, it is regarded as a *nerve of organic life*.*

We have already mentioned that the sympathetic combines the tubular and gelatinous neurine. This it does in every part of its course, but in very variable proportions. Thus, in the cardiac nerves and the ramifications of the solar plexuses, the tubular neurine preponderates; while on the other hand, the gelatinous form is the almost exclusive component of one of the branches by which the sympathetic communicates with the spinal nerves. In some instances the tubular fibres are on the surface; in others they are enclosed in the axis of the nervous trunk. "It is probable that the same change of place between the fibres occurs in these nerves, as that which we have noticed in the cerebro-spinal nerves; so that those fibres which at one part of the nerve were superficial, would at another be deep-seated, and *vica versâ*."†

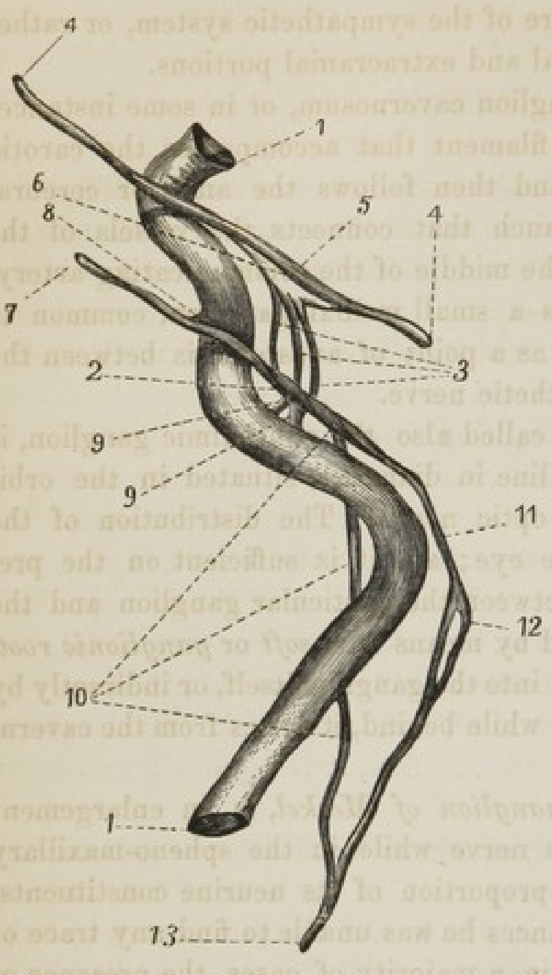
The origin of the sympathetic nerve is variously described by different anatomists. Some consider its inferior or coccygeal extremity to be its commencement; others trace its source to the brain; and again it has been supposed to take its origin from various points of the cerebro-spinal system. The simplest and most intelligible of these methods is, perhaps, that which finds the source of the nerve within the cavity and parietes of the cranium, in the following manner.

The second branch of the fifth pair of nerves, after emerging through the cranium at the foramen rotundum of the sphenoid bone, is connected with the ganglion of Meckel, which gives off a reflected branch, the Vidian nerve, that re-enters the cranium through the pterygoid foramen of that bone: this Vidian

* Wilson. Anatomy, *ut suprà*.

† Todd and Bowman. Physiology, p. 222.

Fig. 336.



Origin of the sympathetic nerve, and its connection with the carotid artery. After Lobstein.

nerve immediately detaches a filament, the deep petrosal nerve, that takes its course to the carotid canal of the petrous bone. The motor externus or sixth nerve, on its way to the cavernous sinus, also gives off one, two or even three filaments, that pass into the carotid canal, and there meet and unite with that from the Vidian nerve. The nervous cord thus formed soon divides in the manner of an open net-work, that surrounds the carotid artery and is hence named the *carotid plexus*.

Fig. 336. 1, 1, the carotid artery; 2, ganglion of Laumonier; 3, three branches proceeding upwards from the ganglion to the sixth pair of nerves; 4, the sixth nerve divided into two fasciculi; 5, superior fasciculus; 6, inferior fasciculus, separated from the superior one by a sulcus: the three branches of the ganglion unite with the inferior fasciculus; 7, deep petrosal branch of the Vidian nerve, running to join the ganglion; 8, twig from the latter branch, going to the tunics of the artery; 9, 9, two filaments sent from the ganglion to the artery; 10, a branch proceeding behind the artery and from the ganglion to join the trunk of the intercostal nerve; 11, a principal branch descending from the ganglion, on the upper surface of the artery, partially divided at 12 by a fissure; 13, trunk of the sympathetic nerve.*

THE CRANIAL GANGLIA OF THE SYMPATHETIC NERVE.

The cranial ganglia of the sympathetic are six in number; the ganglion of Laumonier, the ganglion of Ribes, the lenticular, the spheno-palatine, the otic and the submaxillary ganglia. They are all more or less connected with the sympathetic; and in regarding them as parts of that system, I have followed the arrangement of Bichat, Dr. Erasmus Wilson and several other eminent anatomists.

1. *Ganglion of Laumonier.*—The petrosal nerve, before it joins the carotid plexus, dilates into a small but generally distinct ganglion, which is usually seen on the under surface of the artery within the carotid canal, but sometimes on the cavernous sinus. Fig. 336, 2. It was discovered by Laumonier, whence its name, but it is also called the *ganglion caroticum* or ganglion cavernosum.

* Treatise on the Sympathetic Nerve. Translated by Dr. Pancoast. Pl. VI.

This ganglion, which is flattened and elongated, and the plexus with which it is connected, may be regarded as the centre of the sympathetic system, or rather as the connecting link between its cranial and extracranial portions.

2. *The ganglion of Ribes.*—The ganglion cavernosum, or in some instances the cavernous plexus itself, sends off a filament that accompanies the carotid artery as it passes the sella turcica, and then follows the anterior cerebral artery as far as the communicating branch that connects the vessels of the opposite sides of the brain. Here, on the middle of the communicating artery, the ganglion of Ribes is formed. It is a small medial ganglion, common to the nerves of the two sides, and serves as a point of anastomosis between the superior extremities of the great sympathetic nerve.

3. The *lenticular* or *ciliary ganglion*, called also the ophthalmic ganglion, is a small, grayish flattened body, about a line in diameter, situated in the orbit of the eye on the outer side of the optic nerve. The distribution of the ciliary nerves will be described with the eye; and it is sufficient on the present occasion to notice the connection between the lenticular ganglion and the sympathetic system. This is established by means of a *soft* or *ganglionic root*, which terminates in front either directly into the ganglion itself, or indirectly by means of the nasal root of the ganglion; while behind, it arises from the cavernous plexus.

4. The *spheno-palatine ganglion* or *ganglion of Meckel*, is an enlargement of the second branch of the trigeminus nerve while in the spheno-maxillary fossa. It is variable in size and in the proportion of its neurine constituents, and Cruveilhier states that in some instances he was unable to find any trace of the gelatinous element; but he admits, in a majority of cases, the presence of the gray neurine, so arranged that the nerves may be traced quite through the enlargement. The connection of this ganglion with the sympathetic nerve has been already explained; viz: by means of the petrosal branch of the Vidian nerve, and its anastomosis with the filament from the motor oculi in the carotid canal.

5. The *otic ganglion*, or *ganglion of Arnold*, hereafter to be described, lies on the inner side of the third branch of the fifth pair of nerves directly below the foramen ovale. Its connection with the sympathetic system is derived from a filament that joins the Vidian nerve.

6. The *submaxillary ganglion* lies in contact with the gland of that name, in close relation with the lingual nerve, with which, however, it is only connected by a few filaments. It gives off one or two twigs to the facial artery, and these again communicate with the nervi molles from the cervical portion of the sympathetic.

SPINAL SYMPATHETIC GANGLIA.

Of these ganglia there are three in the neck, twelve in the thoracic region, four in the lumbar region and four or five in the sacral region; in all twenty-

three or twenty-four pairs. The origin of this remarkable chain of ganglia, though subject to some variations of position, may be described in the following terms.

From the ganglion of Laumonier two branches are given off, which descend upon the carotid artery and pass out of the carotid canal. One of these branches runs behind the artery, the other upon its upper surface; and just before they emerge from the canal, they coalesce into a single cord which is the sympathetic nerve. When opposite the transverse process of the second cervical vertebra and behind the carotid artery, it dilates into a ganglion, and this, the first of the spinal series, is called the *superior cervical.*

CERVICAL GANGLIA AND THEIR BRANCHES.

1. THE SUPERIOR CERVICAL GANGLION, situated, as we have observed, in front of the transverse process of the second vertebra of the neck, lies on the superior external margin of the rectus capitis major muscle, with the glosso-pharyngeal nerve in front, and the internal jugular vein and par vagum on its outside. It is partly behind and partly before the carotid artery; and is about an inch in length, tapering at each end, and somewhat flattened throughout.

From the body of the ganglion several filaments are sent off, three or four of which pass in front of the rectus capitis anticus major, and anastomose with the anterior fasciculi of the four upper cervical nerves. These branches leave it at its *external margin.* Other twigs are dispersed to the proximate muscles, the larynx, pharynx and thyroid gland. These are the *internal branches.*

Nervi molles.—The *anterior branches* accompany the carotid artery and its ramifications, around which they form plexuses and occasional small ganglia. They are remarkable for their reddish color and soft texture, whence they have been called *nervi molles;* which, after junction with the laryngeal branch of the eighth pair, are divisible, from their distribution, into three sets, superior, middle and inferior; but they are liable to great variations.

The *superior set* of nervi molles run upwards and anastomose with the pneumogastric, hypoglossal and facial nerves near their exit from the cranium. The *middle set*, two or three in number, separate into many filaments which anastomose with the pneumogastric, glosso-pharyngeal and facial nerves to form the carotid plexus. Some of these branches descend on the carotid to its bifurcation, "and accompany it to its origin, continually interlacing with each other. Others surround, after the same manner, the external carotid and subdivide into a plexus for each of its branches; so that very fine filaments may be traced along the superior thyroidal, facial, occipital and temporal arteries."*

The *superficial cardiac nerve*, called also the superior cardiac, comes from the inferior extremity of the ganglion, but sometimes from the contiguous cord of the sympathetic, and is at once enlarged by a root from the laryngeal branch

* Horner. Anatomy and Histology, ii. p. 513.

of the pneumogastric. It runs down on the inner side of the sympathetic nerve and exterior to the carotid artery, and anastomoses with twigs from the descendens noni and pneumogastric nerves. It also supplies the several proximate muscles, the sterno-hyoid and sterno-thyroid, together with the pharynx and esophagus. Having reached the thorax, it enters that cavity behind the subclavian artery, and goes to the aorta with the carotid artery on the left side and the arteria innominata on the right: and it is afterwards imperceptibly lost on the aorta and in the posterior cardiac and pulmonary plexuses, without being traced to the heart itself. This nerve sometimes dilates into two small ganglia; the *superior cardiac*, which lies just under the inferior thyroid artery, —and the *inferior cardiac ganglion*, within the thorax and most conspicuous on the right side.

2. The MIDDLE CERVICAL or THYROID GANGLION lies on the longus colli muscle, being behind the carotid artery, the internal jugular vein and the pneumogastric nerve. It is opposite to the fifth and sixth cervical vertebræ, and about two lines above the inferior thyroid artery. It is of a rounded elliptical form, and smaller than the first ganglion, being about three-fourths of an inch in length. It is sometimes absent, sometimes double; and is apt to vary on the two sides of the body.

Its *external branches* run to the anterior fasciculi of the fourth, fifth and sixth cervical nerves, between the origin of the scaleni muscles; these are the most superficial branches of this ganglion.

The *internal branches* anastomose with filaments from the superficial cardiac, and form a plexus around the inferior thyroid artery as far as the thyroid gland: this is the *thyroid plexus*.

The *middle cardiac nerve* is formed by the union of several of the internal branches of this ganglion. It passes down the neck on the outside of the carotid artery, and at the top of the thorax separates into a number of branches, some of which enter that cavity before and others behind the subclavian artery. It anastomoses with the inferior thyroid plexus, the inferior cervical ganglion and the pneumogastric nerve.

Other branches of the middle cervical ganglion run upwards and communicate with the superior ganglion.

3. The LOWER CERVICAL GANGLION is a flattened, angular or rounded body, lying near the head of the first rib. It is usually about two lines distant from the first thoracic ganglion, and in rare instances is blended with it. Sometimes it is itself double. It is connected with the first thoracic in three different ways; viz., by a continuation of its trunk; by two very small branches forming a loop around the vertebral artery; and by a larger branch, sometimes double, called the *ansa Vieussenii*, which embraces the subclavian artery.* It is also connected by delicate filaments with the second cervical ganglion: these are the *superior branches*. The *anterior branches* first anastomose together, and then unite in a single cord which is the inferior cardiac nerve.

* Lobstein. On the Sympathetic Nerve. Dr. Pancoast's trans., p. 16.

The *inferior cardiac nerve*, cardiacus minor, anastomoses with the laryngeal and middle cardiac nerves, and passes down in front of the bifurcation of the trachea to join the *great cardiac plexus*. In this course it follows, on the right side, the arteria innominata; on the left, it is not so distinct, but is blended with the middle cardiac nerve and forms its inferior root. It is sometimes deficient on the right side.

The *cardiac ganglion* lies below the arch of the aorta, between that vessel and the pulmonary artery. It is joined by the superior cardiac nerves, and by the right and left cardiac branches given off by the pneumogastric nerve in the lower part of the neck. It gives off various branches to the great cardiac plexus.

THE GREAT CARDIAC PLEXUS.

This plexus lies upon the bifurcation of the trachea, behind the arch of the aorta, and extends between the origin of the arteria innominata and the bifurcation of the pulmonary artery. It is formed chiefly by branches from the three cervical ganglia, and more particularly by the middle and inferior cardiac nerves: it is also aided by branches from the pneumogastric and descendens noni nerves, and from the first thoracic ganglion. All these nerves, from both sides of the neck, coalesce to form this single plexus, which supplies all the nerves of the heart, and distributes its branches in the following manner.

The *anterior* or *superficial plexus* is a small, reticulated offset of the great plexus, placed in front of and upon the ascending aorta near its origin. It is formed by branches from the superior cardiac nerves, and by the cardiac ganglion; and Cruveilhier adds, the ganglion of Wrisberg and its several branches. This plexus sends filaments to the right side of the heart and largely assists in forming the anterior coronary plexus; the latter surrounds the right coronary artery, and is distributed to the right auricle and ventricle, and along the course of the right coronary artery and its branches.

The middle layer of cardiac nerves is composed of two parts: one of these is situated between the trachea and arch of the aorta, above the right pulmonary artery; and the other and smaller part is made up of filaments directly from the great cardiac plexus, and lies between the right pulmonary artery and arch of the aorta. These nerves unite to form the *posterior coronary plexus*, which accompanies the pulmonary artery to the base of the heart and is distributed to the left auricle and ventricle, in the course of the left coronary artery and its branches.

THORACIC GANGLIA OF THE SYMPATHETIC NERVE.

The thoracic ganglia are twelve in number on each side, of a flattened form and irregular outline, and presenting considerable variation in size; the first two and the twelfth being larger than those that are intermediate. Each one is placed on the head of the corresponding rib, covered by the pleura costalis, and they are all connected by the common trunk of the sympathetic nerve.

This connecting nerve, however, is not invariably a single cord, but is sometimes composed of several filaments; and in other instances the number of ganglia is reduced, owing to the merging of two into one. It more commonly happens, however, that this anomaly consists in the combination of the last cervical ganglion with the first thoracic, and of the last thoracic with the first lumbar. In the course of the sympathetic nerve behind the pleura, the intercostal arteries and veins pass behind it; and on the right side it is accompanied by the vena azygos.

The thoracic portion of the sympathetic system sends off two sets of branches, one of which is external, and is connected with the spinal nerves; and another set that is internal, and chiefly dispensed to the abdominal viscera.

The connection of the sympathetic nerve with the dorso-spinal nerves, is seen in Fig. 338. 1, 1, anterior fissure of the spinal cord; 2, anterior or motor root of the spinal nerve; 3, posterior root, with 4, its ganglion; 6, 6, the spinal nerve; 5, its posterior branch; 7, its anterior branch; 8, 8, two thoracic ganglia of the sympathetic, connected by the sympathetic nerve, 9; 10, 11, two filaments, one white, the other gray, connecting the sympathetic ganglion with the spinal nerve.

Fig. 337.

Connection of the sympathetic ganglia with the dorso-spinal nerves. After Todd and Bowman.

The *external branches*, two or three in number, anastomose with the two branches of the corresponding spinal nerve; in other instances, however, the ganglion also sends a twig to the intercostal nerve next below it. These branches are white, and in this particular unlike the ganglionic nerves.

The *internal* or *splanchnic branches*.—The principal of these are the aortic filaments, of which two or three are given off from each ganglion and accompany the intercostal arteries, forming small plexuses around them. Other branches are sent to the esophagus, the longus colli muscle and to the cardiac plexuses. These latter filaments proceed from the upper thoracic ganglion.

The most remarkable trunks from these internal branches are the two splanchnic nerves.

THE GREAT SPLANCHNIC NERVE.

This nervous cord is formed by the union of branches from the sixth, seventh eighth, ninth, and tenth thoracic ganglia, and is placed upon the bodies of the vertebræ, beneath the pleura. The single trunk is completed at or near the eleventh dorsal vertebra, whence it passes downward and inward in front of the

vertebral column: it becomes flattened in its course, penetrates between the fibres of the diaphragm, and immediately forms the *semilunar ganglion.*

THE LESSER SPLANCHNIC NERVE.

This nerve is derived from filaments of the tenth and eleventh, and occasionally from the twelfth dorsal ganglia. These filaments converge into a single cord that passes between the crura of the diaphragm, and having thus entered the abdomen, separates into two branches. One of these runs upwards to join the great splanchnic nerve before its division; the other proceeds directly into the renal plexus.

The *semilunar ganglion*, Fig. 339, 3, is formed, as we have mentioned, by the great splanchnic nerve at its emergence from the diaphragm. It is a large, irregular, flattened ganglion, or an aggregation of smaller ganglia with interstices or perforations, giving the whole structure a remarkably cribriform appearance.

The ganglion of the right side is the larger of the two, being commonly about an inch in length. It lies above the renal artery, and between the vena cava and the crus of the diaphragm. The left ganglion is placed below the splenic artery and upon the left crus of the diaphragm. The ganglia of the two sides of the body communicate by numerous filaments, both above and below the cæliac axis; and from this extended centre, branches are given off in every direction like the rays of the sun; whence this remarkable intertexture of ganglia and nerves is called the *solar plexus*.

Fig. 338.

Great splanchnic nerve and semilunar ganglion. After Lobstein.

Fig. 339 gives a view of the great splanchnic nerve and the semilunar ganglion. 1, trunk of the nerve, which divides below into six or eight branches; 2, branches that anastomose with the dorsal nerves; 3, semilunar ganglion; 4, 4, 4, branches given off by the ganglion to form the superior mesenteric plexus; 5, two foramina in the ganglion.

The experiments of Prof. Flourens have led him to believe, that the semilunar is the only ganglion that exhibits any great sensibility, "and hence it has been considered as a sort of intervention to connect the viscera with the encephalon."*

* Dunglison. Human Physiology, i. p. 73.

THE SOLAR PLEXUS.

This plexus extends from the upper border of the cæliac artery (whence the synonym of *cæliac plexus*) to the lower margin of the renal vessels, and is about two inches in width. It is essentially formed, as we have seen, by the great splanchnic nerves; but it also receives branches from the lesser splanchnic, from the termination of the right pneumogastric and from the phrenic nerves, but chiefly from the right phrenic.

The branches given off from the solar plexus are distributed in delicate networks or plexuses around all the branches of the abdominal aorta; for which reason the names of the plexuses are derived from the arteries on which they are bestowed.

1. The *phrenic* or *diaphragmatic plexus* comes from the upper part of the solar plexus, and enters the diaphragm with the phrenic arteries. It anastomoses in part with the terminal branches of the phrenic nerve.

2. The *cæliac plexus* surrounds the cæliac artery, and immediately separates, like that vessel, into three divisions, the gastric, the hepatic and the splenic.

3. The *gastric* or *coronary plexus* is derived from the upper part of the solar plexus, and receives filaments from the pneumogastric nerve before the latter joins the solar plexus. Some of these filaments ramify upon the cardia, while others follow the coronary artery along the lesser curvature of the stomach, and anastomose with the hepatic plexus. It follows, therefore, that the stomach is chiefly supplied by the pneumogastric nerve. "The filaments from the coronary plexus of the stomach, as well as those of the pneumogastic nerve, after having run for some distance beneath the peritoneum, perforate the muscular coat of the stomach, and appear to be partly lost in it and partly in the mucous membrane."*

4. The *hepatic plexus* is of very large size and divisible into two parts: one of these, which is *anterior*, comes chiefly from the left semilunar ganglion in six or seven strong, reddish branches, which anastomose with filaments from the ganglion of the right side. These branches from the left ganglion, called the *nervi comites* of the hepatic artery, send off, before they enter the liver, a fasciculus of filaments to the pancreas and duodenum. On reaching the liver, the proper hepatic branches are spent upon the hepatic artery and its ramifications, and eventually disappear in the external coat of these vessels. Other fibres are spent upon the ductus communis choledochus.

The *posterior division* of the hepatic plexus, is chiefly derived from the right semilunar ganglion, and accompanies the vena portarum to which it is loosely attached.†

5. The *splenic plexus* is composed of two fasciculi of nervous fibres, one of which comes from the left semilunar ganglion, the other from the right pneumogastric. The plexus thus formed surrounds the splenic artery until it reaches

* Cruveilhier.

† Lobstein, *ut suprà*, p. 27.

the fissure of the spleen, where two nervous filaments are detached to accompany each branch of the artery for a short distance, and then are lost in the contiguous parenchyma.

The *pancreas* is supplied by numerous very fine filaments that descend from the solar plexus.

6. The *superior mesenteric plexus* arises from three sources—the right and left semilunar ganglia, and a branch of the right pneumogastric.

It surrounds the superior mesenteric artery, attends its numerous branches, and is distributed to the whole of the small and to part of the large intestine, —the cæcum and the ascending and transverse colon.

7. The *renal plexus* on each side is derived from the corresponding semilunar ganglion, strengthened by filaments from the cæliac and superior mesenteric plexuses, and by others from the lesser splanchnic nerve. The cords thus formed enter the hilum renale in company with the emulgent artery, and then anastomose freely with each other. They can be distinctly traced around the arterial trunks as far as their third division, but are then lost in the external tunic of those vessels.

8. The *supra-renal* plexus is of variable character. Lobstein has traced eight nervous branches into the capsula renalis, three of which came from the semilunar ganglion and five from the renal plexus. They are of comparatively large size, sometimes exceeding that of the associated arteries.

9. The *spermatic plexus*, the smallest of the series, has its origin in a few filaments from the renal plexus, and descends with and embraces the spermatic vessels. Some branches are sent to the ureter, but in the healthy state of parts this plexus cannot be traced into the internal abdominal ring in man, nor to the ovaria in the female.*

10. The *inferior mesenteric plexus* is placed in front of and upon the abdominal aorta. It is a prolongation of the solar plexus, but receives several branches from the lumbar ganglia: it is distributed around the inferior mesenteric artery as far as the rectum, to the sigmoid flexure of the colon and to the left descending colon, in which course it anastomoses with the colic branches of the superior mesenteric plexus. A fasciculus of the inferior mesenteric plexus descends into the pelvis, and after furnishing branches to the external and internal iliac arteries, assists in forming the *hypogastric plexus*.

THE LUMBAR GANGLIA OF THE SYMPATHETIC NERVE.

The lumbar ganglia are five in number, and lie on the bodies of the lumbar vertebræ; they are of an oblong, tapering form, smaller than the cervical but larger than the dorsal ganglia.

The superior and inferior branches connect these ganglia with each other; some external filaments anastomose with the lumbar nerves, but the internal branches are larger and more complicated; for they form round the trunk of the

* Lobstein, *ut suprà*.

abdominal aorta the *lumbar aortic plexus*, which is strengthened by filaments from the solar and superior mesenteric plexuses, and is finally continued into the hypogastric plexus.

The *hypogastric plexus* formed from the aortic lumbar plexus, from the lower lumbar ganglia and from the sympathetic trunk on each side, lies upon the promontory of the sacrum between the common iliac arteries. It descends deeply into the pelvis, where it is connected by a few branches with the third and fourth sacral nerves: it then forms a remarkable net-work of nervous filaments, which follow the branches of the hypogastric, and are thus distributed to the rectum, ureter, urinary bladder, to the vesiculæ seminales in man, and to the uterus and vagina in the female.*

THE SACRAL GANGLIA OF THE SYMPATHETIC NERVE.

These ganglia, four or five in number, are situated on the sacrum, near the anterior foramina of that bone, and are connected by filaments from one to three in number, which represent the continued trunk of the sympathetic nerve. These ganglia send off branches that anastomose with the sacral nerves, and others in the same direction that run to the levator ani and pyriformis muscles.

These ganglia also send off numerous internal branches that communicate with and enter into the composition of the hypogastric plexus, and, in common with the branches of that plexus, are distributed upon the pelvic viscera.

The last pair of sacral ganglia contribute to form the azygos or *coccygeal ganglion*, which lies on the front of the first bone of the os coccygis, and forms the connecting link between the inferior ends of the sympathetic nerve. Thus by means of this ganglion below, and the ganglion of Ribes in the brain, the circle of the sympathetic system is completed.

FUNCTION OF THE SYMPATHETIC SYSTEM.

The functions of the sympathetic or *endo-nervous system*, as heretofore stated, are by no means determined; and the following remarks are all we have to add on this subject.

We have shown that this system receives twigs from the whole of the cerebral nerves excepting those of the three higher special senses,—smell, sight and hearing, and also from both the anterior and posterior roots of the spinal nerves. Hence the sympathetic connection, direct or indirect, with nearly all the visceral organs; and numerous experiments have rendered it highly probable, that the office of this system consists for the most part in placing the organic into relation with the animal functions; thus tending to harmonize the former series of functions with each other, and to bring the various processes of secretion, nutrition, &c., into mutual conformity.† Hence also its designation of the *nervous system of organic life*, to distinguish it from the cerebro-spinal system, or *nervous system of animal life*. And yet this cannot be the exclusive office of the sym-

* Lobstein, *ut suprà*.

† Carpenter. Physiology, § 929.

pathetic, for since it is a compound nerve, that is to say composed both of white and gray neurine, we naturally look for a compound or blended function.

To be more explicit, the nerves which the sympathetic supplies to the viscera, appear to be, though in variable degrees, the instruments of both sensation and motion independently of the will. This is exemplified by the following facts. The peristaltic action of the intestines of the lower animals may be permanently increased by stimuli applied to the solar plexus; and by similar experiments, the motory power of other fibres, and their influence on the viscera, can also be shown. Thus, the heart is excited by irritating either the superior or the inferior cervical ganglion; and it is mentioned by Valentin, that the same influence causes contraction of the great vascular trunks of the thorax and abdomen, and also of the esophagus. Irritation of the two upper thoracic ganglia is followed by motion of the stomach; and similar results follow analogous experiments on the hypogastric viscera.

After a careful investigation of all the facts connected with this mysterious system of nerves, Doctors Todd and Bowman have arrived at the conclusion that it exercises a three-fold office: first, that of a sensitive nerve to the parts to which it is distributed; secondly, that of a motor nerve for certain muscular parts; and thirdly, that of a nerve for the blood-vessels, supplying them with the power of contractility.

The sensibility of parts supplied by the sympathetic nerve is but moderate in the healthy state, but becomes intense on the occurrence of inflammation; and the associated ganglia are observed to acquire an increased sensitiveness the longer they are exposed to the air.*

THE ENCEPHALON OR BRAIN.

The nervous mass within the cranium is called the encephalon or brain, and is divided into the cerebrum, cerebellum, pons Varolii and medulla oblongata. It is not, perhaps, material in what order these parts are described, provided their connection and relative position are well understood; and since we commenced with the spinal cord, we now proceed with that continuous structure known as the medulla oblongata.

MEDULLA OBLONGATA OR BULBUS RACHIDICUS.

This portion of the brain forms the connecting link between the pons Varolii above and the spinal cord below. Its inferior boundary, therefore, is marked by the margin of the foramen magnum; from which point it passes upwards and slightly forwards, resting upon the basilar process of the

* Wagner. Physiology, p. 516. See also a full exposition of this subject in Dunglison's Human Physiology, i. p. 71, &c.

occiput. Its form is pyramidal, the base being directed towards the pons Varolii, from which to the termination of the pyramid below, is about an inch and a quarter.

The medulla oblongata is marked both in front and behind with a longitudinal fissure, which is continuous with the similar fissure of the spinal cord, and which divides it into two symmetrical lateral cords or columns. Each lateral column is again subdivided by smaller sulci into four subordinate portions, called the corpora pyramidalia, corpora olivaria, corpora restiformia and posterior ganglia. Before describing these bodies separately it may be premised, that the columns themselves are not only continuous in structure, but also in function, with the analogous parts of the cord; the anterior fibres being subservient to motion, the posterior to sensation. Moreover, two of the six lateral bodies just named, and another yet further behind, making three on each side, are regarded by Mr. Solly as so many distinct ganglia, as will be presently explained.

1. The *corpora pyramidalia*, Fig. 339, 1, and Fig. 342, 12, 13, lie on each side of the anterior fissure. They are composed of medullary neurine formed into two cords side by side; they are somewhat rounded where they penetrate the pons Varolii, but they immediately afterwards expand again, and assist in forming the inferior laminæ of the crura cerebri. Fig. 352, 11. When examined about three-quarters of an inch below the pons, a fasciculus of each corpus pyramidale crosses over the fissure to gain the opposite cord, with which it becomes incorporated. This decussation only occurs with respect to the internal fibres, or those forming the proximate parietes of the anterior fissure: it takes place in the downward direction for about half an inch, and is distinctly seen by carefully removing the pia mater.* Fig. 339, 2. Other fibres of the pyramid are continuous with the associated column; while a third set winds round the inferior margin of the corpus olivare, and ascending towards the cerebellum, forms the *arciform fibres*. Fig. 339, 5. Some other filaments are also given off near the point of decussation, and take a nearly similar course with those last described. Fig. 339, 4. The corpora pyramidalia then ascend and diverge to form a large part of the cerebral hemispheres.

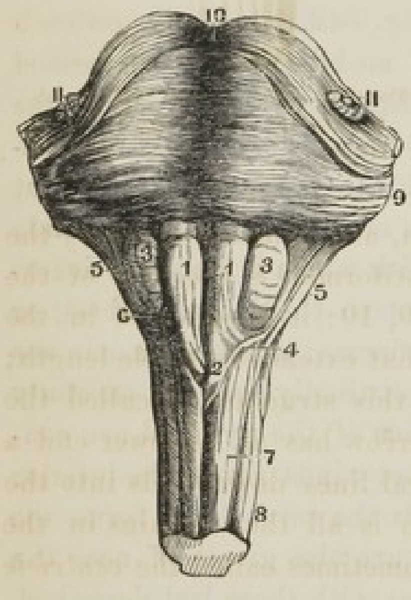
2. The *corpora olivaria*, or *olivary ganglia*, Fig. 339, 3, are two elliptically shaped, prominent and well-defined bodies, placed externally to the corpora

* "This decussation has great interest in reference to the explanation of the phenomena of diseased brain. It is well known that lesion of one hemisphere of the brain, when sufficiently extensive to cause paralysis, will induce that paralysis on the opposite side of the body. And although a very few exceptions have been recorded, this is so constant that it must be regarded as a law, that the influence of each hemisphere is rather on the opposite half of the body, than on that of its own side. It is not, however, meant that the hemisphere has *no* influence on the same side of the body. On the contrary, it is most probable that it does exert some influence from the partial connection of each anterior pyramid, with the antero-lateral column of the spinal cord of the same side. Now the decussation above described, obviously suggests an explanation of this phenomenon, which is among the most interesting that anatomy can offer. In confirmation of this statement it may be remarked, that lesion of one side of the cord *below* the decussation, affects the same side of the body and that alone; whilst diseases of a paralyzing influence, whenever it occurs *above* the decussation, affects the opposite half of the body."—*Todd and Bowman. Physiological Anatomy*, p. 265.

pyramidalia, between the latter and the corpora restiformia: from these bodies they are separated by a sulcus, and from the pons Varolii by a deep fissure. In the downward direction, they do not extend near so low as the pyramids. They are called by Solly the *anterior ganglia* of the medulla oblongata; he supposes the greater part of each ganglion to pertain to the motor tract, and that the true olivary columns lie on the outside of the sensory fibres, and that they connect the origins of the third, fourth and fifth nerves, and the auditory, pneumogastric, glosso-pharyngeal and lingual nerves; and being closely associated with all the ganglia of special sensation, he further supposes their office to be to preside over the tongue as an organ of speech.*

Again, in conjunction with the central substance of the medulla oblongata, the olivary ganglia form the connection between the spinal cord below, and the optic thalami and tubercula quadrigemina above; and since they are composed of a mixture of fibrous and vesicular neurine, it has been inferred that they are in reality the nucleus or essential portion of the medulla oblongata.

Fig. 339.



Anterior view of the medulla oblongata and associated parts. After Quain.

Fig. 339 illustrates the anterior aspect of the medulla oblongata. 1, corpora pyramidalia; 2, the point of their decussation; 3, corpora olivaria; 4, fibres that run from the anterior column to the cerebellum; 5, corpora restiformia; 6, arciform fibres; 7, anterior columns; 8, lateral columns; 9, 10, pons Varolii; 11, roots of the trigeminus nerve.

The olivary bodies have an exterior covering of medullary substance, within which is a mass of vesicular neurine called the *corpus dentatum*, and this last again embraces within itself a white nucleus. The corpus dentatum is of a dentated form, of a yellowish-gray color, and arranged in the manner of a capsule open behind. From its medullary nucleus a series of fibres runs upwards to join the tubercula quadrigemina and optic thalami.

3. The *corpora restiformia* constitute the lateral and posterior parts of the medulla oblongata. They are of a rounded or rope-like appearance, whence their name. Fig. 340, 5. They are continuous below with the antero-lateral and posterior columns of the spinal cord; and above they pass in a diverging manner into the corresponding hemispheres of the cerebellum, constituting their inferior peduncles,—the crura cerebelli.

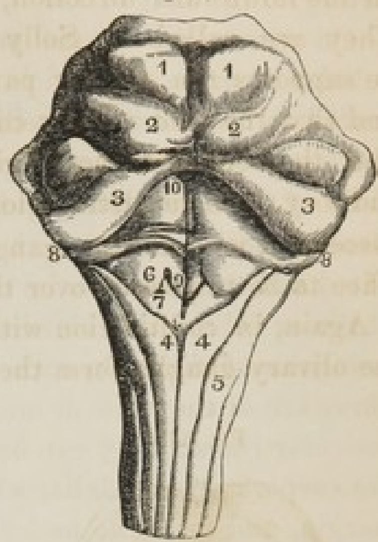
The corpus restiforme embraces the *restiform* or *pneumogastric ganglion* of Solly; who remarks that it forms no prominence on the surface, but is internal, possessing the physical characteristics of other ganglia, and being both the origin and termination of the pneumogastric nerve,—whence its name. Hence, also, he regards it as an important organ in the function of respiration.

* The Human Brain, p. 183.

4. The *posterior ganglia* of Solly, the *posterior pyramids* and *fasciculi graciles* of other authors, constitute the smallest of the four series of columns of the medulla oblongata. They form the inner margin of the posterior fissure where they lie in contact with each other. They consist exclusively of white or tubular neurine, which is continuous with the posterior slender tracts of the spinal cord. On reaching the lower part of the medulla oblongata these pyramids first become somewhat dilated, and then diverging from each other, pass on each side of the restiform bodies. Fig. 340, 4.

Fig. 340 is a posterior view of the medulla oblongata and pons Varolii, the crura of the cerebellum being cut short. 1, testes; 2, nates; 3, superior peduncles of the cerebellum; 4, posterior pyramids; 5, corpora restiformia; 6, fasciculi teretes; 7, roots of the auditory nerve; 8, prominence connected with the hypogolssal nerve; 9, posterior fissure, or calamus scriptorius; 10, floor of the fourth ventricle.

Fig. 340.



Posterior view of the medulla oblongata and pons Varolii. After Quain.

On the posterior surface of the medulla oblongata, and bounded below by the posterior pyramids and above by the corpora restiformia, is the *floor* of the *fourth ventricle* or sinus rhomboideus; Fig. 340, 9, 10: it is elevated in the median line and traversed by a longitudinal fissure that extends its whole length; and from some imaginary resemblance to a pen, this structure is called the *calamus scriptorius*. Fig. 346, 17. The median furrow has at its lower end a small cul-de-sac, that passes for a distance of several lines downwards into the body of the medulla; and this little cavity, which is all that remains in the adult, of the central canal of the spinal cord, is sometimes called the *ventricle of Arantius*,* and by Vicq d'Azyr the *foramen cæcum*.

The *fasciculi teretes* are two slightly prominent bodies placed on the floor of the fourth ventricle, one on each side of the longitudinal fissure. They are composed of mingled fibrous and vesicular neurine, but their connections and uses are as yet uncertain. Fig. 340, 6.

THE PONS VAROLII OR TUBER ANNULARE.

This structure, to which Chaussier gave the more expressive name of *mesocephalon*,† is placed at the upper end of the medulla oblongata, of which it appears at first sight to be a bulbous expansion. It is the segment of a sphere, the convexity resting upon the clivis, or that part of the base of the cranium where the body of the sphenoid bone joins the basilar process of the occiput.

* Quain and Sharpey. Anatomy, p. 687.

† This name is sometimes given to the medulla oblongata, pons Varolii, crura cerebri and corpora quadrigemina, collectively.

It is nearly circular at the base, about an inch in diameter, and is divided into two equal parts by a superficial longitudinal sulcus that lodges the basilar artery. Fig. 339, 9, 10.

On removing the pia mater, its under surface is seen to be composed of tubular neurine, of which the fibres are arranged transversely, and can be traced to the crura cerebelli of which they form a part. This arrangement of the fibres of the mesocephalon forms a direct connection between the opposite sides of the cerebellum, and hence it is called the *commissure of the cerebellum.* Beneath this lamina, which is about a line in thickness, is another, also laminated and transverse in its course, but blended with cineritious neurine. Again, above or behind this blended structure, and near the middle of the pons, is a fasciculus of fibres on each side that runs in the longitudinal direction. These fibres are of the white or medullary kind, intermixed, however, with others of the vesicular class: they can be shown by a little dissection to be continuous with the corpora pyramidalia, which thus penetrate the pons, emerge at its anterior margin, and form the under surface of the crura cerebri.

THE CEREBELLUM.

The *cerebellum*, or little brain, is situated in the posterior chamber of the skull and beneath the tentorium, which last separates it from the cerebrum. Behind and below it is the occiput; and before and at the side it is bounded by the temporal and parietal bones. It is convex above and below: its greater diameter, which is transverse, is about four inches, and it is something more than half that measure in thickness. Fig. 341.

The cerebellum is divided into two equal parts or hemispheres by a longitudinal ridge called the *superior vermiform process*, Fig. 341, 9, and by a fissure that runs in the same direction below and behind, formed in part by the lesser falx of the dura mater. A longitudinal ridge is observed in this sulcus, called the *vermis inferior*, Fig. 341, 10; and that portion of the cerebellum which is embraced between the two vermiform processes, is called by Gall and Spurzheim its *fundamental portion.* On the posterior margin is another sulcus that partially encircles the tubercula quadrigemina; while on the under surface a considerable excavation named the *vallecula*, corresponds with the position of the medulla oblongata, and is continuous with the notch behind.

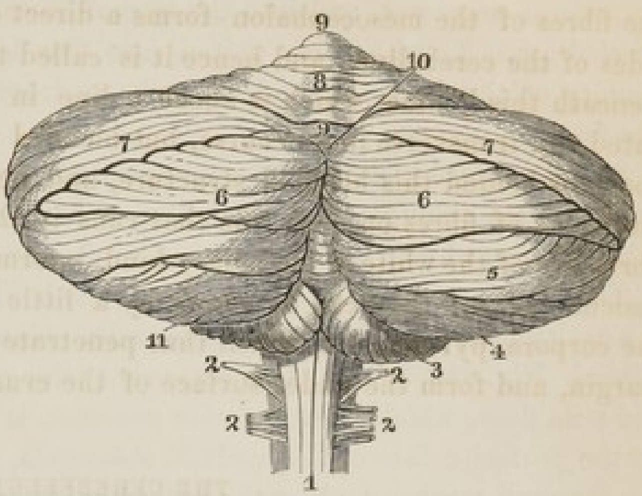
When examined within, the cerebellum is seen to consist of a great number of delicate laminæ or leaf-like plaits, laid one upon the other: these are separated and at the same time kept together, by the pia mater that dips between them; and they are moreover grouped on each side into several subordinate lobes or lobules. These lobules have been examined and described by different authors, but in such variable number and by such diversified names as greatly to embarrass the study of this structure. Several of them are seen in Fig. 341.

A *horizontal fissure* commences in front, passes horizontally outwards and backwards, around each hemisphere, and divides it into an upper and a lower portion. "From this primary fissure numerous others proceed on both the

upper and under surfaces, forming parallel curves, having their concavities turned forwards, and separating the folia from each other. All these furrows do not go entirely round the hemisphere, for they often coalesce with one another; and some of the smaller furrows have even an oblique course between the others. Moreover, on opening the larger fissures, many of the folia are seen to lie concealed within them, and do not reach the surface of the cerebellum."

Fig. 341, taken from Solly,* gives a posterior view of the cerebellum, and the several lobules of which it is composed. 1, spinal cord; 2, posterior spinal nerves; 3, amygdaloid lobule; 4, biventral lobule; 5, lobulus gracilis; 6, inferior semilunar lobe; 7, superior semilunar lobule; 8, lobulus quadratus; 9, superior vermiform process; 10, vermis inferior; 11, pyramid of the cerebellum.

Fig. 341.



Posterior view of the cerebellum. From Solly.

Since the whole exterior of the cerebellum and the entire surfaces of all the laminæ of which it is composed, are covered by vesicular neurine, the proportion of this element of the brain is great indeed. The proportion of fibrous neurine is small in comparison; and this is best shown by a vertical section of the cerebellum, which discloses the beautiful arrangement of parts called the *arbor vitæ;* the trunk, branches and leaves of this imaginary tree being composed of medullary structure everywhere enclosed in cineritious neurine, the one contrasting strongly with the other. Fig. 346, 18.

The trunk of the medullary portion of the arbor vitæ contains within itself the only cineritious neurine of the *interior* of the cerebellum. It is disposed in an irregular mass, with a serrated, uneven surface, about twice the size of the corpus olivare. It is called the *corpus dentatum;* but Gall and Spurzheim have given it the better name of *ganglion of the cerebellum.*† In the centre of this ganglion is contained a medullary nucleus.

The PEDUNCLES OF THE CEREBELLUM.—These parts are the sources whence the cerebellum is derived; or more strictly speaking, they are the media by which it is connected with other portions of the brain. They are divided into three pairs, superior, middle and inferior.

1. The *superior peduncles* constitute the inter-cerebral commissure—*processus è cerebello ad testes.* They extend from the cerebellum upwards and forwards, in a twofold lamina of fibres, to the testes, with which they are inseparably

* The Human Brain, p. 220.

† Mr. Solly, in his excellent work on the Human Brain, which we have so frequently quoted, suggests for this structure yet another name—*ganglion dentiforme.* Every anatomist should be reluctant to give new appellations to parts that are already obscured and embarrassed with useless synonyma.

blended. "They form the anterior part of the lateral boundaries of the fourth ventricle, and give attachment, by their inner borders, to the valve of Vieussens, which is stretched between them. At their junction with the testes they are crossed by the fourth pair of nerves."* Fig. 347, 3, and 349, 11.

2. The *middle peduncles* are the crura cerebelli. Within the cerebellum they can be traced in a radiating manner into the laminæ of the superior and inferior vermiform processes, and into the lateral lobes, and indeed to all parts of the cerebellum. They become united into two large fasciculi at the anterior extremity of the horizontal sulcus, and penetrate the pons Varolii in which they are finally lost.

3. The *inferior peduncles* are the corpora restiformia—processus è cerebello ad medullam oblongatam—consisting of both motor and sensory fibres. They take an upward course, beneath and to the inner side of the crura cerebelli.

The FOURTH VENTRICLE, or sinus rhomboideus, already partially described, is a cavity interposed between the medulla oblongata in front and the cerebellum behind. Fig. 340, 9, 10. It is somewhat triangular, being narrowed at the upper end: its floor, which is its anterior parietes, is formed, as heretofore remarked, by the posterior face of the medulla oblongata, or, more specifically speaking, by the fasciculi teretes, and by the pons Varolii, and it is covered at its upper part by the valvula cerebri and tubercula quadrigemina. At its lower part, however, it is only covered by that portion of the pia mater which is reflected from the cerebellum to the medulla oblongata. We have already noticed the longitudinal fissure forming the *calamus scriptorius*, and the foramen cæcum in which the fissure ends below; and also the *fasciculi teretes*, two small prominences of cineritious neurine, placed one on each side of the upper termination of the fissure. From the upper end of the fourth ventricle, and beneath the tubercula quadrigemina, a canal about a line in diameter, called the *aqueduct of Sylvius*, communicates directly with the third ventricle.

The connections of the valvula cerebri are with the medullary neurine of the cerebellum behind, whence it advances in the form of a thin lamina to the testes, with which it is blended. Its sides are attached to the superior peduncles of the cerebellum; and its posterior border is overlaid for a short distance by a delicate layer of cineritious neurine.

THE CEREBRUM.

The cerebrum constitutes far the largest part of the encephalon. Its longitudinal and transverse diameters are the same as those of the skull, after allowing for the thickness of the cranial bones. Its bulk is about six times as great as that of the other divisions of the brain collectively; and its form is ovoidal, and broadest in its posterior half.

* Dr. Erasmus Wilson.

The *hemispheres* of the brain are two lateral portions, separated from each other by the great longitudinal fissure formed by the falx major of the dura mater. At the bottom of this fissure is a broad medullary band, the *corpus callosum*, connecting the hemispheres together.

The *lobes* of the brain are three on each side, and are divided into anterior, posterior and middle. The *anterior lobe* constitutes the front of the brain and gives form to the forehead. It lies chiefly upon that part of the os frontis constituting the roof of the orbit and the lesser wing of the sphenoid bone. The posterior angle of the latter bone forms a deep sulcus in the cerebral mass called the *fissure of Sylvius*, and this is the boundary between the anterior and middle lobes. The *middle lobe* is lodged in the middle fossa of the base of the skull, between the lesser sphenoidal wing and the margin of the tentorium. This division, however, is in some measure arbitrary, because when the brain is removed from the skull, no line of demarkation exists between the middle and posterior lobes. The *posterior lobe* rests upon the tentorium, which separates it from the cerebellum beneath.

THE CONVOLUTIONS.

The *convolutions* or *gyri* constitute the elongated rounded prominences of the exterior surface of the brain; and they also extend into its fissures, and are continuous throughout. They pursue a winding course, being separated from each other by corresponding sulci lined to the bottom by processes of pia mater. These sulci vary in depth from half an inch to an inch, but are deepest on the outer surface of the brain.

The convolutions are not alike in all brains, nor on the two sides of the same brain; but there is, however, a certain conformity of arrangement that permits of general description; and although the details of this arrangement are unusually embarrassing and unprofitable, we may briefly notice their more obvious features.

All the convolutions can be traced to the fissure of Sylvius, from which they may be said to arise. The precise point of origin is the *locus quadratus*, the anterior perforated substance of some anatomists; and the convolutions, winding in various directions from this centre, are classed by Foville into four orders, in the following manner.

1. The first order embraces a single convolution that commences at the substantia perforata, and turning upwards, passes round the corpus callosum and along its upper surface to the posterior margin of that body: from thence it descends to the base of the brain to terminate near its origin, but on the opposite border of the fissura Sylvii, which last, therefore, it does not cross. This convolution embraces the superior longitudinal commissure, and is the *ourlet* of Foville.

2. The second order of convolutions arises near and also from the former one, and embraces two convolutions: one of these constitutes the external margin of

the corresponding hemisphere of the brain, whence it ascends and forms the superior part of the hemisphere. It terminates at the extremity of the middle cerebral lobe. The second convolution of this order forms the circumference of the fissure of Sylvius.

3. The third order is chiefly seen on the internal surface of the hemisphere, and on the internal face of the fissura Sylvii. These convolutions, as Mr. Solly remarks, form a sort of anastomosis between the convolutions of the first and second order, and vary in number from five to eight.

4. The fourth order is placed on the external surface of the brain. They have no direct connection with the convolutions of the first order, but chiefly occupy the space between the two great lines of the second order.

This is but a meagre outline of a portion of the cerebral mass to which Foville has devoted forty pages of his work on the brain, and to which phrenologists attach the highest importance. Drs. Todd and Bowman, however, have presented a yet more simplified view of these parts, which they arrange into three primitive trunks in the following order.

The *internal convolution* lies parallel to the corpus callosum, which it overlaps slightly on either side. "In front it winds round the anterior margin of the corpus callosum, and is connected with the convolutions of the anterior lobe: posteriorly it divides, appears to be continuous with some posterior convolutions, and passes into the middle lobe forming the hippocampus major. Numerous small folds pass from its upper edge to the superior convolutions.

"The *supra-orbitar convolution* is well developed, and bears a constant relation to the fissure for the olfactory process. The fissure of Sylvius is bounded by a tortuous *external convolution*, which forms numerous connections with others on the external surface of the brain. Some *longitudinal* convolutions are formed on the superior and on the inner surface of the hemispheres, uniting with neighboring ones by means of numerous transverse folds."

The convolutions in man do not present a perfect symmetry on the two sides of the brain, although the *essential convolutions*, more or less modified, are always present. It is a remarkable fact, that "the lower the development of the brain, the more exact will be the symmetry of its convolutions. Thus the brains of all the inferior mammalia, even of those which make the nearest approach to man, are exactly symmetrical. The imperfectly developed brain of a child exhibits a similar symmetry; and that of the inferior races of mankind, in whom the neglect of mental culture, and habits approaching those of the brute, are opposed to the growth of the brain, also present a symmetrical disposition of the convolutions."*

These convolutions have assumed a great importance in the expositions of phrenology by Gall and Spurzheim, who regard each one of them as an organ, or series of organs, which, according to its locality, is the seat of a mental or moral faculty, or of one of the animal propensities.†

* Todd and Bowman. Physiological Anatomy, p. 283.

† Spurzheim. Anatomy of the Human Brain, Pl. vi.

The convolutions are everywhere covered by a thin layer of cineritious neurine, constituting the *hemispherical ganglion* of Solly, to be presently described.

BASE OF THE CEREBRUM.

Before studying the interior of the brain, it seems necessary to understand its external configuration; and to complete this view, we return to the basal surface and examine the several parts interposed between the pons Varolii behind, and the margin of the anterior lobes in front, excepting the nerves of the encephalon, which will be described in another place.

The series of structures embraced in this tract, are consecutively as follow: the crura cerebri, pons Tarini, corpora albicantia, infundibulum, tuber cinereum, pituitary gland, optic commissure, fissura Sylvii and the bulbs of the olfactory nerves. Fig. 342.

THE CRURA CEREBRI.

The CRURA CEREBRI, or *peduncles of the brain*, are two white cords about three-fourths of an inch in diameter, that emerge from, and in front of, the pons Varolii. They are composed of the anterior columns (corpora pyramidalia) and the olivary tract of the spinal cord, which having made their way through the pons, now re-appear at its anterior margin, and immediately diverge from each other to be prolonged through the optic thalami and corpora striata, and thence expanded into the cerebral hemispheres. The crura are continuous, by means of their external fibres, with the tubercula quadrigemina, and they form the floor of the aqueduct of Sylvius above. Fig. 342, 22.

The crura cerebri are covered, on their basal surface, by a lamina of fibrous neurine about two lines in thickness; but a vertical section exposes a subcentral mass of vesicular neurine called the *locus niger*, for which Mr. Solly proposes the name of *ganglion of the trigeminus nerve;* because this nerve, or at least a part of it, can be traced to the locus niger. The latter separates the anterior and posterior fasciculi of the crus cerebri, and is supposed to exert a motor influence. Fig. 347, 12. Above, or strictly speaking, posterior to this ganglion, is a layer of white fibres derived from the posterior portion of the lateral column of the cord,—the sensory columns of Sir Charles Bell.

THE INTERPEDUNCULAR SPACE.—Just before entering the hemispheres of the brain, the crura or peduncles are crossed by the *optic commissure*, formed by the junction of the optic nerves of opposite sides. These white, flattened cords meet at an angle in front, between which and the connected crura behind is a lozenge-shaped interval called the *interpeduncular space*, which includes within its area the following parts; the locus perforatus posterior, pons Tarini, corpora albicantia, tuber cinereum, infundibulum and the pituitary gland.

The LOCUS PERFORATUS POSTERIOR is a fossa situated between the crura cerebri behind and the corpora albicantia before. Its bottom is formed of a layer of vesicular neurine that serves to connect the proximate margins of the cerebral peduncles with each other, and with the corpora albicantia. This is the *pons Tarini.* It is perforated by numerous small blood-vessels, in their course upwards to reach the optic thalami and other parts contiguous to the third ventricle. Fig. 342, 24.

The CORPORA ALBICANTIA, or eminentiæ mammulares, are two white hemispherical bodies the size of a small pea. They are placed between the crura cerebri, and before the pons Tarini. They are covered by medullary neurine externally, and are formed by the anterior crura of the fornix, whence their name of *bulbi fornicis.* Their internal structure is cineritious, and they are connected by a commissure of vesicular neurine. Fig. 342, 25.

TUBER CINEREUM.—This is a plane of vesicular neurine that fills the space between the corpora albicantia behind and the optic tract in front, and assists in forming the floor of the third ventricle. In consequence of the cineritious character of the tuber cinereum, it is now regarded as a ganglion; and from the circumstance of the optic nerve sending some filaments into its substance, and the longitudinal commissure deriving some from it, Mr. Solly suggests that it may be an instrument of power connected in some way or other with the phenomena of vision. Fig. 342, 26.

THE INFUNDIBULUM.—From the middle of the tuber cinereum a conical body of gray neurine projects downwards and forwards to the pituitary gland, to which it is attached by its apex. This conical process is the *infundibulum.* It is about two lines in length, and contains within its base a small cavity that communicates with the third ventricle by means of a direct passage called the *iter ad infundibulum.* The infundibulum assists the tuber cinereum in forming the floor of the third ventricle. Fig. 342, 26.

Although the infundibulum consists principally of vesicular neurine, some white fibres can be traced into it that descend from the optic thalami; whence the infundibulum is regarded as a commissure between the pituitary gland and the thalami.*

The PITUITARY BODY, or *hyopophysis*, or as it is more generally called, the *pituitary gland*, is a cineritious mass of a flattened oval form, occupying the sella turcica of the sphenoid bone, between the cavernous sinuses. The arachnoid membrane is stretched across the upper surface of this body, and the dura mater is interposed between it and the bone. It consists of an anterior and posterior lobe, and weighs, with the infundibulum, about eight grains.

Its structure resembles that of the vesicular neurine of the brain. It is composed of large nucleated cells, surrounded by a granular matter embedded in a white fibrous tissue. It is very vascular, firmer than the cineritious substance of the brain, and larger in the infant than in the adult. Its function is unknown; but it is supposed by some physiologists to be the cerebral ganglion

* Solly.

of the sympathetic nerve. Dr. Todd, on the contrary, classes it with those glands that have no efferent ducts.

Fig. 342. View of the base of the brain, with the associated nerves, of the natural size. 1, small portion of the posterior lobe of the cerebrum, projecting beyond the cerebellum; 2, inferior vermiform process of the cerebellum; 3, lobe of the cerebellum; 4, termination of the medulla oblongata in the spinal cord; 5, decussating fibres of the corpora pyramidalia; 6, spinal accessory nerve; 7, corpus restiforme; 8, ninth or hypoglossal nerve; 9, corpus olivare; 10, pneumogastric nerve; 11, glosso-pharyngeal nerve; 12, 13, corpora pyramidalia; 14, auditory nerve; 15, facial nerve; 16, 20, pons Varolii, with its longitudinal furrow; 17, flocculus, or lobular appendix of the cerebellum; 18, trigeminus nerve; 19, sixth nerve, abducens oculi; 21, fourth nerve, or trochlearis; 22, crus cerebri; 23, motor oculi, or third nerve; 24, locus perforatus posterior, or pons Tarini; 25, corpora albicantia; 26, infundibulum; 27, locus perforatus anterior; 28, tractus opticus; 29, chiasm of the optic nerve; 30, optic nerve; 31, internal root of olfactory nerve; 32, external root of same nerve; 33, trunk of the olfactory nerve; 34, its bulb; 35, longitudinal fissure of the brain, separating its anterior lobes; 36, fissura Sylvii; 37, anterior lobe of the brain.

Fig. 342.

Base of the brain and its nerves. After Quain.*

The fissure of Sylvius.—Passing the optic commissure, which has been already noticed, the next prominent feature on the base of the brain is the fissura Sylvii, separating the anterior and middle lobes and giving passage to the middle artery of the cerebrum. Fig. 342, 36. Connected with this fissure are the *insula* of Reil and the *gyrarium*, or origin of the convolutions. The *insula* consists of five or six small convolutions grouped and concealed within the Sylvian fissure, and surrounded by the middle cerebral artery.

* This drawing is a modified longitudinal section, made by my pupil Mr. Wm. M. Dickeson, from Quain's Nerves of the Human Body, Pl. VIII.

LOCUS PERFORATUS ANTERIOR.

Near the entrance of this fissure, and in front of the optic tracts, there is seen on each side a small quadrangular plane of a gray color, called the *anterior perforated space*,—locus perforatus anterior. It lies directly beneath the corpus striatum. "The cineritious surface of each perforated space is crossed by a broad white band, which may be traced from the middle of the under surface of the corpus callosum in front, backwards and outwards along the side of the lamina cineria towards the entrance of the Sylvian fissure. These bands on the two sides are named the *peduncles of the corpus callosum*."* These spaces are also perforated by numerous foramina for the transit of blood-vessels to the corpus striatum. Fig. 342, 27.

The OLFACTORY BULBS are placed on the under surface of the anterior lobes, one on each side of the longitudinal fissure. Fig. 342, 34.

The *longitudinal fissure* separates the two anterior lobes of the brain and gives passage to the anterior cerebral arteries in their course to the corpus callosum, which forms the boundary of the fissure in front. Fig. 342, 35.

THE HEMISPHERICAL GANGLIA.

The cineritious neurine that forms the exterior envelope of the brain, and commonly designated as the *cortical substance*, is now justly classed with the ganglionic structures. Each convolution consists of a fold of this neurine enclosing fibres of the medullary kind; and it penetrates to the bottom of the sulci, so as to "form one unbroken though undulating sheet over the whole convoluted surface of the brain." Figs. 343, 344.

The thickness of the cortical substance varies from a line to nearly two lines. It is of an ash-color with a tinge of red, much varied, however, by pathological circumstances. In anemic persons it is extremely pale; while in those who have died in robust health, or especially in instances of cerebral congestion, the red tint is much heightened, forming a strong contrast with the subjacent medullary mass. It is not arranged, as formerly taught, in a single layer, but in three layers which alternate with three others of fibrous neurine. The distinction between some of these laminæ may be seen in the healthy state of the posterior convolutions; but it is most obvious in those instances in which the parts have become enlarged by hypertrophy consequent to long-continued inflammation. It requires the microscope to detect these six layers first discovered by Baillarger, and since verified by Solly and Longet.

Some discrepancy of opinion, however, exists in respect to the relative position of these layers; for while Todd and Bowman, who are remarkable for the fidelity of their observations, describe the external layer as vesicular, Baillarger and others insist that it is medullary. The external envelope is extremely deli-

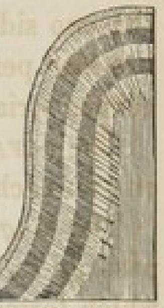
* Quain and Sharpey. Anatomy, p. 701.

cate and consequently liable to be misunderstood; but if the fifth stratum is gray, as generally admitted, we should be disposed to infer that the one exterior to it is white. A convolution thus organized, is seen in Fig. 343, with its basis of tubular neurine. This structure is everywhere penetrated by the medullary neurine, its fibres being disposed more or less at right angles with that portion of the cineritious surface with which they are in relation; while on the other hand these fibres converge inwards towards the central parts of the brain, viz., the optic thalami and the corpora striata. A large proportion, therefore, of the medullary neurine of the hemispheres, the *centrum ovale*, for example, consists of fibres that establish a communication between the hemispherical ganglion and the central gangliform bodies just named.*

Fig. 343.

Fig. 344 gives another view of the six alternating laminæ of a cerebral convolution, together with the straight fibres of medullary neurine by which they are penetrated. In this drawing the exterior layer is represented of the cineritious order.

Fig. 344.



Laminæ of the cerebral convolutions. After Baillarger.

It is sometimes asserted, but hitherto not fully proved, that a part of these medullary fibres pass between the convolutions, uniting those immediately adjacent as well as those more remote. "Such fibres, did they exist, would pass at right angles to those above described, and parallel to the gray surface. They would constitute *intergyral commissures.*"

INTERNAL STRUCTURE OF THE CEREBRUM.

The first object in dissecting the brain is simply to acquire a knowledge of its parts; and for this purpose it makes little difference where we begin, provided the relative position and organic continuity of these parts are subsequently understood.

THE CORPUS CALLOSUM.

In order to see this structure, the hemispheres of the brain should be gently pressed aside by introducing the fingers into the great longitudinal fissure; but a perfect view of it can only be obtained by cutting horizontally through the hemispheres on a level with the corpus callosum. This stage of the dissection exposes a large plane of medullary neurine, of which the free centre is formed of the corpus callosum, and the periphery by the cut surfaces of the cerebral mass; this is the *centrum ovale*. It is bounded externally by the cortical neurine of the convolutions, and dotted with red points indicative of the position of divided blood-vessels.

* Todd and Bowman, p. 283.

The corpus callosum thus brought into view, is a broad band of medullary fibres that forms the floor of the longitudinal fissure, and is the *great transverse commissure* by means of which the two hemispheres are joined together. It is situated in the middle of the centrum ovale, but nearer the anterior than the posterior margin of the brain. It is slightly arched, three inches in length, nearly an inch in breadth, and about two lines in thickness excepting at the ends, where its depth is somewhat greater. The fibres of which it is composed run transversely into the hemispheres on either side, where they are everywhere in contact with the internal layer of the hemispherical ganglia; so that these fibres consequently establish a communication between the cineritious neurine of the whole convoluted surface of both sides of the cerebrum.*

This communication, however, does not result from the mere crossing of fibres from side to side; for the latter can be distinctly traced into the anterior and middle lobes of the brain and part of the posterior lobes. Thus the medullary fibres from the front, sides and superior part of the anterior lobe, pass backwards and inwards in order to reach the front margin of the longitudinal fissure, where they assist to form the corpus callosum. The fibres from the convolutions of the upper and lateral portions of the middle lobes, run downwards and inwards, being joined by those from the convolutions at the base of the brain. The fibres from the upper, under and posterior surfaces of the posterior lobe, take a direction inwards and forwards, and form the corresponding portion of the commissure.†

The corpus callosum is overlapped on each side by the convolutions that form the lower and inner margins of the hemispheres, and these are sometimes called the *labia cerebri;* and the space between the convolutions and the commissure below, is unnecessarily designated as the ventricles of the corpus callosum.

A slight median furrow, the *raphé*, traverses the corpus callosum from front to back, and has on each side of it a linear elevation. These lines are the *striæ longitudinales*, or nerves of Lancisi: they divide the corpus callosum into two equal parts, and are supposed to be commissural in their office.‡ From these striæ others of a filamentous character pass at right angles, in the outward direction, and are lost in the substance of the commissure.

The anterior end of the corpus callosum terminates in a rounded border, the *genu*, which bends downwards to the base of the brain in front of the commissure of the optic nerves. The posterior end, *splenium*, is also rounded, and is continuous with the fornix and cornu ammonis.

The *under surface* of the corpus callosum forms the roof of the lateral ventricles; it is connected behind with the fornix, and in front with the septum lucidum, or longitudinal partition between the ventricles.

The *superior longitudinal commissure* has been so called by Mr. Solly on account of its position and function. It is contained within the internal convolution that overlaps the corpus callosum. It can be traced in front to the locus quadratus, before the fissure of Sylvius, from which point it curves backwards

* Solly, *ut suprà*, p. 207. † Idem.

‡ Todd and Bowman. Physiological Anatomy, p. 285.

and winds round the front of the corpus callosum, receiving fibres from all the contiguous portions of the hemispheres. Behind, it passes over the posterior border of the corpus callosum, and curving forwards, reaches the under part of the middle lobe, and is connected with the hippocampus major. According to Solly, these posterior fibres cross the fissure of Sylvius, and terminate, where the commissure began, in the locus quadratus, having thus performed a complete circuit in the centre of the cerebrum.

THE LATERAL VENTRICLES AND THE CONTAINED ORGANS.

The lateral ventricles lie immediately beneath the corpus callosum, which forms their roof; so that by simply removing the latter the former are brought into view. The ventricles are then seen to be two very irregularly curved cavities running in the direction of the length of the brain, and each composed of three subordinate sulci. These sulci are called the *cornua* of the lateral ventricles, and are named, according to their relative position, anterior, middle and posterior. The roof of these cavities is the corpus callosum; the floor, the fornix, corpora striata and some subordinate parts; and they are separated from each other by a median partition, the *septum lucidum*, which is attached to the corpus callosum above, and to the fornix below.

THE FORNIX.

The *fornix*, or *inferior longitudinal commissure*, is a triangular plane of medullary fibres of which the apex presents forwards. The posterior angles, forming the base, are nearly an inch from each other. The fornix is about a line in thickness; and its fibres are collected both before and behind into two fasciculi or peduncles, called the anterior and posterior crura. Fig. 345, 6, 7, 8. As this body is moreover convex above, it has been compared to "a vaulted roof supported on four pillars, which, unlike pillars in general, are bent nearly double; the anterior pair presenting their concavity forwards, the posterior pair, backwards." It is further remarked by Mr. Solly, that the fornix may, with equal propriety, be said to begin or to terminate at the crura cerebri, so completely are its two extremities connected with those organs.

Mr. Solly describes it as commencing at the *locus niger*, or cineritious nucleus in the middle of the crus cerebri of each side, whence the radicles pass forward to the corpora albicantia, to be there joined by a band from the interior of the optic thalamus; and a careful dissection shows that a twist or turn of this band forms the corpus albicantium of its respective side, as heretofore remarked. Cruveilhier has traced these bands to a connection with the tæniæ semicirculares, and Erle thinks he has discovered a filamentous continuity between them and the optic nerve, and consequently between the latter and the fornix.

After forming the constituent knot of the corpora albicantia, the fibres collect into two rounded cords that describe a curve by passing forwards, upwards and backwards; thus forming the anterior pillars of the fornix, or *crura fornicis.*

These crura form a semicircle, of which the concavity presents backwards and is entirely unattached; but the anterior or convex surface, on the contrary, receives accessory fibres from the anterior cerebral lobe and from the corpus callosum.

The anterior crura fornicis also receive fibres from two other sources, viz., from the tæniæ semicirculares and the peduncles of the pineal gland of their respective sides. The place of junction between the crura in front of the third ventricle is the *corpus fornicis*.

From this point, as we have already observed, the fornix expands on both sides to its base, from the two angles of which the *posterior pillars* are given off. Each of these pillars or crura has a double connection; one of them can be readily followed into the middle or inferior horn of the lateral ventricle, where it is continuous with the *hippocampus major*, and forms in the latter body the thin, overlapping margin called the *corpus fimbriatum*. The second connection of the posterior angle of the fornix, is with the posterior corner of the ventricle, into which it is seen to be continuous with the *hippocampus minor*. A further idea of these connections will be derived from the description of the hippocampi themselves; merely premising, that the base of the fornix, or that portion embraced between the posterior crura, curves upwards, joins the corpus callosum or great commissure, and forms with it a seemingly continuous sheet of medullary neurine; although some anatomists regard this connection in the light of a mere adhesion of parts. Fig. 345, 8.

FORAMEN OF MONRO.

The *foramen of Monro* should be considered in connection with the fornix; for directly behind its anterior pillars, on each side, is a small opening that passes downwards and inwards until the two coalesce into a single foramen that opens into the upper part of the third ventricle, which is thus, by the upward bifurcation of this passage, placed in communication with each of the lateral ventricles. The choroid plexus is prolonged through this opening, and the veins of the corpora striata also pass through it. Fig. 346, 15.

THE SEPTUM LUCIDUM.

The *septum lucidum* next claims attention. It is a very thin longitudinal partition separating the lateral ventricles from each other. It is connected above to the corpus callosum, and below to the fornix, being broad in front and narrow behind. It may be compared to a wedge interposed, with its edge backwards, between the two surfaces it connects together. This septum is composed of two distinct laminæ, of which the external is cineritious, the internal medullary and continuous with the great transverse commissure. Fig. 345, 4.

Between these laminæ is a cavity called the *fifth* or *Sylvian ventricle*, or ventricle of the septum. It is about an inch and a half long and a line in width, but somewhat contracted in the centre. In fœtal life it communicates in front with the third ventricle, but this opening becomes obsolete in after life. Fig. 345, 5.

Rolando describes the septum lucidum as an inversion of the fibres of the hemispheres from the corpus callosum; but Solly derives it from fibres that arise from the front margin of the anterior crura of the fornix, where it is formed by converging filaments from the anterior cerebral lobe and corpus callosum.

THE CORNUA OF THE LATERAL VENTRICLES.

Having now examined the *roof* of these cavities as formed by the great commissure, their *floor* as partly formed by the fornix, and their *partition* as seen in the septum lucidum, we proceed to notice the *three cornua* and their contents.

The ANTERIOR CORNU or *horn*, is a cavity of a curved triangular form: it passes outwards and forwards in the substance of the anterior lobe, and in front of the corpus striatum, whence it gradually descends and terminates near the exterior surface of the corresponding cerebral lobe. Fig. 345, 10.

The MIDDLE OF DESCENDING CORNU takes a somewhat tortuous course: it passes at first a little backwards, then curves consecutively outwards, downwards, inwards and forwards, and having passed in front of the crus cerebri, terminates in the middle lobe (to which it exclusively pertains), near the fissure of Sylvius. Fig. 345, 11. Its roof is derived from the optic thalamus and from the body of the affiliated cerebral lobe; and its inferior and lateral parietes from the following parts which are usually described as contained within it, viz: the hippocampus major, pes hippocampi, per accessorius, corpus fimbriatum, choroid plexus, fascia dentata and transverse fissure.

The *hippocampus major*, or cornu ammonis, is a true cerebral convolution, being in fact "the internal surface of the convolution, *gyrus fornicatus*, of the lateral edge of the hemisphere; the convolution which has been previously described as lying upon the corpus callosum, and extending downwards to the base of the brain, to terminate at the fissure of Sylvius."* Fig. 345, 13. It is formed of cineritious neurine covered by a thin layer of medullary fibres; the former is derived from the convolutions at the base of the brain; the medullary layer comes from the under part of the cerebrum, and, as heretofore observed, is continuous by means of its medullary lamina with the posterior crura of the fornix.

The *corpus fimbriatum*, or tænia hippocampi, is a tape-like band of medullary neurine attached to the inner border of the hippocampus. It can be traced as far as the termination of the hippocampus and is there lost in the body of that structure. Fig. 345, 14. The hippocampus major terminates in front of the middle cornu of the ventricle by a series of knotted elevations, known as the *pes hippocampi;* while behind the hippocampus major and between it and the hippocampus minor, is the *pes accessorius*, also formed of medullary neurine.

The *fascia dentata* is seen on raising the edge of the corpus fimbriatum; it is a narrow serrated layer of vesicular neurine, which is merely a part of the proximate hemispherical ganglion. It is sometimes called *corpus denticulatum*.

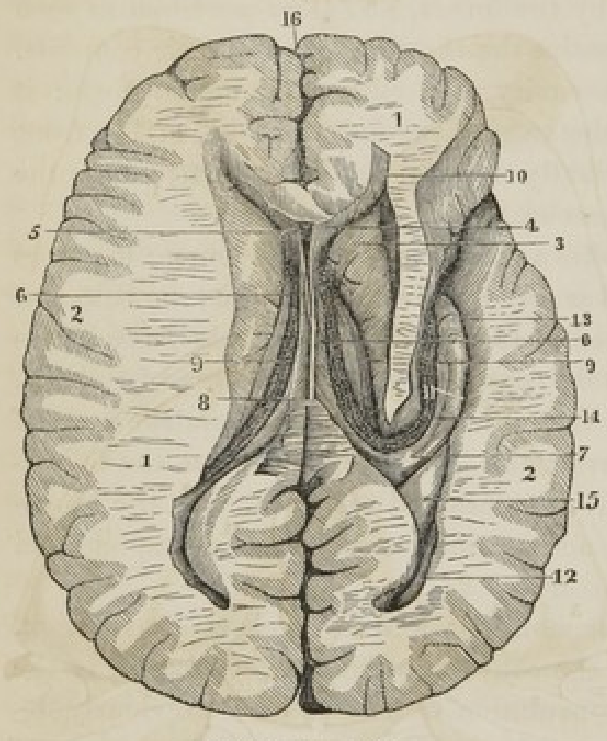
The *transverse fissure of the brain* is interposed between the posterior, under

* Dr. Erasmus Wilson. *Ut suprà.*

surface of the optic thalamus and the contiguous posterior pillar of the fornix on each side. It extends downwards and forwards in the middle cornua; in other words, from the terminal point of one horn to that of the other, reaching internally as far as the foramen of Monro, and externally almost to the fissure of Sylvius. It is through this fissure the pia mater communicates with the choroid plexus within the ventricles.

The POSTERIOR CORNU of the lateral ventricle curves in and out into the posterior lobe, and terminates in a pointed extremity near the surface. Fig. 345, 12. The choroid plexus is not extended to this cavity; but its floor is marked by the *hippocampus minor*—a prominent cord-like elevation, composed of fibrous neurine externally and of vesicular structure within. Fig. 345, 15.

Fig. 345.



The lateral ventricles.

Fig. 345. Transverse section of the brain, showing the corpora striata, lateral ventricles and the associated parts. 1, 1, medullary portion of the hemispheres; 2, vesicular neurine or cortical portion; 3, corpus striatum; 4, septum lucidum; 5, ventriculus septi or fifth ventricle; 6, 6, the fornix; 7, posterior crura of the fornix; 8, base of the fornix; 9, 9, plexus choroides, at the margin of the velum interpositum; 10, anterior cornu of the lateral ventricle; 11, middle or descending cornu; 12, posterior cornu; 13, hippocampus major; 14, tænia hippocampi; 15, hippocampus minor; 16, longitudinal fissure of the brain.

THE CORPORA STRIATA.

The *corpora striata*, or anterior ganglia of the brain, are contained chiefly within the lateral ventricles, of which they largely contribute to form the floor; at the same time that their anterior, convex ends form the posterior boundaries of the anterior cornua of the lateral ventricles.

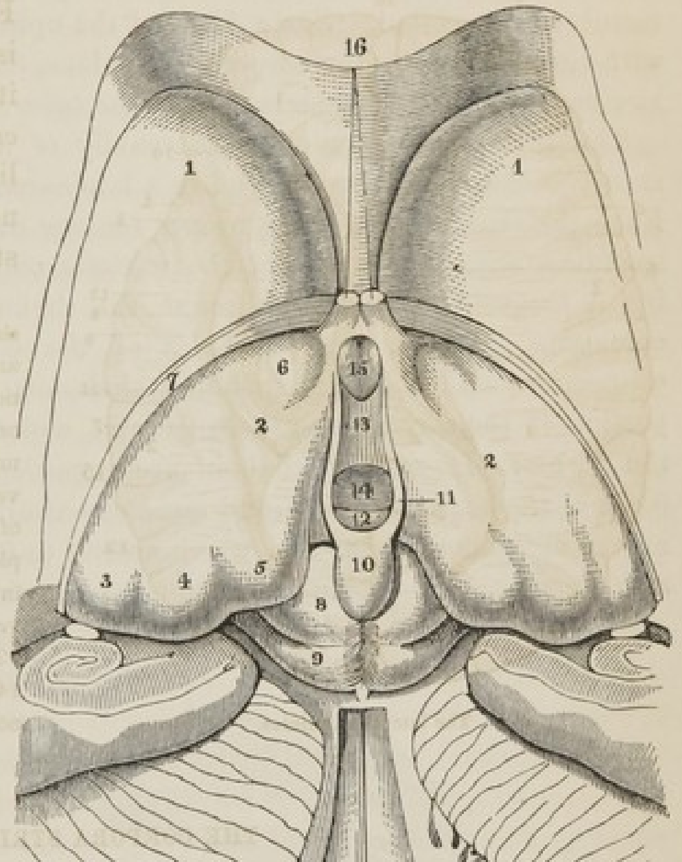
They are two elongated pyriform elevations, of which the convex bases present forward, while in the backward direction they taper to a point and diverge widely from each other, enclosing the optic thalamus within the triangular area thus formed. Fig. 345, 3, and 346, 1.

The corpora striata are composed externally of cineritious neurine; but when divided they are seen to consist of that substance blended with medullary fibres derived from the crura cerebri. These white fibres are collected into fasciculi which, on entering the ganglion, subdivide and radiate in every direction. According to the researches of Drs. Todd and Bowman, a part of these medullary filaments terminate in the ganglion, while others emerge from it and

contribute to form the fibrous matter of the hemisphere; and spreading like the rays of the sun, some forwards, some backwards and others outwards, terminate in the cineritious neurine of the hemispherical ganglia. The corpora striata are also called, in reference to their function, the *motor ganglia of the spinal cord;* for they are connected with the *motor* columns of the crura cerebri, and by means of these, directly with the corpora pyramidalia of the medulla oblongata. This connection is moreover illustrated by the constancy with which paralysis is observed to accompany even trifling lesions of those bodies.

If we now raise the fornix by cutting through its anterior crura, and then lay it backwards over the posterior lobes, we find immediately beneath it a vascular membrane called the *velum interpositum*, which will be presently described with its several connections; and if we next carefully remove this membrane, two prominent bodies, the optic thalami, are brought conspicuously into view.

Fig. 346.



Interior of the brain. After Vicq d'Azyr.

Fig. 346. Optic thalami, corpora striata, third ventricles, &c. 1, 1, corpora striata; 2, 2, optic thalami; 3, corpus geniculatum externum; 4, corpus geniculatum medium; 5, corpus geniculatum internum; 6, tuberculum anterius; 7, tænia striata or tænia semicircularis; 8, 9, tubercula quadrigemina (8, nates; 9, testes); 10, pineal gland; 11, peduncles of the pineal gland; 12, posterior commissure; 13, commissura mollis; 14, 15, third ventricle; 15, marks the position of the foramen of Monro; 16, anterior crura of the fornix, in front of which, but not here seen, is the anterior commissure; 17, calamus scriptorius; 18, cerebellum and arbor vitæ.

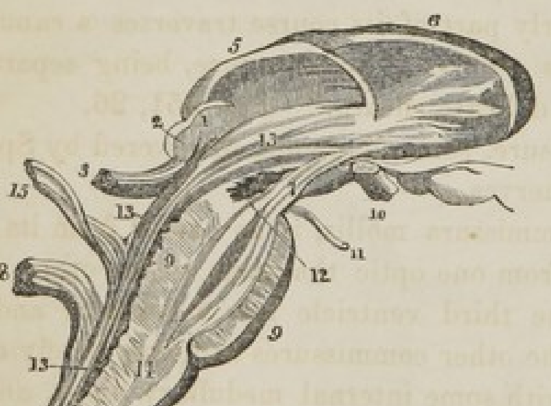
THE OPTIC THALAMI.

The *optic thalami*, or posterior cerebral ganglia, or, physiologically speaking, the *sensory ganglia* of the spinal cord, are two convex pear-shaped bodies, em-

braced as we have already observed, between the divergent limbs of the corpora striata, and lying on the crura cerebri, which they in a manner embrace. Its upper rounded surface is partly within the lateral ventricle, while its posterior attenuated portion projects into the middle horn of that ventricle, and is partly covered by the fornix. Where each thalamus is thus related by its posterior border with the middle cornu, it presents three little elevations called by Vicq d'Azyr the *corpora geniculata*, one of which is internal, a second external and the third intermediate between the two. Fig. 346, 3, 4, 5. They certainly appear to form a part of the thalami, although Mr. Solly believes them to be merely in apposition. Some fibres of the optic tracts seem also to be connected with them. Besides the corpora geniculata, the optic thalamus has, at its anterior margin, a fourth tubercle called the *tuberculum anterius*. Fig. 346, 6.

The thalami are composed externally of medullary neurine, but this substance is blended internally and in a laminated form with cineritious substance. Each thalamus, which is the proper *sensory tract*, is continuous with the corresponding olivary ganglion of the medulla oblongata, as may be seen by making a longitudinal section through the thalamus, mesocephalon and medulla oblongata. Again, the peduncles of the olfactory nerves have a distinct connection with the corresponding thalamus, the former by the passage of a portion of their roots into these ganglia, and the latter through the medium of the fornix. Hence the thalami are regarded by Dr. Carpenter as the chief focus of the *sensory nerves*, and more essentially as the ganglionic centre of the nerves of *common* sensation, which ascend to it from the medulla oblongata and spinal cord. This conclusion is supported by the fact, that all the nerves of pure sense are more or less directly connected with the optic thalami, or with the olivary columns;* at the same time that the thalami appear also to receive motor fibres, some from the olivary and others from the pyramidal tracts.

Fig. 347.



Sensory tract and optic thalamus. From Solly.

Fig. 347 shows the connection of the optic thalami with the sensory tract. 1, anterior optic tubercle (nates); 2, posterior tubercle (testes); 3, processus e cerebello ad testes or intercerebral commissure; 4, spinal cord; 5, optic thalamus; 6, corpus striatum; 7, crus cerebri; 8, corpus restiforme; 9, pons Varolii; 10, optic nerve; 11, third pair of nerves; 12, locus niger; 13, 13, 13; sensory tract; 14, pyramidal or motor tract; 15, sensory root of the fifth pair.

These ganglia form, as we have seen, the upper parietes of the middle cornua of the lateral ventricles; and they embrace between them a narrow, elongated cavity, the *third ventricle*. Fig. 346, 14, 15.

The *tænia semicircularis* is a narrow cord of medullary neurine, placed between

* Principles of Physiology, § 423.

the corpus striatum and the optic thalamus. It runs backwards into the middle cornu of the ventricle, where it is insensibly lost; but in front it can be traced to the anterior crura of the fornix, and thence to the superior longitudinal commissure. Fig. 346, 7. Beneath each of these tænia is a vein, *vena Galeni*, which receives other veins from the corpus striatum and terminates in the choroid plexus.

THE THIRD VENTRICLE AND PARTS CONTIGUOUS.

The *third ventricle* having been exposed by raising the velum interpositum, is seen to be a narrow, oblong fissure, bounded on both sides by the convex margins of the optic thalami. The roof of this cavity, as already remarked, is the fornix; and its floor is formed by the posterior perforated space, the corpora labicantia, the tuber cinereum and the crura cerebri. In front are the anterior crura of the fornix, and behind, the posterior commissure. Fig. 346.

Three commissures are connected with the third ventricle and are found within it: they are called, according to their position, anterior posterior and middle commissures.

The *anterior commissure* passes transversely between the two hemispheres, connecting them together. It is a cord-like fasciculus of medullary fibres about two lines in diameter, placed directly in front of the anterior crura of the fornix. It commences near the pes hippocampi of the lateral ventricle, and at the floor of the Sylvian fissure, by many white and expanded fibres, which converge as they approach the corpus striatum. They penetrate the latter ganglion and receive from it some accessory fibres; and having reached the inner border of this ganglion, form a commissural cord that joins its fellow of the opposite side. In its course through the corpora striata this commissure does not mix with its substance, but in the early part of its course traverses a canal in the ganglion. It moreover resembles a nerve in its structure, being separable into fasciculi of fibres embraced in a delicate sheath.* Fig. 351, 26.

From the outer part of this commissure, some filaments, discovered by Spurzheim, can be traced to the olfactory nerves.

The *soft* or *middle commissure*, commissura mollis, is so named from its soft and pulpy consistence. It extends from one optic thalamus to the other, connects them together, and divides the third ventricle into a superior and an inferior portion. This differs from the other commissures in being chiefly composed of vesicular neurine, blended with some internal medullary fibres, and it corresponds with the gray matter which, crossing the mesial line in the spinal cord, connects the two sides of the cord.† Fig. 346, 13.

The *posterior commissure* is a narrow, flattened band of medullary neurine in the posterior part of the third ventricle. It passes transversely between and connects the optic thalami, directly in front of the optic tubercles and above the orifice of the aqueduct of Sylvius. It sustains the base of the pineal gland, to which it is connected by fibrous matter continuous with the peduncles, and

* Horner. Anatomy and Histology, ii. p. 401.

† Solly, p. 210.

then runs forwards on the upper and posterior surfaces of the corresponding optic thalamus, on which it is insensibly lost. Its lower margin is blended with the upper border of the tubercula quadrigemina. Fig. 346, 12.

The *iter ad quartum ventriculum*, or aqueduct of Sylvius, is a canal that begins in the posterior base of the third ventricle, and passing beneath the proximate commissure and the tubercula quadrigemina, opens into the fourth ventricle.

The *iter ad infundibulum* is another duct or cæcal canal that opens into the anterior angle of this ventricle. It passes downwards to the base of the infundibulum, where it terminates abruptly.

LINING MEMBRANE OF THE VENTRICLES.

All the five ventricles are lined by a continuous membrane of a delicate structure and transparent nature. From the lateral ventricles it can be traced through the aqueduct of Sylvius into the fourth, and through the foramen of Monro into the fifth ventricle. It is most distinct upon the septum lucidum, corpora striata and digital cavities: and it is by some anatomists described as a continuation of the pia mater, by others, of the arachnoid tunic; but neither of these opinions has been demonstrated. Bichat was so confident of the latter arrangement that he called the ventricular membrane the *internal arachnoid.*

The ventricular membrane belongs to the serous class, and from it is derived the halitus always found in small quantity in the cerebral cavities, and which is remarkably augmented in some morbid conditions of the brain.

The so called *canal of Bichat* was supposed by that distinguished anatomist to pass between the posterior end of the corpus callosum and fornix, above the pineal gland, into the third ventricle. He taught that the arachnoid and ventricular membranes were continuous through this channel; but its existence, at least as a constancy, is rejected by most anatomists of the present day.

THE CHOROID PLEXUS AND VELUM INTERPOSITUM.

We have already observed, that when the fornix is separated at its anterior crura and thrown backwards, a delicate membranous network is found placed between that commissure and the third ventricle: this is the *velum interpositum* or tela choroidea. It adheres firmly to the fornix; and the pineal gland is so closely connected with its posterior filaments, as to separate with the velum unless the latter is raised with great care. Fig. 345, 9, 9.

The velum interpositum is a continuation of the pia mater, which enters the ventricles through the transverse fissure, beneath the corpus callosum and fornix, and above the corpora quadrigemina and pineal gland. The membrane thus formed is of a triangular shape, with its base presenting backwards. It keeps the third ventricle closed above, except where this cavity communicates with the lateral ventricles through the foramen of Monro.

The *choroid plexuses*, two in number, form the lateral margins of the velum interpositum, from the foramen of Monro before, to the terminal point of each middle cornu of the lateral ventricles behind: in other words, it descends along the hippocampus major to the fissure of Sylvius. At the latter place the plexuses are narrow and pointed, but they increase in width as they ascend, and form a red fringe of tortuous blood-vessels on each side of the velum. Fig. 345, 9. These blood-vessels consist of both arteries and veins: the latter form two small trunks called *venæ Galeni*, which pass backwards beneath the corpus callosum, and uniting in a single trunk, discharge their blood into the sinus quartus. Fig. 330, 3.

The choroid plexuses are connected with each other at the foramen of Monro; and on raising the velum interpositum, another small plexus will be observed running backwards and terminating in the vena Galeni. It receives the venous blood of the third ventricle. A similar arrangement obtains in the fourth ventricle.

The choroid plexuses are supposed to be covered by a reflection of the lining membrane of the ventricle, which thus excludes them from the ventricular cavity, in the same way that the intestines are placed outside of the sac of the peritoneum. This epithelial covering is said to be composed of rounded corpuscles, "in each of which is seen, besides a distinct nucleus, a small, bright yellow spot."

THE CORPORA QUADRIGEMINA, PINEAL GLAND, ETC.

The *tubercula quadrigemina*, or optic tubercles, are situated upon the crura cerebri, directly behind the posterior commissure of the third ventricle, and beneath the contiguous margin of the corpus callosum. They consist of four rounded elevations, separated from each other by a crucial furrow, of which the longitudinal portion is on a line with the third ventricle. The largest pair of these tubercles is above, and is called the *nates;* the other and smaller pair, the *testes*, is placed behind; and they collectively form a convex body about three-fourths of an inch in diameter, which is perforated by the aqueduct of Sylvius. Fig. 347, 1, 2, and 340, 1, 2.

The nates are covered externally by neurine of a grayish-white color; but the testes are of a lighter tint, being externally nearly as white as medullary matter elsewhere. Internally they are wholly cineritious or gangliform in structure.

These bodies are connected to the optic thalamus by a rounded fasciculus of medullary fibres that extends from the fore and lateral portion of the cerebellum below, to the testes above, and is thence prolonged to the corpus geniculatum internum. These cords constitute the *processus e cerebello ad testes*, which thus connects the cerebellum with the cerebrum, and is, in truth, a peripheral portion of the valve of the brain. Fig. 347, 3. Two smaller fasciculi of the same character are given off from the tubercula quadrigemina on each side, and pass forwards to the thalami and the origins of the optic nerve; one of these

tracts that runs from the nates to the thalamus is called the *brachium anterius;* the other arises from the testes, and is the *brachium posterius* of authors.

The tubercula quadrigemina are placed intermediately between the cerebrum and cerebellum, and may be described as appendages of either. According to Solly, they are the instruments by means of which the physical impressions of light, received by the retina, are converted into sensations of light, color, form, &c.

The VALVE OF THE BRAIN, or valve of Vieussens,—velum medullare,—is a thin plane of medullary neurine that is continuous with the lower margin of the testes, whence it extends as the roof of the fourth ventricle. It is attached laterally to the processus e cerebello ad testes on each side, which processes are, as before stated, but parts of the valve itself, and it merges below in the median portion of the cerebellum. It is narrow above and broad inferiorly. Although its structure is essentially medullary, its lower half is marked by some transverse striæ of cineritious neurine derived from the cerebellum.

This valve is called by Solly the *intercerebral commissure*, for according to his dissections, it connects the cerebrum with the cerebellum in the following manner; 1st, by its superior fibres, which are continuous with the processus e cerebello ad testes; 2d, by other and external fibres of the same processes, which can be traced forwards to the optic thalami; and thirdly, by some descending filaments that can be followed through the locus niger of the crus cerebri, until they become continuous with the motor tract.*

The PINEAL GLAND, or conarium, is a conical mass of vesicular neurine, placed upon the nates of the tubercula quadrigemina, and beneath the posterior margin of the fornix. It is somewhat variable in form and size, but is generally about three lines in diameter. It is connected to the brain by two cords of medullary neurine called its *peduncles:* these peduncles run along the upper, internal border of the optic thalami, and can be readily traced to the anterior crura of the fornix, where they are joined by filaments from the corpora albicantia. In front of the base of the pineal gland is the posterior commissure; and the two structures are connected by a thin transverse lamina of medullary neurine, which may perhaps be regarded as the posterior margin of that commissure. The pineal gland is connected at its base with the velum interpositum, so that the incautious removal of the latter is apt at the same time to separate the gland. Fig. 346, 10.

This body usually contains a cell, or cæcal cavity, that opens into the third ventricle. It also contains an aggregation of gritty particles called the *acervalus cerebri*, not unfrequent in infancy, but rare in the fœtus; and its presence is not constant, according to Meckel, until about the age of six or seven years, after which period it invariably exists. It is usually found in the interior of the gland, either disseminated or collected into a mass; but in other instances the granules occur on the surface, and Cruveilhier has even found them attached to the peduncles.

Solly calls the pineal gland and its peduncles, the *pineal commissure.* It

* On the Human Brain, p. 215.

was believed by Descartes to be the seat of the soul; but modern physiologists have been unable to give even a plausible conjecture as to its function.

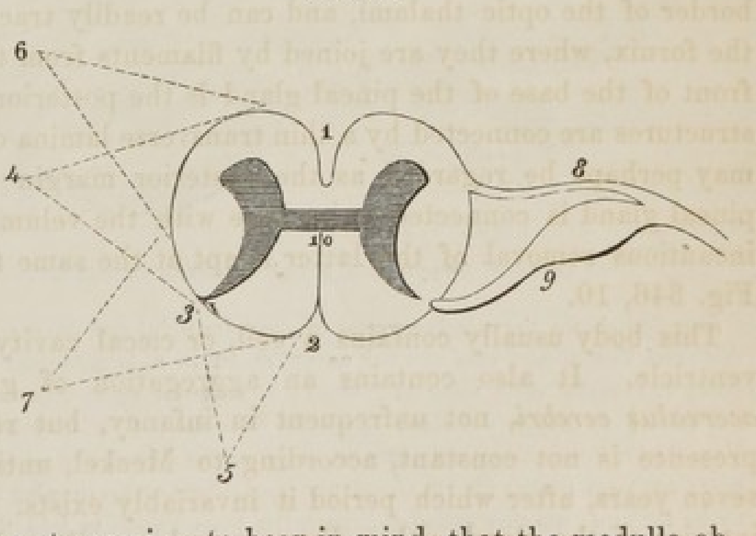
ON THE RELATIVE POSITION AND FUNCTION OF THE ENCEPHALIC ORGANS AND SPINAL CORD.

We have hitherto analyzed the structure of the brain by examining its parts without particular regard to their mutual relations; and it therefore remains to show, by a sort of synthesis, the continuity of this remarkable series of organs.

It has been repeatedly mentioned, in treating of the spinal cord, that the anterior roots of the spinal nerves are nerves of motion, while the posterior roots subserve the function of sensation; hence it is that the anterior column of the spinal cord, on each side, is called the *motory column*, and the posterior the *sensory column*.

This view, however, requires some qualification; for it must be remembered that in the composition of the spinal cord itself, no line of demarkation exists to separate the tract of motion from that of sensation;* for the first is wholly, and the latter partly, embraced in the antero-lateral column: but experiments have led to the conclusion that this line is about the middle of the lateral aspect of the cord. The sensory tract must, therefore, consist of two portions, one of which is behind the postero-lateral fissure and the other in front of it; the latter fasciculus being of course the one that lies in apposition to, and is apparently continuous with, the anterior column. These divisions, so obscure in the spinal cord, become, as we have seen, strongly marked in the medulla oblongata.

Fig. 348.



The annexed outlines, Fig. 348, will exemplify the arrangement in question. 1, 2, represent the anterior and posterior fissures; 3, postero-lateral fissure, whence originate the posterior roots of the spinal nerves; 4, antero-lateral column of the spinal cord; 5, posterior column of the cord; 6, motory portion of the cord; 7, sensory portion; 8, anterior root of spinal nerve; 9, posterior root; 10, commissure connecting the spinal ganglia or cineritious neurine of the cord.

It is necessary on the present occasion to bear in mind, that the medulla oblongata has, on each side, four distinct tracts of nervous matter, viz.: 1, the

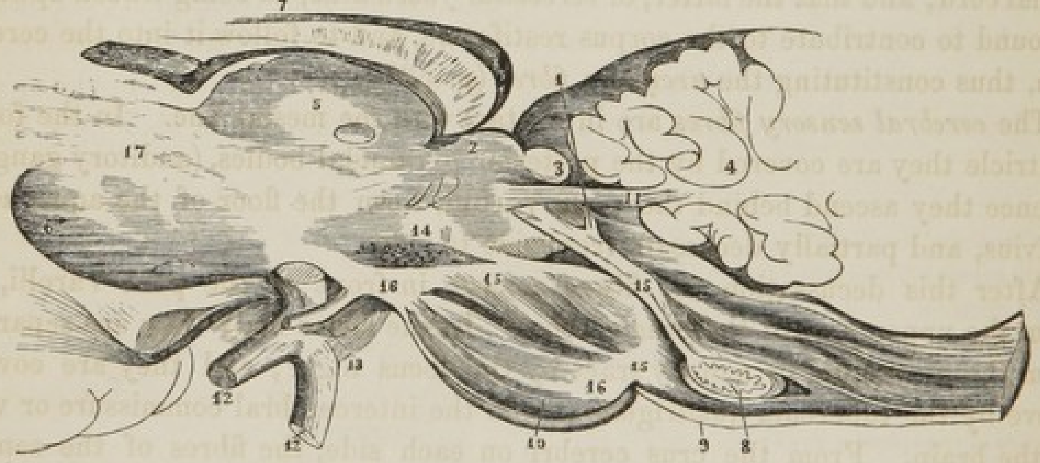
* "That the boundary line between the two organs of sensation and voluntary motion, comprised within the spinal cord, cannot be formed by the posterior peak of gray matter, is very decidedly proved by the fact, that a portion of the fifth pair of nerves, which we know to be a nerve of sensation, is not connected with the posterior, but with the lateral columns."—*Solly*. The Human Brain, p. 188.

anterior pyramid; 2, the olivary body; 3, the corpus restiforme, and 4, the posterior pyramid.

1. THE PYRAMIDAL OR MOTORY TRACT.—If we follow up the motory column, (the anterior divisions of the antero-lateral columns of the spinal cord,) to the medulla oblongata, we shall there find it represented by the corpora pyramidalia, which, in their course forwards, pass through the pons Varolii and reappear in front of that body in the form of two large cords, the crura cerebri. Fig. 352, 11. These cords, having received accessory fibres within the pons, are larger at their exit from, than at their entrance into, that commissure; and immediately on their emergence, diverge from each other, embracing in the intervening angle the pons Tarini. Fig. 342, 24.

This divergence of the motor fibres increases as they ascend, until they radiate, like the rays of the sun, through the corpora striata or anterior cerebral ganglia, and thence by a still greater expansion are prolonged into the hemispheres. Here they contribute largely to the bulk of the brain, and terminate in the great envelope of cortical neurine, the hemispherical ganglion. Whether these terminal fibres are pointed, or form curved anastomoses with each other, is undetermined; but, judging from analogy, we might infer the latter arrangement. Fig. 344. The motor tract also expands partially in the optic thalamus, and has, moreover, filamentous connections with the cerebellum. Fig. 350.

Fig. 349.



Course of the pyramidal and olivary tracts through the pons Varolii. After Solly.

Fig. 349 shows the relative course of the pyramidal and olivary portions of the motor tract through the pons Varolii and crus cerebri, as exhibited in a longitudinal section. 1, motor root of the fifth pair; 2, anterior optic tubercle (nates); 3, posterior optic tubercle (testes); 4, cerebellum; 5, optic thalamus; 6, corpus striatum; 7, corpus callosum; 8, olivary body; 9, pyramidal body; 10, pons Varolii; 11, intercerebral commissure, or processus è cerebello ad testes; 12, 12, optic nerves; 13, third pair; 14, locus niger; 15, 15, 15, olivary tract; one portion running up to the optic tubercles and thence to the thalami; another passing through the pons Varolii to join the crura cerebri: 16, the pyramidal tract running through the pons, the continuation of which through the corpus striatum is indicated at 17.

2. The OLIVARY TRACT is brought into view by cutting into the olivary ganglion, where its roots will be seen in two fasciculi of medullary neurine, one passing before, and the other behind the ganglion, and known as the fasciculi siliquæ. The innermost of these bands, *funiculus siliquæ internus*, accompanies the fibres of the corpus pyramidale into the crus cerebri, in which it becomes

continuous, both in structure and function, with the motor or voluntary tract. The *funiculus siliquæ externus* unites with a fasciculus proceeding from the nucleus olivæ; and the combined column, ascending behind the crus cerebelli, divides into a superior and an inferior band; the latter runs to the upper segment of the crus cerebri, and is supposed to belong to the *sensory tract;* while the superior band ascends by the side of the processus è cerebello ad testes, enters the tubercula quadrigemina, and is lost in the optic thalamus.* This part of the olivary column is called by Solly the *olivary commissure.* Fig. 349, 15, 16.

The reader will see, from the foregoing observations, that the course and function of the corpora pyramidalia are definitively ascertained; viz., that they form the whole of the anterior and part of the posterior cerebral ganglia.† The anatomy of the olivary tract, on the other hand, is still a vexed question; a large part of its fibres being sensory, another part motory;‡ and since the optic thalamus or posterior ganglion is constituted of motor filaments from the corpus pyramidale, and of both motor and sensory filaments from the olivary and posterior tracts, it must subserve a double function in the nervous system. This fact is now generally admitted: but the course and termination of these blended fibres are by no means satisfactorily determined. Fig. 347.

3. THE GREAT SENSORY TRACT.—For the purpose of greater distinctness, it should be remembered that the sensory column, as above stated, consists of two fasciculi, one in front of, and the other behind, the postero-lateral fissure of the spinal cord; and that the latter, or *cerebellar fasciculus,* on being traced upwards, is found to contribute to the corpus restiforme, and to follow it into the cerebellum, thus constituting the *arciform fibres* (p. 537).

The *cerebral sensory fibres* are in contact with the mesial line. In the fourth ventricle they are covered by the posterior pyramidal bodies, (auditory ganglia,) whence they ascend behind the pons Varolii, form the floor of the aqueduct of Sylvius, and partially decussate from side to side.

After this decussation the fibres emerge in front of the pons Varolii, and form the upper part of the crus cerebri. In the latter body they are separated from the pyramidal or motory tract by the locus niger; and they are covered above by the tubercula quadrigemina and the intercerebral commissure or valve of the brain. From the crus cerebri on each side, the fibres of the sensory tract expand into the optic thalamus of the corresponding side. This course of the fibres through the posterior cerebral ganglion is not so distinctly marked as that of the motor tract through the anterior ganglion; for in the former instance the medullary and vesicular neurine are more blended together: but from the outer side of their affiliated ganglion the medullary fibres issue forth, spreading in every direction into the hemispheres, until their progress is arrested by the cineritious envelope of those bodies. Such is Mr. Solly's description of the collective sensory tract, respecting which, however, there is great diversity of opinion.§

* Dr. Erasmus Wilson. Anatomy, p. 413. † Cruveilhier. Anatomy, p. 716.

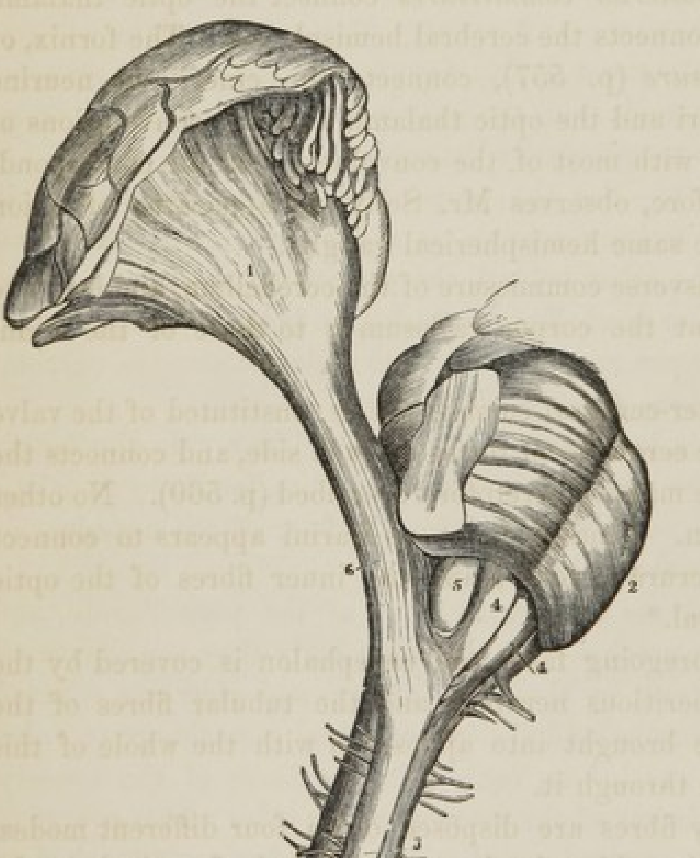
‡ Dr. Reid, apud Solly, p. 239. Dr. Carpenter insists that the olivary tract is composed exclusively of sensory fibres. Elem. of Phys., § 901.

§ Solly. Opera citat., p. 202.

4. The POSTERIOR PYRAMIDS, or auditory ganglia, lie behind the corpora olivaria in the substance of the medulla oblongata, ascend behind the pons Varolii, reach the floor of the fourth ventricle, and are thence prolonged beneath the corpora quadrigemina into the crura cerebri. After forming the upper and outer segment of the crura, the posterior pyramids are continued through the optic thalami and corpora striata into the hemispheres of the brain.*

5. The CRURA CEREBELLI, as heretofore explained, are formed on each side of three fasciculi or peduncles. The first or superior peduncle terminates in the testis of the tubercula quadrigemina. The middle peduncle has been so fully described as to need no further notice (p. 541). The inferior peduncles are derived from the *corpora restiformia*, of which they are a continuation. They diverge as they approach the cerebellum, surround the corpora dentata, and then expand so as to form the medullary stem-like and laminated neurine of the cerebellum. Figs. 352, 6, and 351, 5. The office of this structure appears to be, in part at least, to transmit the influence of the cerebellum to the spinal cord and mesocephalon.

Fig. 350.



Connection of the crus cerebelli with the pyramidal columns of the medulla oblongata. After Solly.

Fig. 350 is particularly designed to show those fibres of the anterior or pyramidal columns, which, ascending to the cerebellum, connect the motor tract with that portion of the encephalon. 1, cerebellum; 2, pons Varolii; 3, anterior columns of the spinal cord; 4, 4, corpora pyramidalia; 5, corpus olivare of the right side; 6, corpus restiforme; its surface having been carefully scraped in order to show the *superficial cerebellar fibres* of the anterior columns. "They are represented rather more distinct and thick than they really appear, though their course and relation to the olivary body are faithfully given."†

The preceding fibres belong to the *diverging* class, and form, by their expansion, the medullary mass of the cerebrum and cerebellum. The other or *converging* series of fibres connects the two hemispheres together, and constitute

* Wilson. Loco citat. This arrangement is altogether denied by some physiologists. *Vide* Carpenter. Elements of Physiology, § 893.

† Solly, Fig. 89.

the structures already described by the name of *commissures*, or connecting media of the different medullary masses, either of the same or of opposite sides of the brain. All these commissures, which we have fully described, are transverse excepting two,—the superior and inferior longitudinal commissures.

The *corpus callosum*, or great transverse commissure (p. 549), is so spread out in the hemispheres of the brain, that its fibres are everywhere in contact with the internal surface of the cineritious neurine of the convolutions; they consequently establish a communication between the whole convoluted surface of both sides of the cerebrum.

The *superior longitudinal commissure* (p. 551), which we have traced from the locus quadratus in the fissure of Sylvius, through the brain, and back again to terminate near the place of its origin, receives the medullary fibres of all the convolutions of the superior and lateral portions of the hemispheres.

The *soft and pineal and posterior commissures* connect the optic thalami, and the anterior commissure connects the cerebral hemispheres. The fornix, or *inferior longitudinal commissure* (p. 557), connects the cineritious neurine (locus niger) of the crus cerebri and the optic thalami, with the convolutions of the two hemispheres, and also with most of the convolutions of the corresponding hemisphere. It is, therefore, observes Mr. Solly, an apparatus of union between different points of the same hemispherical ganglia.

The *pons Varolii* is the transverse commissure of the cerebellum, and is to the hemispheres of that body what the corpus callosum is to those of the brain. Fig. 350, 2.

The *cerebello-cerebral*, or inter-cerebral commissure, is constituted of the valve of the brain and the processus è cerebello ad testes on each side, and connects the cerebrum and cerebellum in the manner heretofore described (p. 560). No other fibres enter into this connection. Finally, the pons Tarini appears to connect the vesicular neurine of the crura cerebri; and the inner fibres of the optic tracts are evidently commissural.*

Thus, to recapitulate the foregoing facts, the encephalon is covered by the hemispherical ganglion of cineritious neurine; and the tubular fibres of the brain are so arranged as to be brought into apposition with the whole of this ganglionic mass and to radiate through it.

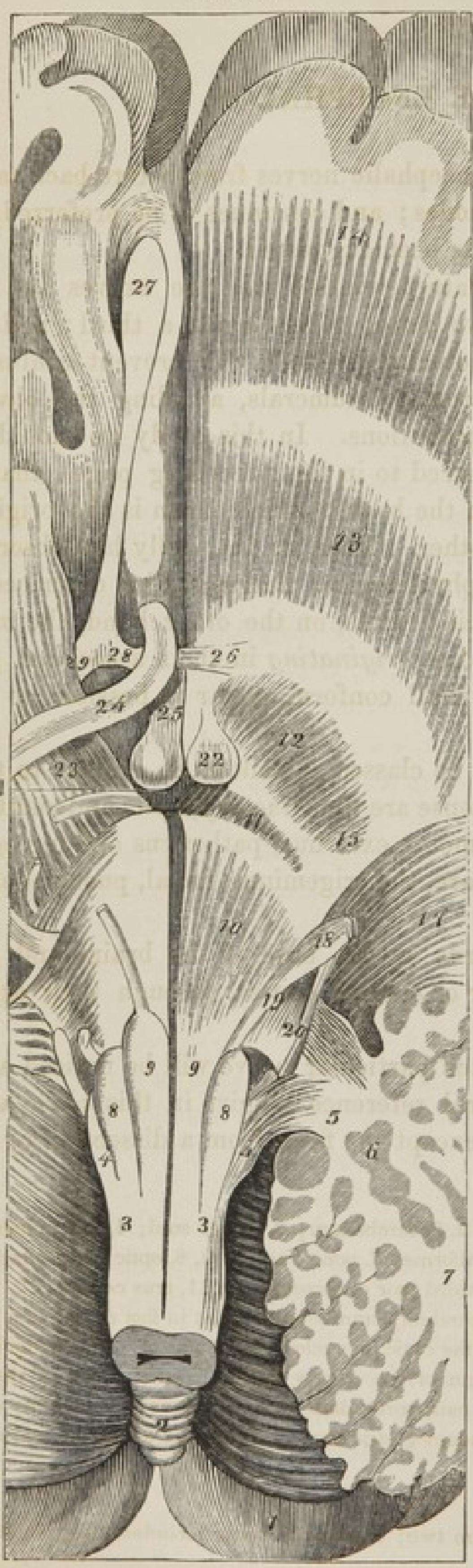
These tubular or medullary fibres are disposed of in four different modes. 1. A part of them commence (speaking in the order of their function), in the convolutions of the anterior, middle and posterior lobes of the brain, pass through the corpora striata, and converging to form the anterior layer of the crus cerebri, perforate the pons Varolii, and re-appears at its posterior margin in the corpora pyramidalia, or anterior columns of the cord. This is the *motor tract*.

2. Another series of medullary fibres commences below in the apparatus of sensation, passes upwards through the pons Varolii, forms the medullary elements of the optic thalamus, and then radiating in the brain, terminates in the same neurine that gives origin to the motor tract: this is the *sensory tract*.

3. Other fibres pass from one side of the brain to the other, and in apposition

* Todd and Bowman, p. 288.

Fig. 351.



Expansion of the medulla oblongata to form the cerebral hemispheres. After Quain.†

to the internal surface of all the convolutions: these fibres constitute the transverse commissure of the brain, which are aided by the smaller accessory commissures.

4. Other commissural fibres pass from front to back, as seen in the superior and inferior longitudinal commissure, which connect together those convolutions situated on the same side of the mesial line, or, in other words, different portions of the same hemispherical ganglion.*

Fig. 351 illustrates the development and expansion of the cerebrum and cerebellum, from the primitive fasciculi of the medulla oblongata. 1, posterior lobe of the brain; 2, inferior vermiform process; 3, 3, medulla oblongata; 4, 4, corpora restiformia, which at 5, expand into the cerebellum; 6, corpus rhomboideum; 7, left lobe of the cerebellum, divided by a longitudinal incision, so as to show the *arbor vitæ;* 8, corpora olivaria; 9, corpora pyramidalia; 10, diverging (motor) fibres of the corpus pyramidale, passing forwards through the vesicular neurine of the pons Varolii; 11, passage of the same fibres through the crus cerebri; 12, passage of the same fibres through part of the optic thalamus, or posterior ganglion of the brain; 13, passage of the same diverging fibres of the corpus pyramidale, through the anterior cerebral ganglion, (corpus striatum,) and 14, their expansion to form the medullary neurine of the cerebral hemisphere; 15, 16, 17, divergence and expansion of the corpus olivare (8), through the posterior cerebral ganglion into the hemisphere, but principally into the posterior lobe; 18, trigeminus nerve; 19, its anterior root, which is continuous with the diverging fibres of the corpus pyramidale; 20, its posterior root, passing forwards from the corpus restiforme; 21, locus perforatus; 22, corpora albicantia; 23, crus cerebri; 24, optic tract; 25, infundibulum; 26, anterior commissure of the brain; 27, bulb of the olfactory nerve; 28, its inner root; 29, its external root.

* Solly. 2d English edit. p. 280.

† Longitudinal section, drawn from Plate X. of Dr. Quain's Nerves of the Human Body, by my pupil Mr. William T. W. Dickeson. See also Fig. 242.

NERVES OF THE ENCEPHALON.

The customary enumeration of the encephalic nerves from before backwards, has some advantages over all other modes; and continues to be preferred, for practical purposes, to any other that has been suggested.

Willis, the author of this nomenclature, classed all the nerves in nine pairs; other anatomists have added two more; others again a third; and the whole number of cerebral nerves is actually twelve.* To prevent confusion, however, we shall adhere to the customary numerals, avoiding the obvious objections to them by the requisite explanations. In this study we should not lose sight of the fact so repeatedly referred to in the preceding pages, that all the cerebral nerves do not originate in the brain; which organ is the origin of one series and the termination of another. Thus, as Mr. Solly has observed, the *sensory nerves* should, in strict physiological language, be described as *terminating* in their appropriate ganglia; while, on the other hand, the *motor* or *voluntary nerves* should be described as *originating* in their associated ganglia; and on the present occasion we shall conform, as far as possible, to this physiological rule.

The nerves of the encephalon may be classed as follows in respect to their functions, viz.:—The nerves of special sense are the olfactory, optic and auditory. Those of motion are, the motor oculi, motor externus, patheticus and hypoglossal. The nerves of compound function are, the trigeminus, facial, pneumogastric and spinal accessory.

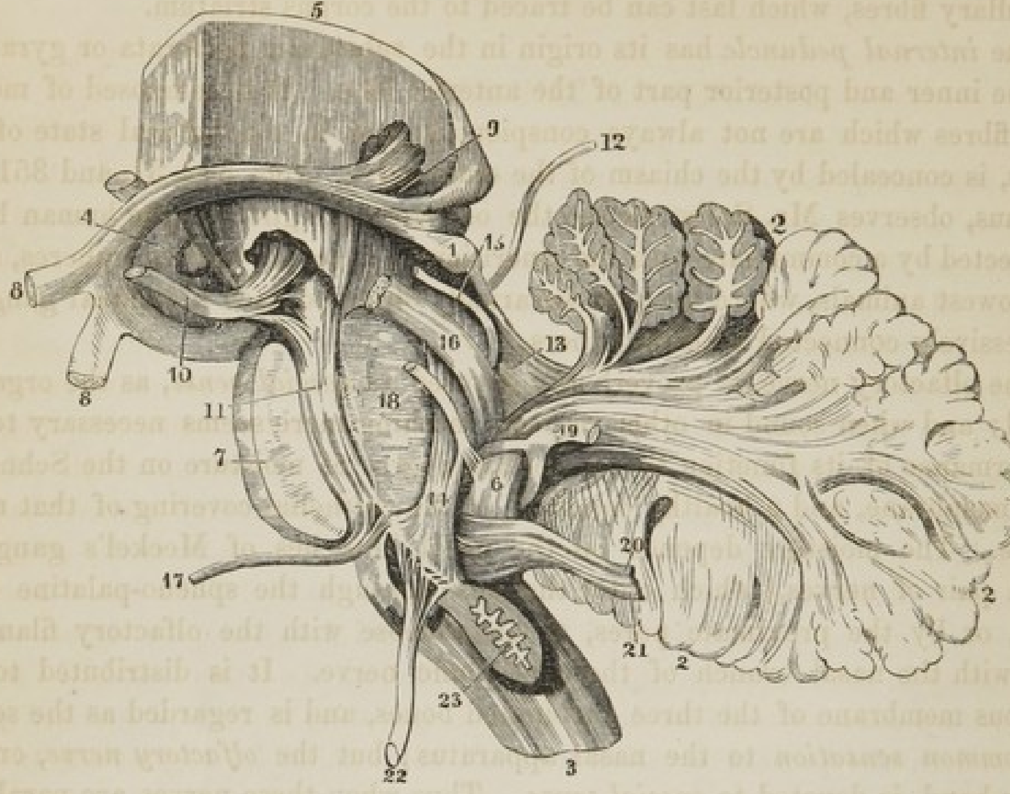
These nerves appear as distinct cords on the base of the brain, and they issue from the cranium, after a longer or shorter course, through their appropriate foramina.

The character and connections of each particular nerve will be noticed as we proceed; but for the purpose of general reference we give in this place a collective view of all the cerebral nerves except the first, from a dissection by Mr. Solly.

Fig. 352. 1, testis, or posterior optic tubercle; 2, 2, cerebellum; 3, spinal cord; 4, tuber cinereum; 5, optic thalamus, divided vertically; 6, corpus restiforme; 7, pons Varolii; 8, 8, optic nerve; one of its roots, 9, enters the substance of the thalamus; 10, third pair or motor oculi; 11, crus cerebri; 12, fourth pair, trochlearis, apparently arising from the inter-cerebral commissure, 13, but in fact descending to the olivary tract, 14, as the latter passes upwards to the optic tubercles; 15, motor or non-ganglionic root of the fifth pair, arising from the posterior margin of the olivary tract; 16, sensory root of the fifth pair; 17, sixth pair, abducens oculi; 18, seventh pair, portio dura or facial nerve; 19, auditory nerve, portio mollis; 20, glosso-pharyngeal nerve; 21, pneumogastric nerve; 22, lingual or hypoglossal nerve; 23, olivary body with the corpus dentatum.

* Five pairs were so classed by Willis as to form two; three pairs being included in his eighth and two in his seventh pair.

Fig. 352.



Nerves of the encephalon. From Solly.

THE FIRST PAIR OF NERVES.—OLFACTORY.

The olfactory nerve lies on the under surface of the anterior lobe of the brain, a very short distance to the outer side of the longitudinal fissure. In regard to function, they must be traced from the nose to the brain. Thus, they originate by fifteen or twenty filaments in the Schneiderian membrane, and converging towards the ethmoid bone, enter the cranium through the foramina of the cribriform plate, where they terminate in two vesicular enlargements called the *olfactory bulbs* or *ganglia*. Each of these ganglia lies in its appropriate fossa in the ethmoid bone; they are not composed exclusively of cineritious neurine, but are blended within with medullary fibres.

Continuous with the posterior extremity of the ganglion, is a long, slender, triangular peduncle or commissure, which continues in the form of a single cord until it arrives opposite the fissure of Sylvius, where it separates into three branches, usually called the *roots* of the olfactory nerve.

The *external branch*, which is the largest, can be traced in the form of a white streak, along the fissure of Sylvius almost to the anterior extremity of the middle lobe of the cerebrum; it is also connected by some filaments with the anterior commissure; but whether it has been traced to the superficial layer of the optic thalamus, as some anatomists maintain, is not certain. Figs. 342, 32, and 351, 29.

The *middle peduncle* is the shortest of the three, is connected with the posterior edge of the anterior lobe of the cerebrum. It is composed externally of

vesicular neurine derived from the proximate convolutions and embracing some medullary fibres, which last can be traced to the corpus striatum.

The *internal peduncle* has its origin in the substantia perforata or gyrarium of the inner and posterior part of the anterior lobe. It is composed of medullary fibres which are not always conspicuous, and, in the natural state of the parts, is concealed by the chiasm of the optic nerve. Figs. 342, 31, and 351, 28.

Thus, observes Mr. Solly, we see the olfactory ganglion of the human brain connected by a commissure with the cineritious neurine of the hemispheres, as in the lowest animals, where we have invariably observed each individual ganglion successively connected with the others.

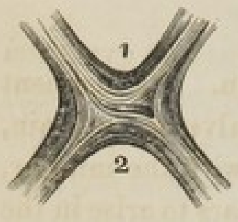
The olfactory nerve is proverbially devoted to *special sense*, as the organ of smell; and when sound in other respects, nothing more seems necessary to the performance of its function than a certain degree of moisture on the Schneiderian membrane, and a healthy condition of the epithelial covering of that membrane. The moisture depends on the nasal branches of Meckel's ganglion, (fifth pair of nerves,) which enter the nose through the spheno-palatine foramen, or by the proximate pores, to anastomose with the olfactory filaments and with the nasal branch of the ophthalmic nerve. It is distributed to the mucous membrane of the three turbinated bones, and is regarded as the source of *common sensation* to the nasal apparatus; but the *olfactory nerve*, on the other hand, is devoted to *special sense*. Thus when these nerves are paralyzed the mucous surface becomes dry, and the function is blunted and even suspended; and too copious a secretion produces nearly similar effects. All substances, before they can be smelt, must undergo a certain degree of solution; and the most sensitive portion of the olfactory apparatus is the highest region of the nasal fossæ.

THE SECOND PAIR OF NERVES.—OPTIC NERVE.

The optic nerve is also a nerve of special sense. It originates within the globe of the eye by that remarkable nervous expansion called the retina, (which will be fully examined hereafter,) the fibres of which coalesce into a single trunk, the optic nerve. Fig. 342, 30. This nerve then perforates the choroid and sclerotic coats of the eye, becomes invested by a sheath from the dura mater, enters the cranium through the optic foramen, and then joining its fellow of the opposite side, the two form the *commissure* or *chiasma* of the optic nerve. Figs. 342, 29, 352, 8, and 354.

The chiasm is directly in front of and somewhat below the tuber cinereum, and rests upon the processus olivaris of the sphenoid bone. Its intimate structure has long been a subject of controversy; but recent investigations leave no question that this commissure is formed in part by the decussation of fibres from opposite sides, and partly by the mere juxtaposition of fibres; and again, the two nervous fasciculi are connected together in front and behind by commissural filaments apparently independent of the optic nerve itself.

Fig. 353.



Chiasm of the optic nerve. After Mayo.

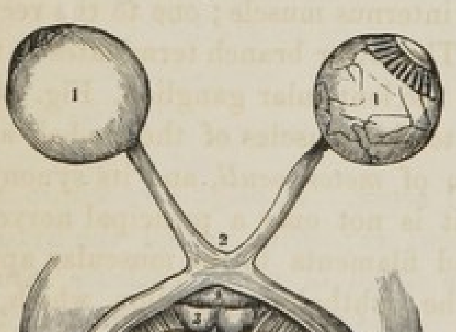
Fig. 353 illustrates this connection. 1, the anterior fibres, which are commissural between the two retinæ; 2, posterior fibres, commissural between the optic ganglia. The central and external fibres constitute the true optic nerve; the former decussating the fibres of the opposite side, while the external fibres are continuous with the nerve of the corresponding side.

The continuation of the optic nerve from the chiasma to the brain is the *tractus opticus;* a large, flattened band of medullary fibres that runs outwards and backwards along the margin of the tuber cinereum, with which latter body it has some filamentous connections. From this point the optic tract passes beneath the crus cerebri just where the crus enters the brain, and forms with its external margin a membranous attachment derived from the arachnoid. Fig. 342, 28.

From the optic chiasm to the crura cerebri the optic tracts diverge widely from each other, forming a curve as they run backwards, and becoming more flattened and broader where they embrace the crura. From the latter point they can be traced to a double termination (or origin as usually described); 1st, to the corpora geniculata of the optic thalamus, and by scattered fibres to the medullary surface of that ganglion, and also to the peduncles of the pineal gland; 2d, to the tubercula quadrigemina, especially testes, and through them to the valve of the brain.* Fig. 354.

We have followed Solly in the preceding account of the origin of the optic nerve. Most anatomists reverse the description, and regard the tubercula quadrigemina as the sources of this nerve; but Rolando rejects both of these views, and assumes that the optic thalamus alone gives origin to it.

Fig. 354.



Optic nerve with its chiasma and tractus. From Quain.†

The optic nerve, as every one knows, subserves the function of vision, and is therefore a nerve of *special sense.* Its office, and its connections with the eye, will be noticed more in detail when we come to treat of the latter organ.

Fig. 354. Optic nerve with its chiasma and tractus, together with the origins of seven other pairs of cerebral nerves. 1, 1, globe of the eye; the one on the left hand is perfect, but that on the right has the sclerotic and choroid removed to show the retina; 2, the chiasm of the optic nerves; 3, the corpora albicantia; 4, the infundibulum; 5, the pons Varolii; 6, the medulla oblongata, the figure being on the right corpus pyramidale; 7, the third pair, motores oculi; 8, fourth pair, pathetici; 9, fifth pair, trigemini; 10, sixth pair, abducentes; 11, seventh pair, auditory and facial; 12, eighth pair, pneumogastric, spinal accessory, and glosso pharyngeal; 13, ninth pair, hypoglossal.

* Solly. Opera citat., p. 291.

† Nerves, Fol. pl. xii. From the reduced drawing in Carpenter's Physiology.

THE THIRD PAIR OF NERVES.—MOTOR OCULI.

This being a *motor nerve*, its origin is to be found in the brain. Its incipient fibres can be in part traced to the tubercula quadrigemina and valve of the brain, whence they descend through the pons Varolii to be connected with the inferior, superficial surface of crus cerebri; and a second set of fibres appears to arise in the locus niger. The nerves of opposite sides converge between the crura cerebri, so as to come in contact without uniting with each other; and they emerge from between the crura about two lines in front of the pons Varolii. Figs. 342, 23, and 352, 10.

From this point the nerve passes forwards on the outer side of the posterior clinoid process, and in the latter position perforates the dura mater: it then runs along the external parietes of the cavernous sinus, and divides into two branches, which enter the orbit through the anterior foramen lacerum, and between the two heads of the rectus externus muscle. Fig. 355, 7.

In this course, the nerve is enclosed in a sheath derived from the pia mater, and afterwards by another from the arachnoid membrane; but the latter is reflected from it at the point where it enters the opening in the dura mater.

Before its division, this nerve receives one or two delicate filaments from the cavernous plexus of the sympathetic, and its two branches are then distributed as follows:

The *upper branch*, which is the smaller of the two, passes over the optic nerve and sends filaments to the rectus superior and levator palpebræ superioris muscles.

The *lower branch* sends a twig to the rectus internus muscle; one to the rectus inferior, and a third to the rectus externus. The latter branch terminates in the inferior oblique muscle, and is connected with the lenticular ganglion. Fig. 355.

Function.—From its general distribution to the muscles of the eyeball as a *nerve of motion*, the third pair gets its name of *motor oculi*, and its synonym of the *common oculo-muscular nerve.* But it is not only a principal nerve of motion to the eyeball; for it appears to send filaments to the muscular apparatus within the eye by the short root of the ophthalmic ganglion, which, as heretofore observed, after passing through that ganglion, escapes from it in the form of ciliary nerves, and may be traced to the ciliary muscle and the iris. It probably serves, therefore, to excite the movements of the iris, and of the other muscular fibres within the eye.*

THE FOURTH PAIR OF NERVES.—PATHETICUS.

This nerve, which is also called the *trochlearis*, is the smallest of the cranial series. It is a strictly motor nerve, and has its origin by soft filaments which are destitute of neurilemma, from the upper end of the valve of the brain: from this point it runs forwards and outwards along the external border of the crus cerebri, and emerges into view at the side of that peduncle and in front of the

* Todd and Bowman. Physiology, ii. p. 102.

pons Varolii. Fig. 342, 21. It then passes forwards, exterior to the cavernous sinus, to which it is attached by fibrous tissue, and in this position is joined by filaments from the sympathetic nerve. It then enters the orbit through the anterior foramen lacerum, and above the muscles. Figs. 355, 8, and 353, 12.

Although the smallest, it is at the same time the longest of the cranial nerves, and is spent, as a nerve of motion, exclusively on the trochlearis muscle.

THE FIFTH PAIR OF NERVES.—TRIGEMINUS.

The fifth or trifacial nerve, is the largest given off from the base of the brain. It is compound in function, a part of it being subservient to sensation and another part to motion. Since it would embarrass the description to trace these parts physiologically, the one from the face and the other from the brain, we will examine its anatomical connections with the latter organ, and explain, at the same time, its functional relations.

The trigeminus nerve is remarkable for its triple root; but two of these roots are much larger than the third, and embrace separate sensory and motory functions, in the following manner. Fig. 342, 18.

The *sensory portion* of the trigeminus, which is also called its *middle* or *greater root*, has its origin, or, physiologically speaking, its termination, in the posterior portion of the antero-lateral column of the spinal cord, about an inch and a half below the pons Varolii.* Fig. 351, 19, and 352, 16. The filaments in their ascent, are connected with the medullary neurine forming the floor of the fourth ventricle; they then enter the pons, and pass between its fibres, until they emerge in a filamentous trunk, at the point where the pons joins the crus cerebelli. The fasciculi of this nerve are thirty or forty in number, and these are divisible into more than an hundred filaments.

The *motory* or *non-ganglionic portion* of the trigeminus, is sometimes described as a continuation of the anterior or pyramidal tract in its passage through the pons Varolii; but Mr. Solly traces it to the olivary portion of the motor tract, where the latter ascends to the tubercula quadrigemina. The nerve thus formed consists of a very few fasciculi, emerges from the pons Varolii close to the sensory cord, and is soon after placed in contact with it. Figs. 351, 20, and 352, 15.

The fifth nerve is thus composed of filaments derived both from the sensory and motor columns of the spinal cord, and in this respect resembles the proper spinal nerves, and also in the mode in which its ganglion is formed, as we shall presently see. Figs. 326 and 359.

The combined filaments, on reaching the tentorium, pass through an oval foramen in that membrane at the anterior extremity of the petrous portion of the temporal bone. The dura mater invests the nerve from this point, forming a canal around it; and at the lower or anterior part of this canal, the nerve in some measure loses its fasciculated character, and expands into the *ganglion of Gasser*. Figs. 359, 8, and 357, 2.

The *Gasserian ganglion* varies from half to three-fourths of an inch in length,

* Solly. On the Human Brain, p. 296.

and is a line or two lines in breadth. It is of a lunated form, whence its synonym of *semilunar ganglion*, and it is also called the *plexus gangliformis.* It lies in a corresponding depression on the upper surface of the petrous bone, near its apex, with the horns of its crescentic body presenting forwards. It presents a remarkably filamentous appearance, and is joined by twigs from the carotid plexus of the sympathetic nerve. If the ganglion be gently elevated, it will be observed that it is exclusively formed by the sensory portion of the nerve; while the anterior or motor root passes beneath and in contact with the ganglion without being connected with it; nor does any connection take place between them within the cranium. Fig. 359, 8, 9.

The ganglion of Gasser gives off three large nervous trunks, of which the first or ophthalmic branch passes out of the skull through the anterior foramen lacerum; the second, or superior maxillary, through the foramen rotundum; and the third, or inferior maxillary branch, through the foramen ovale. We proceed now to trace the course and note the function of these several nerves.

THE FIRST OR OPHTHALMIC BRANCH OF THE TRIGEMINUS.

The ophthalmic is the smallest branch of the fifth pair. It comes from the upper angle of the ganglion, is about an inch in length, somewhat flattened and runs in the direction of the anterior foramen lacerum, through which it enters the orbit. In this course, the nerve is contained in a sheath of the dura mater, derived from that portion of the membrane which forms the outer parietes of the cavernous sinus. Having reached the orbit, it divides into three branches, the lachrymal, frontal and nasal. Figs. 357, 3, and 360, 3.

1. The *lachrymal branch* is the smallest of these branches. It runs along the superior margin of the rectus externus muscle, in company with the lachrymal artery until it approaches the lachrymal gland, when it separates into two branches: one of these is a filament which passes through the spheno-maxillary fissure and unites itself with a similar filament from the second branch of the fifth pair. The other branch passes along the upper surface of the lachrymal gland, and escaping from the orbit through a foramen of the malar bone, anastomoses with a filament of the fascial nerve. The terminal portions of the nerve are then distributed upon the gland, the upper eyelid and the conjunctiva. Fig. 357, 11.

2. The *frontal branch* is the largest of the ophthalmic branches. It passes above the muscles of the orbit, lying between the levator palpebræ superioris and the periosteum, and divides into external frontal nerve and the supra-orbitar. Fig. 357, 12.

The *internal frontal nerve* approaches the trochlea of the superior oblique muscle, and sends off a filament that joins another from the nasal nerve. It also sends twigs to the upper eyelid, some of which anastomose with others from the lachrymal nerve. The nerve then escapes from the orbit over its inner margin, close to the trochlea, and ascending upon the forehead, is distributed to the occipito-frontalis, corrugator supercilii and orbicularis muscles.

The *supra-orbitar nerve* escapes from the orbit through the supra-orbitar

foramen, and is distributed upon the above named muscle, and the integuments of the scalp and forehead. Fig. 357, 15.

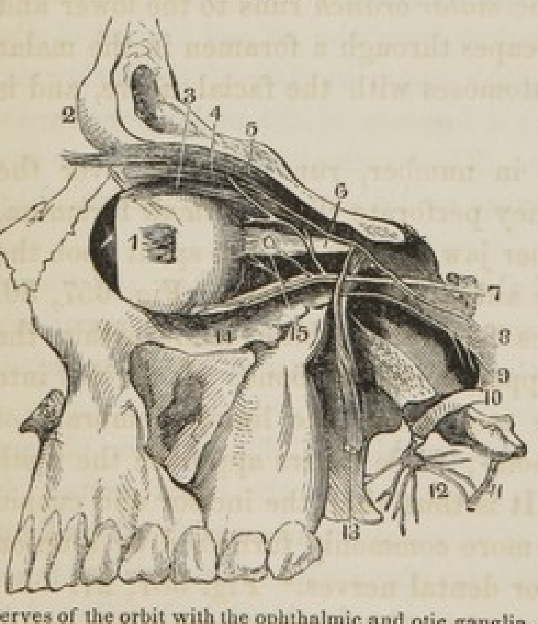
3. The *nasal branch* separates from the ophthalmic trunk, Fig. 357, 3, in the wall of the cavernous sinus, and having reached the orbit, passes forwards to the inner side of that cavity and enters the anterior ethmoidal foramen. Fig. 357, 10, 13. In this course it detaches a branch, *ramus ciliaris*, to the ophthalmic ganglion; and it also sends other branches, generally two or three in number, which have no communication with the ganglion, but penetrate directly into the eyeball and form part of the series of ciliary nerves.

The nasal nerve, after entering the anterior ethmoidal foramen, passes into the cranium, and is seen on a groove at the edge of the cribriform plate of the ethmoid bone, whence it passes into the nose through an aperture at the side of the crista galli. On entering the nasal fossa, this nerve divides into two branches, one of which is distributed upon the Schneiderian membrane as far as the anterior nares, some of its branches terminating on the tip of the nose and alæ nasi. This branch is usually called the *internal nasal nerve*. The *external nasal* or *infra-trochlear nerve* pursues its course within the orbit, being a continuation of the main trunk after the separation of the internal nasal. Fig. 357, 14. Near the trochlea it divides into two branches, and these again into several smaller ones, which supply the eyelids, caruncula lachrymalis, the conjunctiva, lachrymal sac and the muscular fibres at the root of the nose.

THE LENTICULAR GANGLION.

We have already adverted to the *ophthalmic* or *lenticular ganglion*, when describing the sympathetic nerve; but its connection with the fifth pair requires some additional notice.

Fig. 355.



Nerves of the orbit with the ophthalmic and otic ganglia. After Quain.*

Fig. 355 shows the nerves of the orbit, with the ophthalmic and otic ganglia. 1, ball of the eye; 2, superciliary ridge of the left side; 3, superior rectus muscle; 4, superior oblique muscle; 5, levator palpebræ superioris muscle; 6, optic nerve; 7, third nerve, motor oculi; 8, fourth nerve, patheticus, or trochlearis; 9, sixth nerve, abducens oculi; 10, trunk of the inferior maxillary nerve; 11, middle artery of the dura mater, entering the foramen spinale of the sphenoid bone; 12, the otic ganglion; 13, rectus externus muscle, divided and turned down; 14, floor of the orbit; 15, ophthalmic or lenticular ganglion.

This, which is also called the *ciliary ganglion*, lies in the posterior chamber of the orbit, between the optic nerve and rectus externus muscle. Besides filaments from the sympathetic, it is joined by others from the third and fifth pair, and a series of *ciliary nerves*,

* Nerves of the Human Body. Pl. xiii., Fig. 1.

ten or twelve in number, proceed from its anterior border, and run forward to penetrate the ball of the eye, and are distributed upon the iris. It thus forms a connecting link between the three classes of nerves of the eye—motor, sensory and sympathetic. Figs. 355, 15, and 357, 18.

SECOND, OR SUPERIOR MAXILLARY BRANCH OF THE TRIGEMINUS.

This nerve is given off from the middle of the ganglion of Gasser, is somewhat flattened, and pursues a horizontal course to the foramen rotundum of the sphenoid bone, through which it escapes from the cranium. It there becomes a round, firm, nervous cord, which enters and traverses the canal in the floor of the orbit, and appears upon the face at the infra-orbitar foramen. It then divides, beneath the levator labii superioris muscle, into several branches that are distributed to the lower eyelid and conjunctiva, and to the cheek, nose, upper lip and teeth. Fig. 357, 4, 21.

1. The *spheno-palatine branches*, two in number, pass downwards from the superior maxillary nerves, while it is yet in the spheno-maxillary fissure. They are connected with the ganglion of Meckel, and are spent upon the nose and palate. They enter the nose through the spheno-palatine foramen, and are distributed on the Schneiderian membrane.

During the course of the orbitar nerve through its canal in the base of the orbit, the infra-orbitar nerve gives off two branches to the teeth, in the following order.

2. The *infra-orbitar branch* is given off from the upper maxillary nerve in the spheno-maxillary fissure, through which it enters the orbit, and divides into two branches, the temporal and malar. Fig. 357, 21, 28. The *temporal branch* runs in a groove in the outer parietes of the orbit, and after receiving a twig from the lachrymal nerve, reaches the temporal fossa through a foramen in the malar bone. It is then distributed to the integuments of the temple and forehead, and anastomoses with the facial nerve. The *malar branch* runs to the lower and outer margin of the orbit, from which it escapes through a foramen in the malar bone; and having got on the cheek, anastomoses with the facial nerve, and is spent upon the integuments.

3. The *posterior dental branches*, two in number, run outwards over the tuberosity of the maxillary bone, which they perforate through small foramina, and supply the three molar teeth of the upper jaw. They are also spent upon the contiguous gums, and anastomose with the anterior dental nerve. Fig. 357, 30.

4. The *anterior dental nerve* also arises from the orbitar trunk within the orbit, and enters a special canal in the upper maxillary bone. It divides into several branches, some of which reach the teeth along the lining membrane of the antrum, leaving their grooves on the bone; while others approach the teeth through distinct canals in the maxilla. It is thus that the incisor and cuspid teeth are supplied; but the bicuspides are more commonly furnished by a union of filaments from the anterior and posterior dental nerves.* Fig. 357, 27.

After parting with the dental nerves, the infra-orbitar comes out of the infra-orbitar foramen, and appears on the front of the face, where it divides into several

* Horner.

fasciculi. Fig. 357, 28. These are distributed to the eyelids, nose and lips, as follows:

The *palpebral branches* pass upwards through a channel in the bone, and are spent upon the whole of the lower eyelid and upon the orbicularis muscle.

The *nasal branches* pass inwards to the muscles and integuments on the side of the nose.

The *labial branches* run downwards, three or four in number, beneath the levator muscles of the upper lip, to which they are distributed, and also to the mucous membrane of the mouth and the proximate integuments.

THE SPHENO-PALATINE GANGLION.

This body, which is also called the ganglion of Meckel, is situated, as heretofore observed, in the spheno-maxillary fossa, between the pterygoid process of the sphenoid bone and the upper maxilla. The vesicular neurine from which this body derives its ganglionic character is placed at its posterior part; and the spheno-palatine branches of the upper maxillary nerve are not blended with it, but pass independently of it to the nose and palate.

The nerves connected with this ganglion are divisible into four groups,—ascending, descending, internal and posterior.

1. The *ascending branches* consist of several filaments, two of which join the upper maxillary nerve; one to the rectus externus muscle of the eye; and one to the lenticular ganglion, constituting its middle root.

2. The *descending branches* are the *palatine nerves*, four or five in number. They enter the nose through the spheno-palatine foramen, and are spent upon the mucous membrane of the superior meatus, and the upper and middle turbinated bones. Other small branches make their way through foramina in the palate and sphenoid bones, and are distributed to the hard palate, tonsil and upper region of the pharynx.

3. The *internal branches* are the nasal and naso-palatine nerves. They enter the nasal fossa together through the spheno-palatine foramen, and the former are distributed upon the mucous membrane of the upper part of the septum of the nose and upon that covering the two upper spongy bones. The *naso-palatine* nerve is a long, slender branch, that enters the nasal fossa and supplies the membrane of the septum narium; thence it descends downwards and forwards, enters the naso-palatine canal, and afterwards the anterior palatine canal; in the latter position it joins its fellow of the opposite side, and receives filaments from the anterior dental nerves. By this conjunction a small ganglion is formed,—the naso-palatine, or *Cloquet's ganglion*, from which filaments are distributed to the anterior portion of the roof of the mouth.

4. *The posterior branch.*—This is the *Vidian nerve*, of which the course has been described in the account of the sympathetic nerve (p. 420). We have there considered it as reflected back from the superior maxillary nerve, or rather from the spheno-palatine ganglion as connected with that nerve. Strictly speaking, its course should be traced forward *from* the carotid plexus of the sympathetic; but since we have already traced it in the backward direction, we

may here recapitulate what has been already said, in connection with some additional particulars of this singular nerve.

The VIDIAN NERVE passes from the posterior margin of the ganglion directly backwards, through the pterygoid or vidian foramen, and thus reaches the cavity of the cranium. At the anterior end of the petrous bone, and within the foramen lacerum, it divides into two branches, the carotid, or *petrosus profundus;* and the petrosal, or *petrosus superficialis.* The carotid branch crosses the foramen lacerum, enters the carotid canal, and therein contributes to form the origin of the great sympathetic nerve.

The *superficial petrosal nerve* ascends into the cranium through the middle foramen lacerum, and gets to the outer side of the carotid artery, and beneath the ganglion of Gasser and the dura mater: it then runs backwards, is lodged for a short distance in a furrow of the petrous bone, and enters the hiatus Fallopii. It is continued through the hiatus Fallopii to the aqueduct of that name, where it joins the gangliform enlargement of the facial nerve.*

THE THIRD BRANCH OF THE FIFTH PAIR OF NERVES.

This large nerve, called also the *inferior maxillary*, comes from the lower and posterior part of the ganglion of Gasser, and running forwards, passes out of the cranium through the foramen ovale of the sphenoid bone. Just anterior to this point it is joined by the motor root of the fifth pair, that part which comes from the pons Varolii without being connected with the ganglion of Gasser, and makes its exit from the cranium through the foramen ovale. Figs. 359, 6, 9, and 357, 5.

Soon after this union, the nerve divides into two branches, one of which is external, the other internal, and are separated from each other by the external pterygoid muscle.

The smaller or external division, sometimes called the anterior branch, separates into five sets of nerves, called from their distribution the masseter, the two temporal, the buccal and the pterygoid nerves.

1. The *masseter nerve* passes outwards and backwards along the margin of the external pterygoid muscle, and in front of the articulation of the lower jaw: it then gets between the insertion of the temporal and external pterygoid muscles, to the inner surface of the masseter, on which it is minutely distributed. While contiguous to the articulation of the lower jaw, the masseter nerve sends some filaments to that joint. Fig. 359, 2.

2. The *temporal nerves*, two in number, pass horizontally outwards between the zygomatic fossa and the external pterygoid muscle, whence they ascend to, and are distributed upon, the temporal muscle. Figs. 359, 1, and 357, 9.

3. The *buccal nerve* passes through the external pterygoid muscle, to which it supplies some filaments, and then descends to the buccinator muscle on which it is distributed, and also to the buccal glands, and the contiguous mucous membrane of the mouth. Fig. 359, 3.

* Quain and Sharpey, Anatomy, p. 785. Wilson, Anatomy, p. 463.

4. The PTERYGOID BRANCHES, two in number, are furnished to the internal and external pterygoid muscles, but chiefly to the former. Fig. 359, 4.

The posterior and larger branch of the lower maxillary nerve divides into three branches, the superficial temporal, the inferior dental and the lingual or gustatory nerves.

1. The SUPERFICIAL TEMPORAL, or *anterior auricular nerve*, is distributed to the ear and the temple. It often commences by two roots, separated by the middle artery of the dura mater; it passes directly backwards behind the articulation of the lower jaw, and then ascends between that joint and the ear, being covered by the parotid gland. On emerging from beneath the gland, it divides into two terminal branches, the *anterior* and *posterior temporal*.

The *anterior temporal branch* runs to the top of the head, where it is distributed to the integuments, and sometimes anastomoses with the temporal branch of the upper maxillary nerve.

The *posterior temporal branch* gives filaments to the anterior auricular muscle and the proximate integuments of the ear.

Before these terminal branches are given off, the anterior auricular nerve gives small twigs to be distributed to the external ear; others run to join the facial nerve and otic ganglion; and several branches are distributed around the meatus auditorius and the articulation of the lower jaw.

2. The INFERIOR DENTAL NERVE runs between the two pterygoid muscles, in company with the corresponding artery, and gets to the posterior mental foramen, at which point it detaches a small branch, the *mylo-hyoid*, to the muscle of that name: it perforates the internal lateral ligament at its point of insertion, follows a groove in the contiguous surface of the bone, and sends filaments to the submaxillary gland and digastric muscle. Fig. 357, 22.

The inferior dental nerve then enters its canal in the lower jaw, and passing forwards in the middle of the bone, close to the fangs of the teeth, detaches a branch to each of them, from the last molar to the first incisor, and filaments to the intervening gum. When the nerve approaches the anterior mental foramen, it sends off a large branch that emerges from that foramen and appears upon the chin, where it separates into two fasciculi. Fig. 357, 29. One of these is spent upon the lower lip and the integuments of the chin; the other goes to the muscular fibres at the angle of the mouth, and the proximate glands and mucous membrane.

3. The GUSTATORY OR LINGUAL NERVE passes downwards from its origin in company with the inferior dental nerve, being at first beneath the external pterygoid muscle, where it is joined by the chorda tympani. It then gets between the internal pterygoid muscle and the lower jaw, and inclines inwards to the side of the root of the tongue, above the submaxillary gland, and concealed by the angle of the lower jaw. Fig. 357, 24. It next curves forwards between the mylo-hyoideus and hyo-glossus muscles, and behind the duct of the submaxillary gland, anastomosing with the hypoglossal nerve, and detaching filaments to the lining membrane of the mouth and sublingual gland. Fig. 359, 14. It then diverges into seven or eight fasciculi, which run forwards on the side of the stylo-glossus muscle, and terminates in the papillary structure of the tongue. Fig. 357, 358, 10.

THE OTIC GANGLION.

The *otic* or *auricular ganglion* is formed by several filaments from the third branch of the trigeminus. It lies near the foramen ovale, at the point where the motor fasciculus joins the lower maxillary nerve. Its outer side is in contact with that nerve; its inner surface is close to the cartilaginous part of the Eustachian tube and the circumflexus palati muscle; and behind it, is the middle meningeal artery.* Fig. 357.

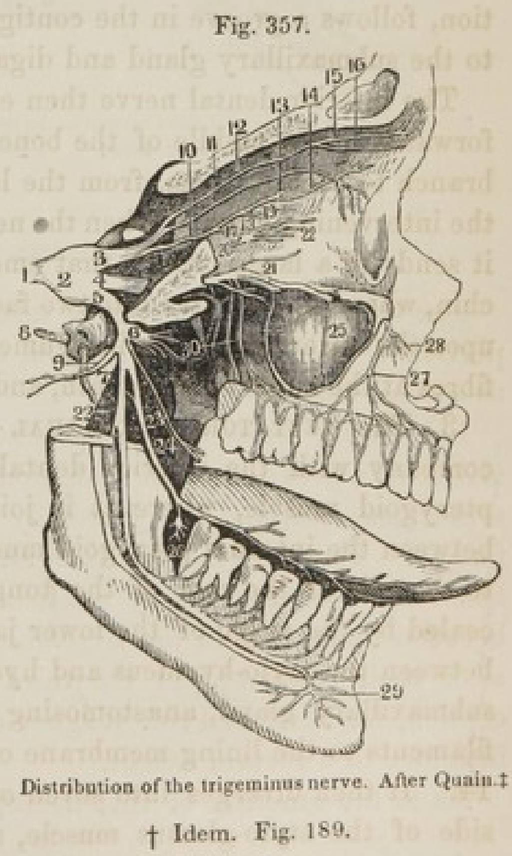
Various filaments diverge from this ganglion: one of these contributes to the nervous anastomosis of Jacobson, connecting the superficial petrous, sympathetic and glosso-pharyngeal nerves together; another branch goes to the tensor tympani muscle; and a third to the circumflexus palati. A filament also anastomoses with the auditory nerve.

Fig. 356.

The otic ganglion. After Quain, as copied from Arnold.

Fig. 356. The otic ganglion, as seen from the inner side of the dissection, is represented in the annexed drawing as a small, white, orbicular body, on the third branch of the trigeminus. 1, ganglion of Gasser; 2, first division of the trigeminus; 3, second division; 4, third division; 5, branch to tensor palati; 6, superficial petrosal nerve; 7, chorda tympani; 8, internal pterygoid muscle; 9, carotid artery, embraced by the sympathetic nerve; 10, mastoid process; 11, membrana tympani; 12, bones of the tympanum.†

Fig. 357.



Distribution of the trigeminus nerve. After Quain.‡

The annexed engraving, Fig. 357, illustrates the course and distribution of the three branches of the trigeminus nerve. 1, trunk of the trigeminus; 2, ganglion of Gasser; 3, first or ophthalmic branch; 4, second or superior maxillary branch; 5, third or inferior maxillary branch; 6, muscular division of the latter nerve; 7, 8, chorda tympani, showing its connection with the gustatory nerve; 9, the temporal nerve; 10, the nasal nerve, or oculo-nasalis; 11, the lachrymal nerve; 12, frontal nerve; 13, continuation of the nasal nerve through the anterior ethmoidal foramen, into the nose; 14, infratrochlear branch of the nasal nerve; 15, supra-orbitar branch of the frontal nerve; 16, supra-trochlear branch of the frontal nerve; 17, branch of the nasal nerve to the ophthalmic ganglion; 18, ophthalmic ganglion (directly beneath the fissure); 19, ciliary branch of the nasal nerve, going to the ball of the eye; 20, branch given off from the ophthalmic ganglion to the inferior division of the third nerve; 21, continuation of the superior maxillary nerve along the floor of the orbit; 22, inferior dental nerve; 23, one of the muscular branches of the inferior maxillary nerve; 24, gustatory branch of that nerve, going to the tongue; 25, dental branch of the

* Quain, Anatomy, p. 792.

† Idem. Fig. 189.

‡ Nerves of the Human Body, fol. Pl. xiii., Fig. 2.

superior maxillary while in its canal, and passing between the mucous membrane and outer wall of the antrum to the teeth. The other dental nerves are seen behind it; 26, the submaxillary ganglion; 27, anterior dental branches of the upper maxillary; exit of the infra-orbitar nerve; 29, terminal branches of the upper maxillary, distributed to the face. The mental nerves or termination of the inferior maxillary.

THE SUBMAXILLARY GANGLION.

This ganglion, respecting which some remarks have been already made (p. 527), lies upon the gland of the same name. Its origin is variously described by different anatomists; but is generally regarded as formed by the chorda tympani, "which, after joining the gustatory nerve, leaves it, and unites to and forms this ganglion, with the assistance of some two or more filaments from the gustatory nerve, and one or two from the cervical portion of the sympathetic."*

This ganglion sends off five or six branches which radiate in the substance of the submaxillary gland, and others which go to the mucous membrane of the mouth and to the duct of Wharton. Figs. 357, 26, and 358.

Fig. 358.

Submaxillary ganglion and third branch of the trigeminus. After Sir C. Bell.†

The connections of the submaxillary ganglion are exemplified in Fig. 358. 1, small root of the trigeminus, which joins the lower maxillary division; 2, larger root, with the ganglion of Gasser; 3, ophthalmic nerve; 4, upper maxillary nerve; 5, lower maxillary nerve; 6, chorda tympani; 7, fascial nerve; 8, submaxillary gland, with the submaxillary ganglion directly above it; 9, inferior dental nerve; 10, gustatory nerve.

FUNCTIONS OF THE TRIGEMINUS.

The trigeminus is a nerve of mixed or compound function, inasmuch as one portion of it is devoted to motion, another to sensation, and a part of it again to special sense.

Let us for a moment recapitulate the parts of this remarkable nerve. It arises by a great external root, that expands within the cranium into the Gasserian ganglion, and it is joined by a smaller root that lies on the inside of the former. The resemblance this structure bears to that of the spinal nerves, has long been noticed by anatomists, Fig. 326; but there is this difference between them, that in the trigeminus the two fasciculi of fibres are not blended after their contact; yet the third branch may be regarded as a partial exception, for here, as Prof. Wagner observes, the fibres from the two sources do interlace to a certain extent.

As to the function of this nerve, physiologists are united in opinion except-

* Horner. † Copied from Drs. Quain and Sharpey's modified drawing. Anat. Fig. 186.

ing in relation to some collateral details. Thus, the *larger* or *ganglionic portion* is composed of *sensory fibres*, that correspond in all respects with the posterior root of the spinal nerve. Fig. 359, 7. When this nerve is divided in the inferior animals, they give strong evidence of pain, and the parts to which the nerve is distributed are all deprived of sensation; viz., the integuments of the forehead, temples, eyelids, nose, mouth and greater part of the ear; the conjunctiva, Schneiderian membrane, the mucous membrane of the mouth, of the upper portion of the pharynx, the surface of the tongue, the gums and teeth; yet, notwithstanding this absence of sensation, the faculty of muscular motion remains unimpaired.* The first or ophthalmic, and the second or upper maxillary branch, both belong exclusively to the class of sensory nerves. The third, or inferior maxillary nerve, combines both functions.

The lesser or *motor root* resembles the anterior root of the spinal nerves. Fig. 359, 6. It embodies the lingual and dental portions of the third branch of the trigeminus, and contains the motory filaments that subserve the function of mastication; for when galvanized in an animal just dead, it excites powerful action in the jaws, which are snapped and ground together. When divided in a living animal, the lower jaw falls from paralysis of the associated muscles. When the section is confined to one side, the jaw loses its parallelism, even in a state of repose, but particularly in the act of chewing; but this motor portion of the fifth pair, however, has no agency in the action of the muscles of the cheek, lips or soft palate.†

Fig. 359.

The trigeminus nerve and its branches. From Sir Charles Bell.‡

Fig. 359. In order further to illustrate the several parts of this interesting nerve, it is here represented dissected out and seen on its lower surface; 7, its posterior or sensitive root before it enters the ganglion; 8, Gasserian ganglion; 6, the anterior or motor root passing the ganglion; 10, the third or lower maxillary division; 9, the motor portion joining the lower maxillary nerve, and forming a plexus with it; from this plexus the muscular nerves are given off to the muscles of the lower jaw, thus: 1, temporalis; 2, massetericus; 3, buccinato-labialis; 4, pterygoideus; 5, mylo-hyoideus. The other branches are the following; 11, division that joins the portio dura; 12, mandibulo-labralis; 13, chorda tympani; 14, gustatory nerve; 15, first or ophthalmic branch of the fifth pair; 16, second or superior maxillary branch.

* Wagner. Physiology, p. 498.

† Idem. Loco citat.

‡ The Nervous System of Human Body, Plate viii.

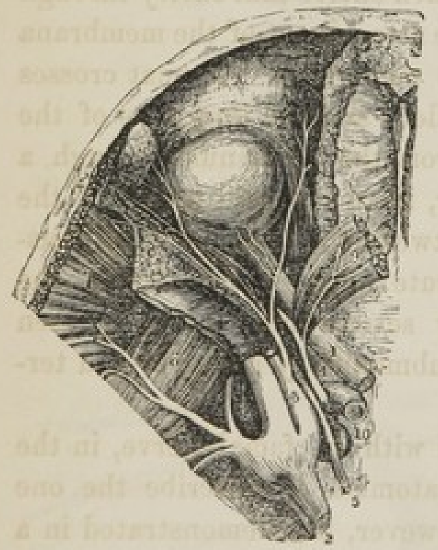
Sensation and motion are, therefore, combined in the third branch of the trigeminus, but the sensitive function is greatly in preponderance. The superficial temporal nerve is not merely sensitive, as was formerly supposed, but contains some motory fibrils derived from the lesser portion. The dental branch is also of a mixed nature, but distributes all its motory filaments to the mylo-hyoideus muscle.

The lingual or gustatory branch is at once a nerve of *special sense*, from its agency in the function of taste, and of common sensibility, from its simple endowment of sensitiveness. Yet the sense of taste is not destroyed by dividing this nerve, whence the latter is regarded only as a partial agent in this function, in which it is assisted by the glosso-pharyngeal nerve.

MOTOR EXTERNUS OCULI, OR SIXTH PAIR OF NERVES.

This nerve, also called the *abducens oculi*, arises by several filaments from the base or upper end of the corpus pyramidale, under the posterior margin of the pons Varolii. It passes forwards parallel with the basilar artery, and about half an inch below the posterior clinoid process penetrates the dura mater. It then curves upwards, enters the cavernous sinus, where it crosses the carotid artery, and passes through the anterior foramen lacerum into the orbit.

Fig. 360.



Deep nerves of the orbit. After Arnold, as given by Drs. Quain and Sharpey.

While in the cavernous sinus, this nerve is joined by a filament from the ophthalmic, by another from the ganglion of Meckel, and by several from the carotid plexus. It is distributed exclusively to the abductor or rectus externus muscle of the eye.

Fig. 360. Deep nerves of the orbit, brought into view by removing the roof of that cavity, and dividing the levator palpebræ superioris and rectus superior muscles. 1, optic nerve; 2, trigeminus; 3, ophthalmic nerve; 4, motor oculi; 5, motor externus; 7, temporal muscle; 8, cut surface of the bone; 9, rectus superior and levator palpebræ muscles divided; 10, carotid artery.

THE SEVENTH PAIR OF NERVES.

In this designation two distinct nerves are included—the facial and auditory nerves.

THE FACIAL NERVE.

The *facial nerve*, or *portio dura*, has its origin in the medulla oblongata, in

which it derives filaments both from the corpus restiforme and corpus olivare, together with others from the pons Varolii. It emerges from the groove between the restiform and olivary bodies, and passes forwards to enter the meatus auditorius internus, wherein it is connected by anastomosing filaments with the auditory nerve.

At the bottom of the auditory meatus the facial nerve enters the aqueduct of Fallopius, in which it continues until its exit from the cranium. Its course is at first horizontally outwards, between the cochlea and vestibule, where it forms the gangliform enlargement called *intumescentia gangliformis*, and receives the petrosal branch of the Vidian nerve. This ganglion lies at the angle of the nerve, where it turns backwards over the fenestra ovalis towards the tympanum, along which cavity it descends to the stylo-mastoid foramen, and there escapes from the cranium.

During its course through the canal in the temporal bone (aqueduct of Fallopius), the facial nerve gives off several branches in the following manner.

1. The *tympanic branch* is a mere thread, that enters the cavity of the tympanum and is spent upon the stapedius muscle.

2. The *chorda tympani* is a distinct, white nervous cord that separates from the facial nerve just before the latter emerges from the bone, and runs to the upper and posterior parietes of the tympanum. It then enters that cavity through a foramen between the base of the pyramid and the attachment of the membrana tympani, and is invested by the tympanic mucous membrane. It next crosses the tympanum between the manubrium of the malleus and the long crus of the incus, being adherent to the former, and issues from the tympanum through a foramen on the inner side of the fissure of Glasser, in the glenoid cavity of the temporal bone. The chorda tympani then lies between the two pterygoid muscles, where it joins the gustatory nerve at an acute angle, is enclosed in the same sheath, and connected with that nerve by several filaments. It then inclines downwards and forwards, penetrates the submaxillary ganglion and terminates in the submaxillary ganglion.

The intimate connection of the chorda tympani with the facial nerve, in the substance of the petrous bone, has led many anatomists to describe the one nerve as a branch of the other. John Hunter, however, has demonstrated in a satisfactory manner, that the chorda tympani is in reality the continuation of the Vidian nerve, which, as heretofore explained, is a recurrent twig of the second branch of the trigeminus that enters the petrous bone at the Vidian foramen, and soon after joins the facial nerve, though still retaining its individual character.

The preceding branches are given off from the facial *within* the temporal bone; but the following, viz.: the posterior auricular, stylo-hyoid and digastric come from it after its emergence from the stylo-mastoid foramen.

3. The *posterior auricular nerve* runs backwards beneath the ear, and between the meatus and mastoid process, and is joined by the auricular branch of the pneumogastric. Opposite the mastoid process it divides into two branches; one of these runs anteriorly and is distributed upon the contiguous muscles of

the ear; the other branch, posterior or occipital, is spent upon the posterior belly of the occipito-frontalis muscle and the scalp.

4. The *stylo-hyoid branch* is distributed, as its name implies, to the stylo-hyoid muscle. It is a long, slender cord, connected by filaments with the carotid plexus of the sympathetic nerve.

5. The *digastric branch* arises from the facial nerve in common with the stylo-hyoid. It is distributed upon the digastric muscle, and connects with the glosso-pharyngeal and pneumogastric nerves.

After giving off the preceding branches, the facial runs forwards and downwards into the substance of the parotid gland, and therein divides into several large branches, from two to five in number, forming a plexus by their anastomosis. This plexus is reinforced by branches from the superficial temporal and inferior maxillary, which wind around the neck of the lower jaw.* Two large trunks, the *temporo-facial* and the *cervico-facial*, arise from the above-mentioned plexus, and ramifying on the side of the head, face and neck, constitute that remarkable divergence of nerves known as the *pes anserinus.*

6. The TEMPORO-FACIAL NERVE penetrates the parotid gland, and forms, with some other nerves, a plexus on the side of the face from the mouth to the temple, in three sets of branches.

The *temporal branches*, two or three in number, detach filaments to the parotid gland, and ascending over the zygoma, are spent upon the anterior auris and orbicularis oculi muscles and the contiguous integuments. These nerves anastomose with each other, with the temporal branch of the upper maxillary nerve, and with the frontal branches of the ophthalmic.

The *malar branches* run over the malar bone, and getting near the outer margin of the orbit, are distributed to the orbicularis palpebrarum and corrugator supercilii muscles. They anastomose with the lachrymal and infra-orbitar nerves.

7. The CERVICO-FACIAL NERVE also penetrates the parotid gland, behind the ramus of the lower jaw, and separates into three principal divisions in the following order.

The *buccal branches*, two or three in number, pass across the face beneath the masseter muscle and the skin, and are distributed upon the muscles and integuments between the eye and the angle of the mouth. They anastomose with filaments of the third branch of the trigeminus, and freely with each other.

The *submaxillary branch* supplies the angle of the mouth, and the muscles and integuments between the chin and the lip.

The *infra-maxillary branch* is distributed upon the upper part of the platysma myoides muscle and the proximate integuments, forming arches across the side of the neck as low down as the os hyoides, and anastomosing with the anterior fasciculus of the third cervical nerve.†

Functions.—The facial is a motory nerve, distributed to the superficial mus-

* Horner.

† Quain and Sharpey. Anatomy, p. 799.

cles of the face and ear, and enables the countenance to assume the varied expression characteristic of the different affections and passions. When this nerve is galvanized, the whole of the associated muscles are thrown into the most active contractions; and when it is divided, paralysis of all the parts to which it is distributed is the consequence: the face becomes at once vacant and devoid of expression, the salivary glands secrete imperfectly, and, after a time, the muscles become completely emaciated.*

Sir Charles Bell observes, that the facial nerve exists only in those animals in which there is a necessity in some constant motions between the face and respiratory organs; and his experiments led him to believe that this nerve is the *respiratory nerve of the face;* and that the motions of the lips, the nostrils and the velum palati, are governed by its influence, when the muscles of these parts are in associated action with the other organs of respiration. Thus sneezing and coughing, according to Sir Charles Bell, result entirely from the influence of these respiratory nerves; which, moreover, direct all those actions that have even the remotest connection with the act of respiration.†

The office of the *chorda tympani*, considered as a branch of the facial nerve, is not yet made entirely clear. It appears to exercise a motor influence upon the parts to which it is distributed, and especially on the duct of the submaxillary gland; but its connection with the parts within the tympanum renders it certain that it is in some way auxiliary to the function of hearing.

It has been long known that the facial nerve possesses some sensitive properties, which are first detected after its exit from the foramen stylo-mastoideum, and especially after it has passed through the parotid gland. This sensibility appears to be owing to an anastomosis with the pneumogastric nerve in the aqueduct of Fallopius, in the face with the trigeminus, and in the neck with the spinal nerves.

THE AUDITORY NERVE.

This nerve, called also the *portio mollis* of the seventh pair, is perfectly distinct in distribution and function from the facial nerve; and in the numerical order of Sœmmering, is designated as the eighth pair of nerves. Fig. 342, 14.

Since this is a nerve of special sense, its origin, in a strictly physiological description, should be traced *from* the ear to its connection with the encephalon. Thus it may be said to commence in the pulp that lines the labyrinth; its fibres, assuming a firmer consistence, coalesce into two filamentous cords, called, from their associations, *cochlear* and *vestibular.* These cords unite at the bottom of the meatus auditorius internus into a single trunk, which receives accessory filaments while in the meatus from the facial nerve, and then enters the cranium to terminate, according to Solly, in the following manner.

On reaching the point where the facial nerve emerges from the margin of the

* Wagner, *ut suprà.*

† The Nervous System of the Human Body, p. 70, *et seq.*

pons Varolii, the auditory nerve divides into two portions: one of these enters and is lost in the corpus pyramidale; the other winds round the corpus restiforme, crosses the fourth ventricle, and terminates in the striæ medullares on the floor of that ventricle. Fig. 352, 19.

Function.—The auditory nerve, as its name imports, subserves the sense of hearing; that faculty by which the mind appreciates those undulations of the air, which, acting on the tympanum, give rise to the phenomena of sound. This nerve is, therefore, one of *special sense*, nor does it possess in itself any other power. It does not seem capable of any very distinct reflex actions; yet it is supposed that the muscles of the tympanum are called into action by impressions made upon the auditory nerve, and reflected through the auditory ganglion in the same manner as the diameter of the pupil is regulated through the optic nerve.* To this and some associated phenomena we shall advert when describing the ear.

THE EIGHTH PAIR OF NERVES.

This division of the encephalic series embraces three distinct nerves, all of which combine the functions of sensation and motion: they are in the order of their origin, the glosso-pharyngeal, pneumogastric and spinal accessory nerves.

1. THE GLOSSO-PHARYNGEAL NERVE.

This nerve, which is strictly the ninth in numerical order, arises from the corpus restiforme, and from the cerebellar fibres of the anterior columns. Its roots are from four to six in number, and emerge from the fissure that intervenes between the corpus restiforme and the olivary ganglion, beneath the posterior margin of the pons Varolii. It is thus placed directly above the pneumogastric nerve, with which it anastomoses within the cavity of the cranium. Figs. 342, 11, and 361, 1.

Its filaments collect into a cord which is enclosed in a separate sheath of the dura mater, and passing backwards and outwards to the posterior foramen lacerum, makes its exit from the skull, in company with the pneumogastric and accessory nerves. Fig. 352, 20. In this course the glosso-pharyngeal nerve has two enlargements, called the jugular and petrous ganglia.

1. The *jugular ganglion* of Müller is the smaller of the two, and occupies the groove formed for the nerve in the foramen lacerum. Its length seldom exceeds a line, and is frequently even less; and it is connected only with the posterior fibres of the nerve. Fig. 361, 4.

2. The *petrous ganglion* of Andersch is found about half an inch below the former, and is contained in a hollow in the lower border of the petrous portion of the temporal bone. It is of an oblong form, three or four lines in length,

* Carpenter. Principles of Physiology, § 446.

and embraces all the filaments of the glosso-pharyngeal nerve. It detaches branches by which the latter is connected with other nerves at the base of the cranium.* Fig. 361, 5.

These *communicating branches* run to the facial, pneumogastric, spinal accessory and sympathetic nerves, which thus constitute an intimate plexiform arrangement. One of the most interesting of the communicating nerves is the tympanic nerve of Jacobson.

The *tympanic nerve* is not always derived from the ganglion of Andersch, but sometimes from the nerve above the ganglion. It enters a bony canal in the jugular fossa, and then divides, according to Dr. Erasmus Wilson, "into six branches, which are distributed upon the inner wall of the tympanum, and establish a plexiform communication with the sympathetic and sixth pair of nerves. The *branches* of *distribution* supply the fenestra rotunda, fenestra ovalis, and Eustachian tube; those of *communication* join the carotid plexus, the petrosal branch of the Vidian nerve and the otic ganglion."† Fig. 361, 6.

The following branches are given off from the glosso-pharyngeal nerve after its emergence from the foramen lacerum.

1. The *carotid branches*, which spread themselves on the internal carotid artery, and anastomose with the sympathetic nerve.

2. The *pharyngeal branches*, three or four in number, are very small nerves which are distributed upon the muscular structure of the pharynx. The pharyngeal plexus, as heretofore stated, is formed by filaments from this nerve and others from the pneumogastric and sympathetic nerves.

3. The *lingual branches* are distributed to the mucous membrane of the side and base of the tongue, and are in part lost in its papillary structure.

4. The *tonsillar branches* surround the tonsil at its base, and send filaments to the mucous membrane of the fauces and soft palate.

Function.—The office of the glosso-pharyngeal nerve is evidently of a mixed character. We have shown that the hypoglossal nerve conveys motor power to the tongue; while this organ receives common sensibility and touch in part from the gustatory branch of the trigeminus, and in part from the glosso-pharyngeal; and Dr. Carpenter is of the opinion, that this nerve is the exclusive medium through which impressions made by disagreeable substances taken into the mouth, are propagated to the medulla oblongata so as to produce nausea and vomiting.

In proof, however, that the glosso-pharyngeal is a compound nerve, if its smaller root be stimulated, powerful contractions take place in the middle constrictor of the pharynx and stylo-pharyngeus muscles, and in those of the lower part of the face. On the other hand, Dr. Reid's experiments go to show that these actions are not direct, but reflected; not caused by the direct influence of the glosso-pharyngeal nerve upon the muscles, but by the cranial end of the nerve upon the medulla oblongata, whence the change is propagated to the muscles through the pneumogastric nerve and the fibres of the facial, which

* Quain.

† Human Anatomy, Dr. Goddard's edition, p. 431.

emanate from the same part of the nervous centre. From these experiments, which it seems unnecessary to enlarge upon, it has been inferred that the glosso-pharyngeal is one of those sensitive nerves capable of exciting motion through its influence upon motor fibres, implanted immediately contiguous to it in the nervous centre.*

2. THE PNEUMOGASTRIC NERVE.

This nerve, called also the *par vagum*, is part of the eighth pair of most anatomical systems, but is, in fact, the tenth pair of nerves. This nerve, like some others of this series, performs the double function of motion and sensation; and in physiological strictness, one portion of it may be described as originating in the brain, and the other as terminating there. To avoid confusion, we will suppose the whole fasciculus to arise within the cranium.

The pneumogastric nerve arises from the restiform body, by many filaments that emerge from the fissure between the corpus olivare and the corpus restiforme; they are ten or fifteen in number, and are arranged in three flattened fasciculi in which the fibres lie side by side; those above being connected with the glosso-pharyngeal nerve,—and those below with the accessory nerve of Willis. Figs. 342, 10, and 361, 2.

After a course of about half an inch, these fasciculi combine in a single nervous cord, that runs outwards and backwards in its own canal in the dura mater, and passes out of the cranium through the posterior foramen lacerum, and in front of the internal jugular vein. In the foramen, the pneumogastric nerve is connected closely with the glosso-pharyngeal and accessory nerves by dense cellular membrane, but it is separated from the jugular vein by a small bony spine that arises from the petrous bone and projects into the foramen lacerum.

Two ganglia are formed in this primary portion of the nerve, in the following manner.

1. The *superior ganglion*—ganglion superius—is also called, from its connection, the ganglion of the root of the pneumogastric nerve. It is about the fourth of an inch in diameter and of a spheroidal form. It lies within the foramen lacerum, and is connected by filaments with the facial, accessory and sympathetic nerves, and with the petrous ganglion of the glosso-pharyngeal. Fig. 361, 7.

2. The *lower ganglion*—ganglion inferius—is an enlargement of the pneumogastric nerve about half an inch below the former ganglion, and entirely exterior to the skull. It is nearly an inch long, of a reddish color, and communicates with the spinal accessory, hypoglossal, spinal and sympathetic nerves, which by their interlacement form the *plexus gangliformis*. This arrangement lies at first behind the internal carotid artery, but afterwards curves between the internal jugular vein and the carotid. Fig. 361, 9.

From the inferior ganglion the pneumogastric nerve descends in the neck,

* Todd and Bowman. Physiology, ii. p. 117.

from the transverse process of the atlas to the top of the thorax. In this course it is contained in the same sheath with the primitive carotid artery and internal jugular vein, being placed behind those vessels.

At the root of the neck the two pneumogastric nerves take different courses: that of the *right side* runs between the subclavian artery and vein and enters the posterior mediastinum, where it joins the esophagus and accompanies it, posteriorly, to the stomach. The *left pneumogastric* crosses the root of the left subclavian artery and the arch of the aorta, descends behind the root of the lung, and reaches the stomach along the anterior surface of the esophagus.

In this long course the pneumogastric nerve gives off the following branches: the auricular, pharyngeal, superior laryngeal, recurrent laryngeal, cardiac, pulmonary, esophageal and gastric.

1. The AURICULAR NERVE comes from the superior ganglion of the pneumogastric, and is at once joined by a filament from the glosso-pharyngeal. It then enters a canal in the petrous bone near the base of the styloid process, passes for some distance through the bone and joins the facial nerve in the aqueduct of Fallopius. This branch reappears on the surface in front of the mastoid process, and terminates on the integuments of the back of the ear. Fig. 361, 8.

2. The PHARYNGEAL NERVE arises from the inferior ganglion at its upper part, and runs downwards behind the internal carotid artery in order to reach the upper margin of the middle constrictor of the pharynx. It then anastomoses with branches from the glosso-pharyngeal, superior laryngeal and sympathetic nerves to form the *pharyngeal plexus*. From this plexus branches are supplied to the muscular and mucous structure of the pharynx. Fig. 361, 13.

3. The SUPERIOR LARYNGEAL NERVE comes also from the inferior ganglion, with which it appears to be continuous. It passes downwards behind the internal carotid artery, to the opening in the thyreo-hyoid membrane, which it enters in company with the superior laryngeal artery. It divides into two branches which supply the lining membrane of the larynx, and it then sends a communicating filament to the recurrent laryngeal nerve. Fig. 361, 14.

The superior laryngeal nerve is regarded as the nerve of *sensation* to the larynx.

4. The CARDIAC NERVES are two or three filaments given off from the pneumogastric in the lower part of the neck. They cross the common carotid artery, and anastomose with the cardiac branches of the sympathetic and with the great cardiac plexus.

5. The *recurrent*, or *inferior laryngeal nerve*, is a large branch which, on the *right side*, arises from the pneumogastric, directly after it has passed between the subclavian artery and vein. It then curves round the former vessel so as to get behind it, and mounts up towards the larynx, covered by the common carotid and inferior thyroid arteries. On the *left side*, the recurrent nerve winds around the arch of the aorta, just below the origin of the left subclavian artery, and then runs upwards to the trachea. In this course the recurrent laryngeal detaches the following branches.

It sends filaments to the cardiac branches of the pneumogastric, and others

that anastomose with twigs from the inferior cervical ganglion of the sympathetic. It is distributed to all the muscles of the larynx excepting only the crico-thyroid; sends branches to the pulmonary and cardiac plexuses, to the esophagus, inferior part of the thyroid gland, and to the mucous membrane and glands of the trachea.

The laryngeal recurrent is the proper *motor nerve* of the larynx.

6. The PULMONARY BRANCHES divide into two sets, called from their direction, anterior and posterior. The *anterior* filaments anastomose with others from the sympathetic nerve to form the anterior *pulmonary plexus.* The *posterior* branches are more numerous than the anterior, are distributed to the root of the lungs behind, and being joined by filaments from the third and fourth thoracic ganglia of the sympathetic, form the *posterior pulmonary plexus.*

7. The ESOPHAGEAL NERVES are derived from the pneumogastric within the thorax, both above and below the pulmonary branches. The branches from opposite sides unite over the esophagus to form the *esophageal plexus,* from which numerous filaments are sent off to the muscular and mucous tissues of the esophagus.

8. The GASTRIC NERVES from the pneumogastric are arranged as follows. The nerve, on entering the abdomen through the esophageal orifice of the diaphragm, gives off filaments that unite with others from the opposite side, and form a plexus round the cardiac orifice of the stomach.

The *right pneumogastric* then subdivides into numerous branches, which are distributed upon the posterior face of the stomach, to its lesser curvature and to the pylorus, where they terminate by anastomosing with the left pneumogastric, and with filaments from the gastric plexus of the sympathetic. Other branches go to the solar plexus, and are blended with the latter in its distribution to the liver, vena portarum, duodenum and pancreas.

Fig. 361.

Diagram of the connections of the glosso-pharyngeal, pneumogastric and accessory nerves. After Bendz.*

Fig. 361 is a diagram of the three nerves usually described as constituting the eighth pair. 1, root of the glosso-pharyngeal nerve; 2, roots of the pneumogastric nerve; 3, roots of the accessory nerve; 4, jugular ganglion; 5, petrous ganglion; 6, tympanic branch; 7, upper pneumogastric ganglion; 8, auricular branch; 9, lower pneumogastric ganglion; 10, branch from the last named ganglion to the petrous ganglion; 11, inner portion of the accessory nerve; 12, outer portion of the same nerve; 13, pharyngeal branch of the pneumogastric; 14, superior laryngeal branch; 15, branches to the sympathetic; 16, fasciculus of the accessory nerve, prolonged with the sympathetic; 17, cerebellum; 18, medulla oblongata; 19, spinal cord.

* From Quain and Sharpey's Anatomy, 5th ed., Fig. 194.

The *left pneumogastric* terminates in filaments that are lost upon the anterior face of the stomach; others traverse the lesser curvature to the pylorus, where they anastomose with the nerve of the opposite side, and with the gastric branches of the sympathetic, and are finally merged in the solar plexus.*

Function of the pneumogastric nerve.—It has been already remarked that this nerve is compound in its function; in other words that it contains filaments both of sensation and motion, respecting which the following are the principal facts determined by physiological experiment.

The pharyngeal branches are subservient to motion alone. The inferior laryngeal is the principal motor nerve of the larynx, while the superior laryngeal is the sensitive nerve of that organ. The cardiac branches exert a slight influence on the muscular movements of the heart; but the pulmonary branches are both motor and sensitive, and exert an important influence in respiration. The esophageal branches are of the sensory class; and the gastric branches influence both the motions and secretions of the stomach; but they are not essential either to secretion or complete chymification.†

If the pneumogastric nerve be divided in the neck on one side only, respiration is more or less embarrassed; but when both nerves are cut, death soon follows. If the nerve be severed beneath the lungs, either above or below the diaphragm, death ensues; but whether from the mere division of the nerve, or from the violence done to surrounding parts, has not been clearly proved.

3. NERVUS ACCESSORIUS, OR SPINAL ACCESSORY NERVE.

This nerve, in the old numerical system, is regarded as part of the eighth pair; but it is strictly the *eleventh cranial nerve*, being different in origin and distribution from either of the associated trunks. Figs. 342, 6, and 361, 11, 12.

It arises by a variable number of filaments or roots, generally from eight to twelve, which come from the medulla oblongata and from the spinal cord: three or four of these roots can be traced to the former, and six or seven to the latter source. The roots derived from the spinal cord come off as low down as the fourth or fifth cervical nerve, Fig. 361, 3, 3, and emerge out of the posterior lateral fissure: they soon unite in a common trunk that ascends between the posterior fasciculi of spinal nerves and the ligamentum denticulatum, and enters the cavity of the cranium behind the vertebral artery, and through the occipital foramen. It is frequently connected by filaments to the posterior root of the first and second cervical nerves; a junction that has a knotted appearance, not altogether resembling either a ganglion or a plexus; but, as Dr. Horner observes, is peculiar, and looks as if one nerve was wrapped around the other. This spinal portion of the nerve, on reaching the cranium, is joined by the roots from the posterior fasciculus of the medulla oblongata, and a common trunk is thus formed which is the accessory nerve, and which runs outwards and down-

* Horner. Anatomy and Histology, ii. p. 509.

† Todd and Bowman. Physiology, ii. p. 127.

wards through the posterior foramen lacerum, in the same sheath with the pneumogastric nerve.

While in the foramen, this nerve is connected by filaments with the superior ganglion of the pneumogastric: at its exit it separates at once into two branches, one of which passes externally, the other internally.

The *internal* or smaller branch is connected with the pneumogastric at the base of the skull, and is blended with it beyond the inferior ganglion.* Fig. 361, 11.

The *external branch* is the combination of the trunk of the accessory nerve. It turns backwards behind the internal jugular vein, and having reached the sterno-mastoid muscle, perforates it, and anastomoses with the second, third and fourth cervical nerves. In this course the accessory nerve sends branches to the sterno-mastoid muscle, and its final distribution is upon the trapezius, which it supplies throughout. Fig. 361, 12.

Function.—The accessory nerve is regarded by most physiologists as one of pure motion; and that such is the sole office of the *external* branch, there can be no question; but the observations of Drs. Todd and Bowman, the latest on this subject, have led to the conclusion, that the *internal* branch consists of afferent or sensory fibres.

This nerve is called by Sir Charles Bell, the *superiór respiratory nerve of the trunk;* for his experiments proved that its division interrupts a collateral source of respiratory action, by suspending the motion of the mastoid and trapezius muscles.

THE HYPOGLOSSAL OR LINGUAL NERVE. NINTH PAIR.

This is, in reality, the eleventh nerve, and the last of the cerebral series. Mr. Solly supposes it to arise, like the spinal nerves, by two roots, one of which is connected with the brain by means of the anterior column of the cord, while the other is associated with the vesicular neurine of the olivary body. It commences by several filaments, generally ten or fifteen in number, which emerge from the groove between the corpus pyramidale and the olivary ganglion. Fig. 342, 19. The several filaments unite into two cords which penetrate the dura mater by distinct openings, and then unite in a single trunk that passes out of the cranium through the anterior condyloid foramen. After its exit, the hypoglossal nerve runs forward between the internal jugular vein and internal carotid artery, and descends with the former, till it gets on a line with the angle of the lower jaw. It then crosses the hypoglossus muscle to the genio-hyo-glossus, in which last it is continued beneath the tongue to the apex of that organ. The hypoglossal nerve is flattened where it lies in contact with the hyoglossus muscle.

The connections of the hypoglossal nerve are with the pneumogastric at the base of the cranium; and lower down, with the first two cervical nerves and the sympathetic. Fig. 352, 22.

The branches of this nerve are the following:

1. The *descendens noni* is a long, slender cord, given off from the hypoglossal

* Quain and Sharpey.

when the latter comes in contact with the occipital artery, whence it descends upon the sheath of the carotid, until it reaches the middle of the neck. It here forms a loop with the second and third cervical nerves, in the manner of a plexus, from which branches are distributed to the omo-hyoid, sterno-hyoid and sterno-thyroid muscles.

2. The *thyro-hyoid nerve* comes from the hypoglossal near the margin of the hyoglossus muscle, and descending over the greater cornu of the os hyoides, is spent upon the thyro-hyoideus muscle.

3. Besides the two preceding branches, the hypoglossal nerve detaches filaments that communicate with the gustatory nerve; they ascend on the hyoglossus muscle near its anterior margin, where they form a small plexus.

Function.—The hypoglossal is chiefly and perhaps exclusively a motor nerve, whence the synonym of *motor linguæ;* for it guides the tongue in the various operations of chewing, swallowing, and articulating. If it be divided, the tongue becomes paralyzed, but special sense (that of taste) and common sensibility remain unimpaired.

Some physiologists rank the hypoglossal with the nerves of compound function, because it possesses some slight sensory properties, which last have been observed on irritating its trunk just after its exit from the cranium. It is supposed, however, that this sensitiveness arises from filaments derived from the cervical nerves, with which the hypoglossal freely anastomoses.

If after perusing the preceding account of the nervous system, the student feels himself involved in doubt and obscurity in relation to various parts of it, he may console himself with the reflection, that the same difficulties have embarrassed all those who have attempted to unravel this mysterious structure. Enough, however, is known both of its arrangement and function, to reward the toil of the learner; and as regards the rest, he must be content to await the developments of future investigation.

ORGANS OF SENSE.

Under this head are classed the eye, the ear, the nose, the tongue and the tactile portions of the nervous system. With respect to the functions of taste and touch, we shall add a few physiological remarks in the sequel; but the organs of sight, hearing and smell, however, call for a more detailed exposition, which we now proceed to give.

THE EYE AND ITS APPENDAGES.

The eye is placed in the bony orbit, which, as we have seen, is beautifully constructed by the bones of the cranium and face, and so arranged as to give room for the free motions of the eye, and the muscles by which those motions are performed. It is surrounded or accompanied by other accessory parts, as the nerves, blood-vessels, adipose tissue, lachrymal apparatus, the eyebrows, eyelids and some subordinate structures, all which are included in the general designation of

APPENDAGES OF THE EYE.

The EYEBROWS, *supercilia*, are two tegumentary prominences placed over the upper arch of the orbit on each side. Fig. 362, 1. They are covered with coarse hair, that grows outwards towards the temples, and serves to protect the eye against a glare of light, and from the dust and perspiration that are liable to accumulate on the forehead. The supercilia, moreover, have a strong influence in expressing some emotions of the mind, which they do by the contraction of the muscles beneath them,—the occipito-frontalis, orbicularis oculi and corrugator supercilii, but more particularly by the last of these muscles. The bare space between the eyebrows is called *glabella*, but in some persons this also is covered with hair, rendering the brows continuous.

The EYELIDS, *palpebræ*, are placed in front of the orbit, and when shut, serve to close that cavity in front and exclude light from the eye. They consist of a basis of cartilage, with skin, muscular fibres and mucous membrane. Fig. 362, 2.

The TARSAL CARTILAGES, or, more strictly speaking, *fibro-cartilages*, are two

in number, one above, the other below. They are about an inch in length, but the superior is somewhat broader than the lower one. It is the third or half of an inch in breadth, of a semilunar form, with a thin upper margin to which is attached the levator palpebræ muscle. The inferior cartilage is flat, about two lines wide, elliptical in shape, and placed in the substance of the lower lid. The palpebral cartilages lie between the orbicularis muscle externally and the tunica conjunctiva internally.

The tarsal cartilages are connected together at their ends, producing an angle of junction; the angle next the nose is the *internal* or *greater canthus;* the other is the external or *lesser canthus of the eye.*

The internal canthus is connected with the proximate part of the upper maxillary bone by the *ligamentum palpebrale internum*, a cord-like tendon, which at the same time serves for the origin of the orbicularis oculi muscle. It passes horizontally into the orbit, is nearly half an inch in length and causes a slight corrugation or folding of the skin. The *external palpebral ligament* is given off in a bifurcated manner, from the external extremity of the tarsal cartilages to the frontal process of the malar bone within the orbit, to which it is attached.

The *orbito-tarsal ligament*, also called the broad tarsal ligament, is a strong, fibrous membrane interposed between the tarsi and the bony margin of the orbit, attaching the one to the other. Its obvious use is to connect and sustain these parts. The external palpebral ligament above described, is in reality a thickened portion of the orbito-tarsal ligament.

The orbicularis muscle, which forms, as above stated, a part of the eyelid, has been heretofore described; and the skin that overlies it differs from common integument only in being more delicate and containing no fat-cells.

The *tunica conjunctiva* constitutes the internal or fourth, and by far the most delicate layer of the eyelid. It is a fine transparent membrane, closely adherent to the tarsal cartilage. It covers the anterior portion of the eye-ball, including the cornea: it is thence reflected to the lids, and extends for a short distance into the lachrymal passages, where it becomes continuous with the lining membrane of the lachrymal sac, Meibomian glands and lachrymal ducts. Where it covers the cornea, the conjunctiva is extremely delicate and has no perceptible blood-vessels; it is almost equally thin on the eyelids, where it constitutes a very vascular membrane, but that portion covering the sclerotica is thicker and much less adherent.

The MEIBOMIAN GLANDS, or glands of the eyelids, are lodged in grooves in the tarsal cartilages, and covered by the tunica conjunctiva. They are about twenty in number in the lower lid, and thirty in the upper. Each gland is two or three lines in length, and consists of a serpentine, convoluted tube, the walls of which are cellular all round, so that it has been compared to a bunch of berries united without stalks. These cells open into the common tube, which has its orifice on the margin of the lid behind the eyelashes. Sometimes two tubes coalesce and have only a single excretory duct. The Meibomian glands secrete

a transparent, viscid fluid, that gives greater consistence to the tears and thus prevents their too ready overflow from the lids.

The *eyelashes*, *cilia*, are disposed in three rows on the margin of each eyelid. They curve upwards from the upper lid, and downwards from the lower, and decussate each other when the eye is closed. They serve to protect the eye from the ingress of dust and other extraneous substances. At the inner end of each eyelid, about a fourth of an inch from the internal canthus, is the punctum lachrymale, leading into the lachrymal sac; and from the punctum inwards the cilia are deficient.

The *caruncula lachrymalis* is a red, fleshy-looking body the size of a grain of wheat, placed at the inner canthus and covered by the tunica conjunctiva. It consists of seven or eight glandulæ, aggregated together, but opening by separate orifices. They secrete a fluid analogous to that of the Meibomian glands. The caruncles are furnished with some short, delicate hairs. Fig. 362, 3.

The *valvula semilunaris* is a duplicature of the conjunctiva at the outside of the caruncula. It sometimes contains a minute plate of cartilage, which is the basis of the third lid in animals,—the *membrana nictitans* of birds.

The *tensor tarsi* muscle has been already described, page 178.

Vessels of the eyelids.—The arteries of the eyelids are the internal and external palpebral, derived from the ophthalmic, facial and temporal. They form the *arcus palpebralis* above and below.

Nerves.—The nerves of the eyelids are chiefly derived from the frontal, lachrymal and infraorbitar branches of the trigeminus; and also from the facial, which supplies the orbicularis muscle.

Fig. 362.

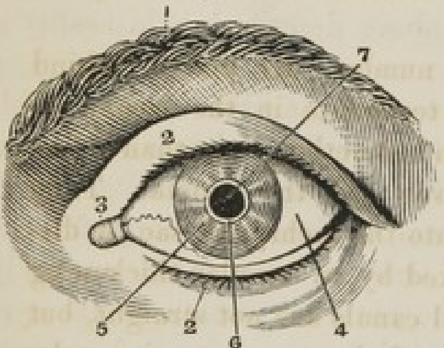


Fig. 362. Eye of the natural size and state. 1, supercilia; 2, upper and lower lids and cilia; 3, inner canthus and caruncula lachrymalis; 4, cornea; 5, iris; 6, inner and circular fibres of the iris,—the *sphincter iridis* muscle; 7, pupil.

THE LACHRYMAL ORGANS.

These embrace the lachrymal gland and ducts, the puncta lachrymalia, the canals leading from them into the lachrymal sac, the sac itself and the ductus ad nasum.

The LACHRYMAL GLAND is partly lodged in a concavity in the upper and outer region of the orbit, and consists of two parts, the orbitar and palpebral.

The superior or *orbitar portion* is about three-fourths of an inch long, narrow and flattened, and occupies the lachrymal fossa of the os frontis, to which it is attached above. Its lower or concave surface rests upon the rectus externus muscle. Its anterior extremity lies close behind the superior external border of the orbit; but the nerves and vessels enter at its posterior border.

The *palpebral portion* of the gland is smaller but thinner than the other. It

lies upon the upper eyelid, and extends downwards nearly to the upper margin of the tarsal cartilage. The two portions of the gland are continuous in structure, and embraced in a strong fibrous membrane, that serves the purpose of a capsule.

The lachrymal gland is of a pink color and consists of an aggregation of lobules. It gives off from eight to twelve excretory ducts, some from the orbitar, others from the lachrymal portion, that open, almost invisibly, on the posterior surface of the upper lid, where they perforate the conjunctiva, a line above the cartilage. These orifices are arranged in a row about half an inch long, from the external canthus to the centre of the lid.

The *lachrymal secretion*, known as the tears, is thin, watery and transparent. It is composed chiefly of water, with a very small proportion of solid matter in the form of salts, and albuminous and mucous compounds. It is ordinarily secreted in moderate quantity for the purpose of cleansing and lubricating the eye; and it is afterwards received into the puncta lachrymalia, and conveyed thence through the nasal duct into the lower meatus of the nose.

The *punctum lachrymale* is seen on the free surface of each eyelid near the inner canthus. It is marked by a small elevation, the *papilla lachrymalis*, the orifice of which being always open, is distinctly seen by a partial eversion of the lid. The puncta are about a line in length. The upper one is directed downwards and backwards, the lower one upwards and backwards towards the globe of the eye.

The *lachrymal canals*, *canaliculi*, also two in number, are placed behind the orbicularis muscle and the tensor tarsi, and terminate in the lachrymal sac. Each canal is about half an inch in length and something less than a line in diameter, being thus greatly dilated in comparison with the puncta. They converge at the inner angle of the eye, and open into the lachrymal sac by distinct but proximate orifices, each of which is marked by an annular thickening of the lining membrane of the sac. The lachrymal canals are not straight, but angular; and each receives its respective fasciculus of the tensor tarsi muscle, by means of which it is drawn inwards and the sac dilated.

The LACHRYMAL SAC is lodged in the depression, *fossa lachrymalis*, formed conjointly by the os unguis and upper maxillary bone. It is continuous above with the lachrymal canals and below with the nasal duct: in front of it is the ridge formed by the anterior inferior angle of the orbit, and behind it is the internal palpebral ligament. It is composed of reddish, vascular mucous membrane replete with follicles: it is united internally to the contiguous bone by areolar tissue, and externally, by the same medium, to a fibrous continuation of the orbicularis muscle. The fibrous exterior of the sac may be described as a distinct tunic, of which the mucous membrane forms the lining.

The cavity thus formed is cylindrical in shape, more than half an inch in length, and terminates on a level of the floor of the orbit in a fold of the mucous membrane, and this fold marks the end of the sac and the commencement of the nasal duct.

The LACHRYMAL DUCT, *ductus ad nasum*, is a cylindrical canal, somewhat flat-

tened, commencing, as above mentioned, on the floor of the orbit, and terminating by a dilated orifice in the inferior meatus of the nose, directly below the anterior border of the lower turbinated bone. It curves slightly forwards and outwards in its course, and is somewhat contracted in the centre. It is from three-fourths of an inch to an inch in length, and consists of a delicate mucous membrane surrounded by a fibrous tissue that connects it with the adjacent bones. It is a delicate, vascular structure, deriving its blood from twigs sent off by the ophthalmic artery, and its nerves from the first branch of the trigeminus.

Muscles of the eyeball.—These have been heretofore described (page 177), but their names may be recapitulated on the present occasion; viz., the rectus superior, rectus inferior, rectus internus and rectus externus. These are the *four straight muscles*, and act by drawing the eyeball directly upwards, downwards, internally and externally. The two oblique muscles are the obliquus superior and obliquus inferior, the former directing the ball downwards and outwards, the latter downwards and inwards. These muscles are furnished with nerves by the motor oculi, or third pair; by the trochlearis or fourth pair; by the ophthalmic or first branch of the trigeminus, and by the motor externus or sixth pair.

THE EYEBALL.

The ball or globe of the eye, *bulbus oculi*, lies in the anterior half of the orbit, surrounded and supported by adipose matter and by its appropriate muscles and some subordinate parts. Its diameter is about an inch, which, in the European, is generally admitted to be a little more in the antero-posterior direction than in the transverse measurement; but these proportions, according to the observations of the accurate Dr. Horner, appear to be reversed in the Negro.

The *ocular capsule*, *capsula oculi*, is a strong fibrous membrane, firmly applied to the ball of the eye behind, where it merges into the sheath of the optic nerve, but is continuous in front with the perichondrium of the tarsal cartilages. All the muscles of the ball lie behind it and perforate it by their anterior extremities in order to reach the sclerotica.*

TUNICS OR COATS OF THE EYE.

The eyeball is composed of three concentric envelopes, viz., the sclerotica, with the cornea in front; the choroides with the iris in front; and the retina, which is internal. These, with some subordinate parts, make up the solid constituents of the eyeball, which is a hollow sphere filled with three fluid or semi-fluid substances—the aqueous humor, the crystalline lens and the vitreous body.

* Von Behr. Handbook of Anatomy, § 496.

THE SCLEROTICA.

The SCLEROTIC COAT—*sclerotica*—is composed of white fibrous tissue arranged in numerous layers crossing each other at right angles, and forming a tunic of great strength.* It is of a white, glossy, opaque appearance, with a bluish tint, known in common language as "the white of the eye." It is dense, inextensible, much stronger behind, where it is a line in thickness, than in front: it is provided with very few blood-vessels and seems to be wholly destitute of nerves.

The sclerotica forms five-sixths of a sphere; the remaining sixth, which is in front, being filled by the cornea. The optic nerve penetrates the sclerotica behind, about the eighth of an inch on the inner side of the axis of the eye: Fig. 354. It enters, not in a solid trunk, but by fasciculi separated by fibrous tissue; so that when the nerve is divided on a level with the sclerotica, the aperture has a cribriform appearance, *lamina cribrosa.* One of these foramina, central and larger than the rest, is the *porus opticus*, through which the central artery of the retina enters the ball of the eye.

The anterior circular opening of the sclerotica is levelled all round for the reception of the cornea: it is strengthened above or behind this opening by the attachment of the tendons of the four recti muscles, and its exterior surface appears rough from these insertions; but its internal face is smooth and shining, and covered by a delicate cellular tissue interposed between it and the choroid coat.

This glossy appearance of the internal face of the sclerotica is attributed by Meckel and others to a prolongation of the arachnoid tunic after it has entered the chamber of the eye with the optic nerve: it forms an annular enlargement around the cribriform foramen of the sclerotica, whence it lines that membrane, being internally united to it as far as its anterior margin. The tunica arachnoidea, therefore, lines the sclerotica precisely as it lines the dura mater within the cranium.† It is sometimes called the *lamina fusca scleroticæ.*

THE CORNEA.

The CORNEA is a beautifully transparent, firm, elastic membrane, forming the segment of a smaller but more convex sphere than the sclerotica, into the bevelled edge of which it is placed with so much firmness that the two structures cannot be separated except by very protracted maceration. Viewed from within, the cornea is exactly circular; but seen from the outside, its transverse diameter is observed to be a little less than the vertical, owing to the sclerotica overlapping it much more above and below than at the sides. This structure,

* Todd and Bowman, Physiology, ii. p. 16.

† J. F. Meckel. Manual of General and Descriptive Anatomy, iii. p. 153. Henlé denies this reflexion of the arachnoid.

moreover, is not lenticular, or thicker in the middle, as often described; but the anterior and posterior surfaces present parallel curvatures.* Fig. 365, 1, 2.

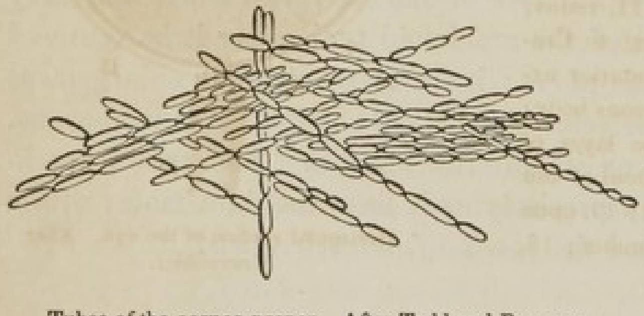
The cornea is composed of five lamina, viz., the conjunctival epithelium, the anterior elastic lamina, the cornea proper, the posterior elastic lamina, and the posterior epithelium.

1. The *conjunctival epithelium* consists of "three or four layers of superposed particles, inclining to the columnar form, where they rest on the anterior elastic lamina, and becoming imbricated scales on the surface." It forms, after death, a slimy covering, that gives the cornea its opaque appearance.

2. The *anterior elastic lamina* is a transparent, homogeneous stratum, coextensive with the front of the cornea, and forming the anterior boundary of the cornea proper. "It is a peculiar tissue, the office of which seems to be that of maintaining the exact curvature of the front of the cornea; for there pass from all parts of its posterior surface, and in particular from its edge into the substance of the cornea proper and the sclerotica, a multitude of filamentous cords, which take hold, in a very beautiful manner, of the fibres and membrane of those parts, and serve to brace them, and hold them in their right configuration. Its thickness is about the $\frac{1}{2000}$th of an inch."†

3. The *cornea proper* is the basis of this structure, and that upon which its strength mainly depends. "It is a peculiar modification of the white fibrous tissue, continuous with that of the sclerotic. At their line of junction the fibres which, in the sclerotica, have been densely interlaced in various directions, and mingled with elastic fibrous tissue, flatten out into a membranous form, so as to follow, in the main, the curvature of the surface of the cornea, and to constitute a series of more than sixty lamellæ, intimately united to one another by very numerous processes of similar structure, passing from one to the other, and making it impossible to trace any one lamella over even a small portion of the cornea. The resulting areolæ, which in the sclerotic are irregular, and on all sides open, are converted in the cornea into tubular spaces, which have a very singular arrangement, hitherto undescribed. They lie in superposed planes, the contiguous ones of the same plane being for the most part parallel, and crossing those of the neighboring planes at an angle, and seldom communicating with them."‡ These tubes are not distended with any fluid, but are moistened in the same way as the areolæ of ordinary cellular tissue. Fig. 363.

Fig. 363.



Tubes of the cornea proper. After Todd and Bowman.

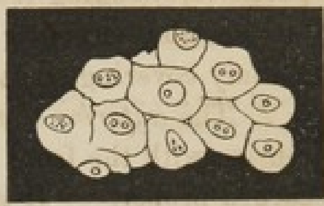
4. The *posterior elastic lamina*, *cornea elastica*, is a firm, thin, transparent membrane, yet dense and elastic as cartilage, and unchangeable by the action of

* Todd and Bowman. Physiology, ii. p. 17.
† Idem. Op. citat, ii. p. 20.
‡ Idem, op. citat., ii. p. 20.

boiling water. It does not pass over upon the iris, but extends to its exterior margin, and terminates between the sclerotica and the ciliary ligament with a sharp edge. It is sometimes called *membrana Demoursii.**

5. The *posterior epithelium*, called also epithelium of the aqueous humor, is an exceedingly delicate lamina, exactly resembling the analogous structure in serous membranes. It covers the posterior surface of the membrana Demoursii, and terminates at the external margin of the iris.

Fig. 364.

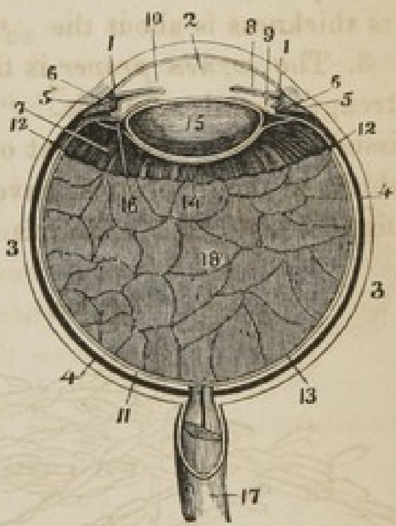


Posterior epithelium of the cornea.

Fig. 364. Posterior epithelium of the cornea. After Drs. Todd and Bowman.

No blood-vessels have been traced into the cornea proper; but two sets of vessels, superficial and deep-seated, surround its margin: the former are extended a short distance upon the conjunctiva, but they terminate in veins at from $\frac{1}{8}$th to $\frac{1}{2}$ a line from the point of ingress. The deeper vessels appear at first to enter the cornea proper; but they terminate in veins at the point of junction between the cornea and sclerotica.

Fig. 365.



Horizontal section of the eye. After Cruveilhier.

Fig. 365. Horizontal section of the eye. 1, 1, the cornea, fitted into the sclerotica; 2, its posterior lamina, or cornea elastica, forming the anterior parietes of the chamber of the aqueous humor; 3, 3, sclerotica; 4, 4, choroid coat; 5, 5, ciliary ring or ligament; 6, its internal surface, corresponding to the ciliary processes; 7, ciliary body, or corona ciliaris of the choroid coat; 8, iris; 9, posterior chamber of the aqueous humor; 10, anterior chamber of the aqueous humor; 11, retina; 12, 12, termination of the retina, according to Cruveilhier and others, *margo dentatus*, at the posterior extremities of the ciliary processes of the vitreous body; 12, vitreous humor; 13, hyaloid tunic, one layer of which passes behind, 14, and the other in front of the crystalline lens; 15, lens; 16, canal of Petit; 17, optic nerve, invested by a sheath from the dura mater; 18, vitreous humor or corpus vitreum.

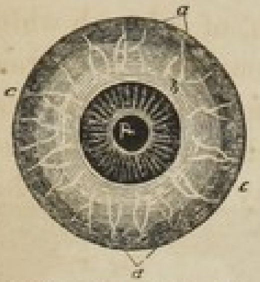
THE CHOROID COAT.

We have seen that the first coat of the eye is formed by the sclerotica and cornea; we have next to show that the second coat is composed of the choroid tunic and the iris, with some collateral parts. Fig. 366.

The *choroid coat, tunica vasculosa*, is a membrane composed in part of fibrous tissue analogous to that of the sclerotica, but chiefly made up of blood-vessels and pigment cells. The latter give it a deep-black color on the inside, but its external surface is of a rich brown tint. It is placed immediately within the sclerotica, which it lines throughout, the two being united by

* Von Behr, § 498.

Fig. 366.



Choroid coat and iris. From Sœmmering.

a delicate filamentous tissue of a brown color and loose texture, the *lamina fusca.* Its internal surface is covered by the retina, which, however, is not adherent: it is open in front where it is bounded by the ciliary ligament and the iris, and behind it is perforated by the optic nerve. At the latter point the choroid adheres pretty firmly to the sclerotica.

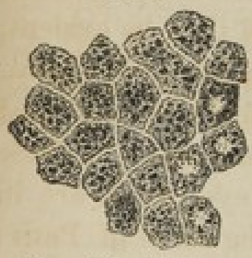
Fig. 366. Anterior view of the eyeball after the removal of the cornea and sclerotica. *a, a,* choroid coat; *b,* ciliary ligament; *c,* ciliary nerves; *p,* pupil.

The choroid is usually, though artificially, described as composed of three coats, in the following manner.

The *first* of these tunics, or that which is external, consists of numerous veins arranged in a curvilinear form, and converging, before they leave the choroid, into four or five trunks called *vasa vorticosa*, which empty into the posterior ciliary veins. This layer of the choroid is continuous in front with the ciliary ligament.

The *second* layer is the *tunica Ruyschiana*, a plexus of arterial capillaries disposed in a close net-work more elaborate behind than in front, and all derived from the posterior ciliary arteries. This layer of the choroid is continuous in front with the ciliary body.

Fig. 367.



Choroidal epithelium.

The *third* layer is the *choroidal epithelium*,—a single lamina of nucleated particles covering the internal surface of the second or capillary tunic. These particles or cells are of a pentagonal or hexagonal shape, and filled with pigment; whence this structure is called *membrana pigmenti.* Fig. 367.

Fig. 367. Choroidal cells filled with pigment, except in some few instances, which show the central white nuclei. From Drs. Todd and Bowman.

Fig. 368.

Pigment cells of the substance of the choroid.

Fig. 368 represents pigment cells from the substance of the choroid membrane, magnified 320 diameters. From Drs. Todd and Bowman.

Pigment cells.—Besides the pigment cells of the membrana pigmenti, a free deposit of this coloring matter also exists in the substance of the choroid. These cells are "extremely variable in shape, and lie in various directions among the other elementary tissues. Similar ones are found in the iris, and sparingly in the anterior part of the sclerotic. They are so loaded with pigment that their nuclei are often obscured by it."* The pigmentary matter within these cells is of a sepia tint, and so tenacious of its coloring principle as to be wholly insoluble in any known medium excepting diluted liquor potassæ. Fig. 368.

The pink hue of the eye in albinos is owing to the absence of pigment in the

* Todd and Bowman, ii. p. 22.

choroid and iris; and is, in fact, derived from the unprotected blood-vessels of the parts just named.

The *ciliary ligament* is a ring upwards of a line in width, of a bluish-white color and composed mainly of a dense cellular tissue. It connects the choroid and sclerotica intimately together, but adheres so much more closely to the former that it always comes away with it. The iris is attached to the anterior margin of the ligament, so that the sclerotica and cornea may be readily peeled from the choroides and iris, without impairing the continuity of the last named membrane. Figs. 369, and 373, 4.

Fig. 369.

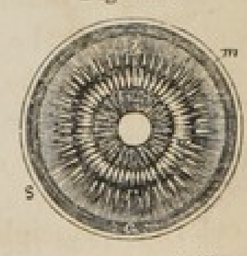
Ciliary ligament and choroid coat. From Sœmmering

The ciliary nerves and blood-vessels concentrate at the ciliary ligament prior to their distribution in the contiguous structures; and this ligament also receives the anterior ciliary arteries, at the point where they penetrate the sclerotica to reach the interior of the eye.

Fig 369. Anterior view of the eye, the iris being removed. *a, b*, ciliary ring or ligament; *c, c*, choroid coat showing at *v* the vorticose arrangement of the veins, *vasa vorticosa*.

The ciliary body and processes.—"The internal face of the choroid coat, as well as its anterior margin, undergoes a very remarkable change from the general plan of this tunic, by forming what is called the ciliary body (*Corpus ciliare, corona ciliaris*). In order to see this in the most favorable manner, the eye should be laid on the cornea, and its posterior half cut away. It will then be evident, that just behind the iris, and within the circumference of the ciliary ligament, the internal face of the choroid coat forms a considerable number of radiated folds or little ridges, which converge from behind forwards and inwards. These folds commence by striæ almost imperceptible to the naked eye, which are in contact with the fore part of the vitreous humor, and with the canal of Petit; and thereby not only impress the neighboring portion of the tunica hyaloidea with their shape, but even leave upon it the black pigment with which they themselves are covered. These folds, when they get near the circumference of the iris, coalesce one with another, and terminate in a considerable number (from fifty to sixty, according to Sœmmering) of processes (*processus ciliares*), the central extremities of which are loose, and float in the aqueous humor. Some of these processes are longer than others. Fig. 371, 5. As a whole, the ciliary processes constitute a ring of radiating filaments a line or more in length, placed along side of, and in contact with, one another; the external periphery of the ring adheres to the ciliary ligament, and through it to the greater circumference of the iris, so that the ring appears, but fallaciously, to be continuous with the iris."* Fig. 370.

Fig. 370.



Choroid coat and ciliary processes. From Sœmmering.

Fig. 370. Internal view of the choroid coat and ciliary processes, as seen by a vertical section of the eyeball. *a, b*, corona ciliaris or ciliary body, the rays of which are adherent to the choroid at *b*, and free at *a*; *s*, sclerotic coat; *c*, choroid coat

The processes are extremely vascular and are filled with irregular pigment

* Horner. Anatomy and Histology, ii. p. 447.

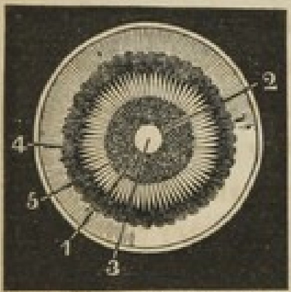
cells. On their internal surface is a tough, colorless lamina composed of imperfect nucleated cells, by means of which they are connected with the hyaloid tunic. Fig. 365, 7.

THE IRIS.

The iris occupies the opening of the choroid in front, where it presents a plane surface in a vertical position, having the lens behind and the cornea in front. It is attached by its periphery to the ciliary ligament, and by the latter to the choroid coat, with which it is by some anatomists regarded as a continuous, though modified structure. Where it joins the ciliary ligament, it also becomes continuous, through its anterior surface, with the posterior elastic lamina of the cornea. Fig. 371.

The iris is free except at these peripheral attachments, floats freely in the aqueous humor, and has a sub-central opening, the *pupil*, for the admission of light to the retina. The pupil is circular, but varies from about $\frac{1}{20}$th to $\frac{1}{3}$d of an inch in diameter, according as the iris is dilated or contracted. Fig. 371, 3. The posterior surface of the iris, *uvea*, is thickly covered with pigment; but the anterior surface is the seat of the *color of the eye*, so remarkably and beautifully varied in the human species, and presenting numerous blended tints of black, brown, blue and gray.

Fig. 371.



Uvea and ciliary body. From Sœmmering.

Fig. 371. In this instance the lens and vitreous humor have been removed, and the iris and proximate parts are seen from behind. 1, 2, uvea; 3, pupil; 4, *ora serrata*, which is supposed by Sœmmering and Weber not to be a part of the ciliary body, but a mere collection of pigment;* 5, ciliary processes.

The iris is very generally regarded as a modification of muscular tissue. Its radiating fibres converge from the periphery to the centre, and by their power of contraction produce dilatation of the pupil, *dilatator iridis;* another and circular set surrounds the pupil, and performs the part of a sphincter by contracting that opening. These last constitute the *lesser circle* of the iris, in contradistinction to the exterior or *greater circle*, and are the *sphincter iridis* of Monro.† Fig. 373, 6. Light is the stimulus of these actions, which, as we have heretofore remarked, belong to the *reflex* class: in other words, the optic nerve appears to be the medium through which the impression is conveyed to the nervous centres, while the third pair conducts the motor impulse to the iris. The muscular fibres of the iris are not under the control of the will, and in this respect, as well as in their structural arrangement (being destitute of striæ), are classed with the muscles of organic life. They are blended with a congeries of blood-vessels and nerves, and connected together by a delicate areolar tissue.

In the fœtus the pupil is closed by the *membrana pupillaris*, which is attached to the contiguous surface of the iris, thus separating the anterior from the posterior chamber of the aqueous humor. This membrane disappears just before birth, or is seldom perceptible at that period. Fig. 372.

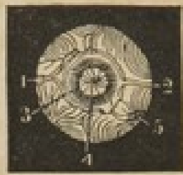
* Weber. Anatomical Atlas, Tab. xix., Figs. 35, 36, and explanations, p. 113.

† See Dr. Monro's Heads of Lectures, edited by his son, Pl. 5.

BLOOD-VESSELS AND NERVES OF THE CHOROIDES AND IRIS.

The blood-vessels and nerves of the choroides and iris are very numerous, and arranged in a singularly beautiful manner.

Fig. 372.



Membrana pupillaris. From Sœmmering.

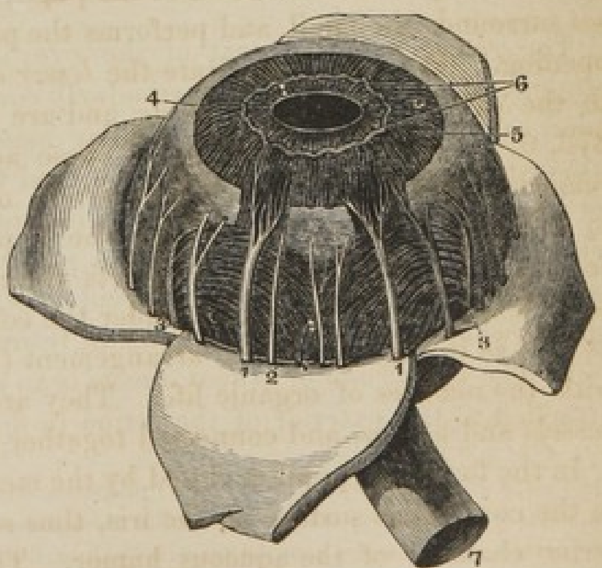
Fig. 372. The iris and the contiguous parts of the choroid coat seen in front, with the *membrana pupillaris*, from a seven months child. 1, 2, long ciliary arteries; 3, iris; 4, membrana pupillaris; 5, vasa vorticosa of the choroid coat.

The ARTERIES are branches of the ophthalmic, and consist of two sets, the long ciliary and the short ciliary. The *long ciliaries*, two in number, penetrate the posterior parietes of the sclerotica, and running forward between that tunic and the choroides, reach the iris to which they are distributed. The *short ciliary arteries*, twelve to twenty in number, also penetrate the sclerotica behind, and divide into a great number of anastomosing branches, that enter the ciliary body and inosculate with the vessels of the iris.

The VEINS of the choroides are arranged in the exterior layer in that remarkable intertexture called the *vasa vorticosa*, to which allusion has already been made. They unite in twelve or fourteen trunks, which, after passing for some distance in the substance of the sclerotica, become reduced to four or five, and escaping from that membrane, discharge their contents into the ophthalmic vein. Fig. 369, *v*, and 373, 3. These veins are associated with the arterial capillaries of the *tunica Ruyschiana*, bringing back the blood conveyed by the latter to the eye.

There is, consequently, another set of veins corresponding to the long and short ciliary arteries, running contiguous to and parallel with them. These *vena comites* bring back the blood of the iris, and terminate in the other and larger venous trunks.* Some of the veins of the iris enter the long ciliary veins, but others communicate with the vasa vorticosa.

Fig. 373.



Nerves of the choroid tunic and iris. After Zinn.

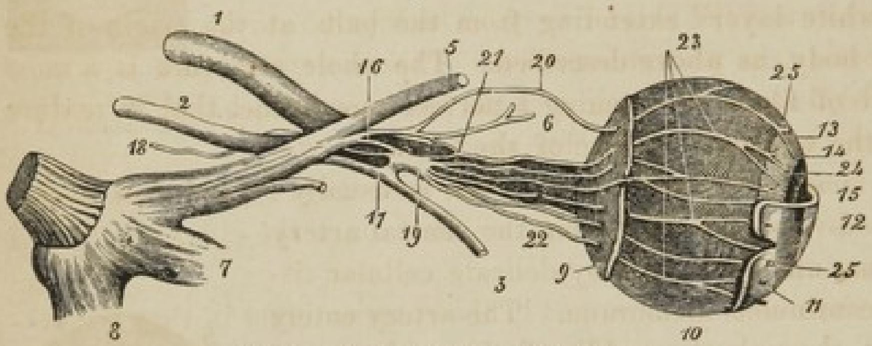
Fig. 373 represents a dissection of the eye in which the sclerotica has been dissected off and turned down, in order to expose the nerves and some of the blood-vessels. 1, 1, ciliary nerves entering the ciliary ligament and passing forward to the iris: the ligament is dissected away in two places to show their course; 2, smaller ciliary nerve; 3, vasa vorticosa, or veins of the exterior layer of the choroides; 4, ciliary ligament and muscle;† 5, converging fibres of the greater circle of the iris; 6, looped and knotted form of these fibres near the pupil; the knots or enlargements being regarded as ganglia by Meckel. Within them is seen the *lesser circle*, sphincter iridis, with its converging fibres; 7, the optic nerve.

* Horner. *Ut suprà.*

† In many searches for the ciliary muscle, I have never been able clearly to identify it in the human

NERVES.—These are the *ciliary*, derived from the ophthalmic ganglion. They come off in variable numbers from fifteen to twenty, and penetrating the sclerotica in advance of the optic nerve, run forward between that tunic and the choroides in an isolated manner until they reach the ciliary ligament; upon this structure they are freely distributed, whence it has been regarded by Sœmmering as a ganglion—*annulus gangliformis*. From the ciliary ligament the ciliary nerves enter the iris, upon which they terminate. Fig. 373, 1, 1.

Fig. 374.



Nerves of the eyeball. From Longet.

Fig. 374. Eye of the right side, showing the ophthalmic lenticular, or ciliary ganglion, its roots and branches, together with the ganglion of Gasser. 1, optic nerve; 2, trunk of the motor oculi; 3, inferior branch of the latter nerve; 4, ganglion of Gasser; 5, its ophthalmic branch; 6, nasal branch of the ophthalmic, cut off; 7, superior maxillary branch of the trigeminus; 8, inferior maxillary branch of the same nerve; 9, posterior portion of the sclerotic coat, perforated by the ciliary nerves; 10, choroid coat; 11, anterior portion of the sclerotic coat, traversed from within outwards by the ciliary nerves; 12, inferior segment of the cornea; 13, ciliary ligament; 14, iris; 15, pupil; 16, sensitive root of the ophthalmic ganglion, derived from the nasal branch of the ophthalmic nerve; 17, its short or motor branch; 18, sympathetic filament; 19, ophthalmic ganglion; 20, the strait or direct ciliary nerve, derived from the nasal branch; 21, anastomosis between the nasal branch and short ciliary nerve; 22, ciliary nerves from the ophthalmic ganglion; 23, the same nerves a little flattened, and anastomosing with each other on the surface of the choroid coat; 24, motor ramuscles of the same nerves, extended to and distributed upon the iris; 25, ciliary filaments that perforate the sclerotic coat to be distributed upon the conjunctiva.*

THE RETINA.

The *retina* or third coat of the eye, is formed, like the others, of several laminæ, of which three are particularly conspicuous, viz., the tunica Jacobi, the nervous membrane and the vascular membrane. It commences at the point where the optic nerve enters the eye, and terminates behind the ciliary body in an irregular border, *ora serrata*. It is thicker behind than before, of a grayish-white color with a tinge of red, of a pulpy consistence and nearly transparent. It has no attachment to the choroid coat, and is only united to the vitreous humor where the retina terminates in front. Figs. 365, 11, and 375.

1. The *membrana* or *tunica Jacobi* is an extremely delicate web-like structure, attached to the exterior of the retina in flocculent portions which are best seen

eye. It is described as "a grayish, semi-transparent structure behind the ciliary ligament, and covering the outside of the ciliary body;" whence its fibres radiate backwards, from the junction of the sclerotica and cornea, to be inserted into the posterior part of the ciliary body and into the more prominent parts of the ciliary processes which approach the lens. Its action in some of the lower animals (in which it is readily demonstrated), appears to be to advance the ciliary processes, and with them the lens, towards the cornea.—*Todd and Bowman*, ii. p. 27.

* Longet. Système Nerveux, ii. p. 693.

by floating the eye in water after removing the choroid. With care it may be dissected from the optic nerve to the termination of the retina;* but I confess my own attempts have not been so complete. It belongs to the serous membranes, and forms the connecting medium between the choroidal epithelium and the retina. It is described by Von Behr as consisting of rod-shaped corpuscles or closed cylinders, which are soft, flexible and easily torn, and filled with an oily material.

2. The *nervous membrane*, *lamina nervosa*, occurs next in the order of dissection. It is the true expansion of the optic nerve, forming "a thin, semi-transparent bluish-white layer" extending from the bulb at the origin of the retina to the ciliary body, as above described. The whole structure is a most intimate intertexture of filaments forming a perfect membrane, that in texture strongly resembles the vesicular neurine of the brain.

3. The *vascular membrane*, *lamina vasculosa*, is usually regarded as a congeries of minute blood-vessels derived from the central artery and vein of the retina, and connected by delicate cellular tissue so as to form a continuous membrane. The artery enters at the *porus opticus*, through the middle of the optic nerve, (which last it perforates a short distance from the eyeball,) and then radiates to all parts of the retina.†

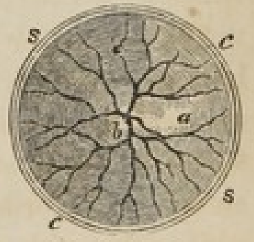
Fig. 375.

Retina. After Sœmmering.

Fig. 375. The retina, after the removal of the choroid coat. 1, the retina; 2, optic nerve; 3, iris; 4, vitreous body; 5, termination of the retina at the posterior extremities of the ciliary processes of the vitreous body.

The *yellow spot* of Sœmmering, *macula lutea*, is an orange-colored elliptical fold of the posterior face of the retina, precisely in the axis of the eye. Fig. 376. This fold or prominence has an aperture in its summit, whence the name *foramen of Sœmmering*, often applied to it; and Drs. Todd and Bowman state, that on removing the sclerotic and choroid coats with extreme care, the interior of the globe can be seen from the outside through this foramen. The yellow spot is about $\frac{1}{24}$th of an inch in diameter; it has been discovered in man, the ape family and in some reptiles, but is said in all instances to disappear before adult age. Its uses are unknown.

Fig. 376.



Yellow spot and central artery of the retina. From Sœmmering.

Fig. 376. The yellow spot of Sœmmering, seen in the axis of the eye, with the entrance of the central artery of the retina about the eighth of an inch on the inner side of the axis. *a*, yellow spot; *b*, point of entrance of the optic nerve; *c*, choroid coat; *s*, sclerotic coat.

* Horner. Specimens of this kind are preserved in Dr. Horner's Anat. Museum.

† We have preferred to describe these coats of the retina in the usual order and with the adopted nomenclature, because there exists great discrepancy in both respects among the best observers. For those who are desirous of further information we may observe, that Drs. Todd and Bowman (Physiology, ii. p. 29), separate the retina into three laminæ independently of the tunica Jacobi; viz., a granular layer externally, a vesicular gray layer in the centre, and a fibrous gray layer externally, all which are composed of nervous matter variously arranged. They discard the term *vascular layer*, because the vessels are equally distributed to the vascular and fibrous layers, are connected by the same nervous tissue, and consequently do not form of themselves a distinct lamina.

HUMORS OF THE EYE.

These are three perfectly transparent media, of very different consistence, occupying the ball of the eye and preserving its rotundity and fulness, while at the same time they perform an essential part in the phenomena of vision.

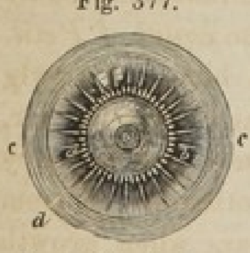
THE VITREOUS HUMOR, OR VITREOUS BODY.

The *vitreous humor*, *corpus vitreum*, fills the area of the retina and consequently by far the greater part of the interior of the eyeball. It is embraced in a most delicate, transparent membrane, the *hyaloid tunic*, which not only invests it, but sends processes in every direction so as to form a multitude of partitions, and corresponding subdivisions, of the hyaloid cavity. While contained within the tunic, the vitreous humor has the seeming consistence of jelly; but if its membrane be punctured, the fluid escapes with the clearness of distilled water, and the consistence of a very thin and slightly viscid mucilage.

The hyaloid membrane presents, on its external surface, a transparent layer of cells that connect it with the retina. The anterior face of the membrane separates into two laminæ, one of which passes in front of, the other behind, the crystalline lens; and where these laminæ meet at the periphery of the lens all round, they form an annular closed cavity called the *canal of Petit*, said to contain a peculiar fluid. Fig. 365, 16.

The *zonula Zinnii*, or *corona ciliaris*, is by some anatomists regarded as a separate structure; by others, as pertaining to the hyaloid membrane, which last is probably the correct view; for it appears to be merely so much of that membrane as is interposed between the anterior border of the retina in front, and the crystalline lens behind. It consequently lies directly behind the ciliary body, and is thrown into folds and depressions that correspond exactly with those of the ciliary processes. The two structures are so intimately united, that when the corona is detached from the contiguous processes, it generally retains some of the pigment derived from the latter bodies. The posterior border of the corona ciliaris is undulating and indented, forming the *ora serrata*, and impinges on the anterior boundary of the retina.

Fig. 377.



Zonula Zinnii. From Sœmmering.

Fig. 377. Anterior view of the eyeball after the removal of the choroid coat and iris, showing the ciliary processes of the vitreous body, or *Zonula Zinnii*. *a*, *b*, zone of Zinn; *c*, *c*, retina; *d*, junction of the retina with the outer margin of the processes.

The vitreous humor is supplied with a twig from the central artery of the retina, that enters it near the optic nerve. In the fœtus it conveys red blood; and in the adult becomes visible by a skilful injection.

THE CRYSTALLINE LENS.

This lentiform body is placed in the anterior body of the vitreous humor, the one being excavated in a cup-shaped manner for the reception of the other. Their apposition is such that the lens projects in front, and in profile presents the section of a smaller sphere in contact with a larger one. It lies in contact posteriorly with the hyaloid tunic, which, as heretofore observed, is also prolonged over it in front so as to form a complete envelope. Fig. 365, 15.

This body is a double convex lens, the posterior convexity being considerably greater than the anterior: but these proportions vary with the age of the individual, being more spherical in the fœtus, and becoming more and more flattened in the progress of age. Thus in infancy it projects into the aqueous humor so as to touch the iris; while in the adult it is appreciably separated.

Fig. 378.

Crystalline lens. After Sœmmering.

These changes are illustrated in Fig. 378. 1, lens at birth; 2, at six years of age; 3, form of the lens in adult life.

A casual inspection of the lens shows that it is composed of concentric laminæ, that become firmer towards the centre, which is occupied by a spheroidal nucleus. The external layers are in the semifluid state of jelly, including so much water that it has been regarded as a peculiar fluid interposed between the border of the lens and its contiguous capsule, whence the name *liquor Morgagni;* but this is now generally believed to result from the absorption of a portion of the aqueous humor into the proper capsule of the lens after death.

When heat, boiling water or acids are applied to the lens, each lamina is disposed to separate, on its anterior surface, into three triangles; so that the whole structure is readily resolved into three wedge-shaped masses, which in life are connected together by a dentiform arrangement of the proximate surfaces.

The exterior surface of the lens is covered by polyhedral nucleated cells, perfectly transparent, forming the connecting medium between the lens and its capsule. The latter is a complete sac, imperforate to either blood-vessels or nerves. It is of a firm consistence, perfectly transparent, and in its physical characters closely resembles the elastic lamina of the cornea. It is much thicker before than behind, and has around its peripheral margin that remarkable annular cavity of the hyaloid membrane already described as the *canal of Petit.*

During the period of growth, the capsule is furnished with blood by a twig from the central artery of the retina, which, passing through the vitreous humor, reaches the posterior face of the capsule and is distributed upon it in a capillary net-work. At the border of the capsule they anastomose with other vessels from the ciliary processes; but this vascular arrangement disappears when growth ceases.*

* Todd and Bowman, ii p. 36.

The long or transverse diameter of the lens in adult age is about one-third of an inch; the antero-posterior measurement something less than the sixth of an inch; and its weight is between three and four grains.

Chemically examined, the lens has been found to consist of more than half water combined with thirty-six parts of albumen, with fractional traces of alcoholic extract, salts, &c.

THE AQUEOUS HUMOR.

This fluid, which is composed of little besides water, occupies the anterior and posterior chambers of the eye, as formed by the vertical septum of the iris. Since these chambers communicate freely through the pupil, the aqueous humor is of course continuous through the same channel, being bounded in front by the cornea and behind by the lens, and a narrow circle of the hyaloid tunic. Most works on anatomy describe this cavity as lined by a delicate epithelium called the *membrane of the aqueous humor;* but Doctors Todd and Bowman, among the most accurate observers of the present day, assure us that they have not been able to detect it. Fig. 365, 9, 10.

BLOOD-VESSELS OF THE ORBIT.

The arteries of the orbit are derived, as we have noticed under the head of Angeiology, from the ophthalmic branch of the internal carotid, and they enter the orbit through the optic foramen, at the outside of the optic nerve. On the present occasion we will merely revert to the following particulars.

The *lachrymal artery* is a long branch given off from the ophthalmic just within the orbit, whence it runs forward and upward to reach the lachrymal gland. Having supplied the gland, its remaining filaments are given to the upper eyelid.

The *ciliary arteries* are of three sets,—the short, long and anterior. The *short ciliary arteries* are from twelve to fifteen in number; embrace the optic nerve in nearly parallel lines as they approach the sclerotica, which membrane they perforate about a line from the nerve. The *long ciliary arteries*, two in number, also pierce the sclerotica behind, and take their course forward between the choroid and sclerotica till they reach the ciliary ligament, where they separate into many branches. These vessels are thus distributed to both the choroid coat and the iris. The *anterior ciliary arteries* arise from the muscular branches of the ophthalmic at the anterior border of the orbit: they form a vascular circle around the eyeball in front, penetrate the sclerotica a line or more behind the margin of the cornea, and are distributed upon the iris. All these ciliary arteries anastomose freely within the ball of the eye.

The *central artery of the retina*, having penetrated the optic nerve half an inch behind the eyeball, passes through the centre of that nerve until it gets within the eye. It is then distributed to the retina, the lens and the vitreous humor. Fig. 376.

The *veins* of the orbit and eyeball concentrate in the orbit into a single large

trunk called the ophthalmic vein or sinus ophthalmicus, which enters the cranium through the optic foramen, and empties its blood into the cavernous sinus at the side of the sella turcica.

FUNCTION OF THE EYE.

The eye supplies the *sense of vision*,—a function by means of which we obtain a knowledge of the presence, form and color of external objects; and this is accomplished through the agency of light, directly or indirectly received upon the retina. This object is accomplished by the admission of the rays through a small aperture into a large cavity,—the former being represented by the pupil, the latter by the posterior chamber of the eye: they first strike the cornea, which, being of greater density than the surrounding air, partially refracts them; they then enter the aqueous humor, where a part is arrested and absorbed by the iris, and the remainder transmitted through the pupil to the crystalline lens; these last are the only rays that are strictly subservient to vision.

The rays on reaching the lens undergo a twofold refraction, one at the anterior, the other at the posterior surface of that body; whence an increased convergence of the rays, in order to bring them to a focus on the retina at the bottom of the eye. The refracting power is in proportion to the *density* of the lens, being greatest in the centre and gradually less and less to the margin.

Every object that impresses its image on the retina, is there placed in an inverted position. A simple experiment may satisfy any one on this point. Thus, if the sclerotic and choroid coats be carefully dissected from the posterior part of the eye of an ox or any other large quadruped, so as to leave the retina unbroken, and the eye so prepared be placed in a hole in a window-shutter in a darkened room, with the cornea on the outside, all the objects of the external scene will be inverted upon the retina.*

THE ORGAN OF HEARING.

The sense of hearing does not strictly belong to one organ, but to several; and these are grouped into three divisions; the external ear, the tympanum and the labyrinth.

THE EXTERNAL EAR.

This is a fibro-cartilaginous structure placed on the side of the head, with the mastoid process behind and the zygoma in front. Its peripheral margin is called the *pinna*, excepting the depending part below, which is the *lobus*. The latter is a fibrous structure with some fat-cells covered by the common integument. It is destitute of cartilage, and remarkably variable in size in different persons. Fig. 397, 7.

* Roget. Physiology, ii. p. 475.

The pinna, on the other hand, is subdivided into a number of subordinate parts in the following manner.

The *concha* is a funnel-shaped concavity in the lower part of the ear, leading into the meatus externus. Fig. 379, 8.

The *helix* commences in the concha by a small elevation: it separates the concha into two unequal cavities, and passing forwards, becomes continuous with the rim of the ear;—that inverted portion forming its scroll-like periphery, and terminates behind and below in the lobus. Fig. 379, 1, 1, 1.

The *antihelix* is a curvilinear ridge that commences at the anti-tragus, passes upwards and forwards and then bifurcates. Fig. 379, 2, 2. The space between these two crura is the *scapha* or *fossa navicularis*. Fig. 379, 3. The antihelix is often more prominent than the helix itself; and the depression between them, extending from the upper extremity of the ear almost to the lobus, is the *fossa innominata*.* Fig. 379, 4.

The *tragus* is an angular plate of cartilage, situated in front of the concha, and merging into the helix behind. It deepens the concha and forms its external boundary. Fig. 379, 5.

Fig. 379.

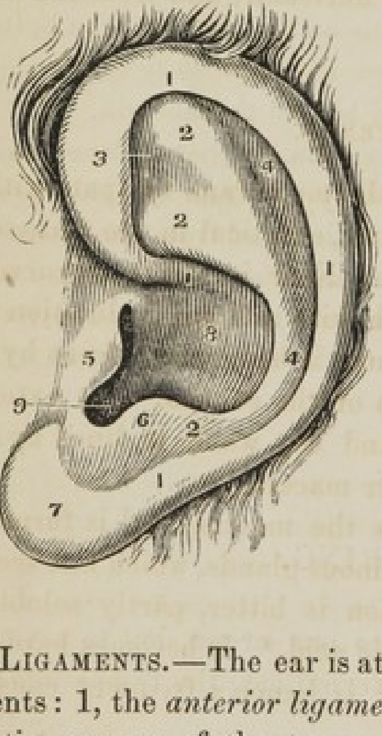


Fig. 379. The external ear. 1, 1, helix; 2, 2, 2, the antihelix; 3, scapha, or fossa navicularis; 4, 4, fossa innominata; 5, the tragus; 6, the antitragus; 7, the lobus; 8, the concha; 9, meatus auditorius externus.

The *antitragus* is another angular prominence, at the posterior and inferior part of the concha, and continuous with the antihelix. Fig. 379, 6.

The cartilage of the ear is of a nearly uniform thickness. It is covered by perichondrium and by the common integuments, but has little or no adipose tissue. It is also covered, like the rest of the surface, by fine hairs, which are longer and more numerous on the inner face of the tragus.

Ligaments.—The ear is attached to the side of the head chiefly by three ligaments: 1, the *anterior ligament* is connected by one end to the root of the zygomatic process of the temporal bone, and by the other to a nodule on the helix directly above the tragus; 2, the *posterior ligament* is attached behind to the mastoid process, and in front to the proximate margin of the concha; 3, the *superior ligament* is connected above with the temporal fascia, and beneath with the upper border of the concha.

Muscles.—Besides those muscles that move the whole ear, there are several smaller ones apparently designed to act upon its several parts; but their action, owing to their rudimentary state, is extremely limited, nor are they more strongly developed in savage than in civilized man.† They are seven in number.

* These terms, and that of fossa innominata, are variously applied by different writers on Anatomy.

† Von Behr. Hand Book, § 506.

1. *Helicis major.*—This is a narrow, oblong fasciculus about half an inch in length. It is placed at the arched anterior and superior part of the helix, its fibres running vertically from the top of that cartilage to its pointed margin in front.

2. The *helicis minor* is a delicate fasciculus upon the posterior margin of the helix where the latter commences in the concha.

3. The *tragicus*, a three-cornered muscle with vertical fibres, lies upon the tragus cartilage, and sometimes blends its fibres with those of the helix major.

4. The *antitragicus* is a short and narrow fasciculus that runs obliquely upwards from the antitragus cartilage to the contiguous margin of the antihelix.

5. The *transversus auriculæ* lies on the posterior surface of the ear, and extends from the convexity of the concha to the external part of the antihelix.

6. The *dilatator conchæ* is attached to the helix in front, whence it runs outwards and downwards to be inserted into the tragus. It draws the tragus forwards and dilates the concha.

7. The *obliquus auriculæ* (Arnold) is upon the internal surface of the ear, on the prominence between the concha below and the scapha above.

The arteries of the ear come from the posterior auricular, and from the anterior auricular branch of the temporal.

MEATUS AUDITORIUS EXTERNUS.

This passage leads from the concha without to the membrana tympani within. It is about an inch in length, three lines in diameter, elliptical in the transverse direction, and slightly constricted in the middle. Near its origin it curves a little upwards, and then pursues its course inwards with a slight inclination forwards to its termination. The orifice of the meatus is bounded in front by the tragus cartilage, and behind by the raised margin of the concha. Its external third is cartilaginous, its inner two-thirds bony, and the whole is lined by epidermis that may be readily withdrawn entire after maceration.

The true skin is more sensitive as it penetrates the meatus, and is furnished with short, firm hairs and an abundance of ceruminous glands, which last secrete the wax of the ear. Fig. 380, 2. This secretion is bitter, partly soluble in water, and contains a yellow oil, and salts of lactic acid.* It becomes hardened when allowed to accumulate in the meatus and is hence a frequent cause of deafness.

The meatus auditorius derives its arteries chiefly from the posterior auricular. Its nerves come from the third branch of the trigeminus and from the auricular branch of the pneumogastric.

THE MEMBRANA TYMPANI.

This membrane, known also as the *drum of the ear*, is an imperforate septum placed between the termination of the meatus externus and the cavity of the tympanum. Its position is very oblique, its lower margin inclining inwards at

* Von Behr. Hand-Book of Anatomy, § 507.

an angle of 45° from the floor of the meatus. It is thin, elliptical, semitransparent and elastic, with a depression in the centre caused by the attachment internally of the manubrium of the malleus. Its greater diameter is a little less than half an inch. Fig. 380, 3.

The membrana tympani is formed of three layers. The first and external lamina is the skin, with its cuticle and cutis vera; the second or central layer is the proper *tympanic membrane*, a strong fibrous radiated structure, which has been described by Sir Everard Home as muscular. The third or inner layer is merely a continuation of the lining mucous membrane of the tympanum.

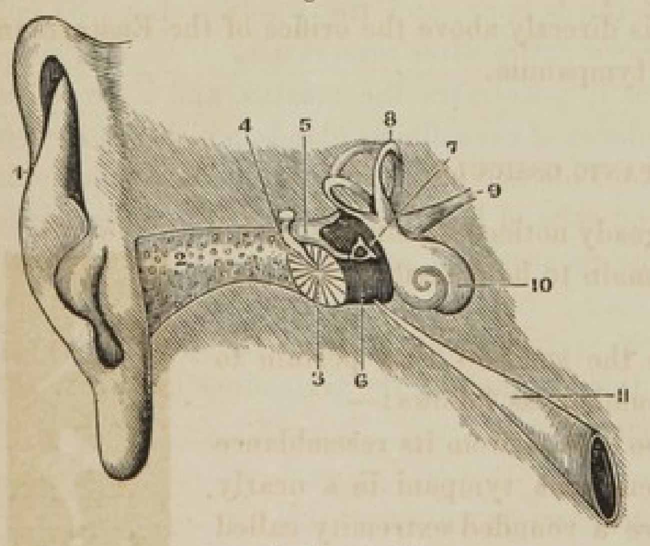
The membrana tympani derives its arteries from the posterior auricular and internal maxillary trunks, and its nerves from the auricular branch of the trigeminus.

CAVITY OF THE TYMPANUM.

The cavity of the tympanum is the central part of the auditory apparatus, having the meatus externus without, and the labyrinth internally. It is placed within the petrous portion of the temporal bone, and is of an irregular oblong form, being about four lines and a half in its greater, and two in its smaller diameter.* Fig. 380, 6. The following parts present themselves in connection with this cavity.

1. *Eustachian tube.*—There are several openings into the tympanum, of which the Eustachian tube is the largest. This canal is about two inches in length, and extends from the upper region of the pharynx to the anterior margin of the petrous bone. The opening in the pharynx is funnel-shaped and more than a fourth of an inch in diameter. It is composed of fibro-cartilage, though much thinner at its base, and in this form extends for an inch and a quarter in a direction backward and outwards to terminate in the osseous part of the tube. Fig. 380, 11.

Fig. 380.



Internal and external ear.

Fig. 380. The internal and external ear. 1, ear; 2, meatus auditorius externus, with its ceruminous glands; 3, membrana tympani; 4, malleus; 5, incus; 6, cavity of the tympanum; 7, stapes; 8, semicircular canals; 9, auditory nerve entering the cochlea; 10, cochlea; 11, Eustachian tube.

This second or bony division of the canal extends to the tympanum, a distance of three-fourths of an inch, and terminates in that cavity by an orifice about half a line in diameter. The mucous membrane of the pharynx with its tesselated

* Von Behr. Hand-Book of Anatomy, § 509.

epithelial cells, is continued into the Eustachian tube and thence into the tympanum, which is lined by it throughout.

5. The *fenestra ovalis*, or foramen ovale, sometimes also called the fenestrum vestibuli, is an aperture a line and a half long in the superior part of the internal parietes of the tympanum, and has the promontorium directly below it. It opens into the vestibulum, but is covered by the lining membrane of these cavities and by the base of the stapes.

3. The *promontorium* or promontory, is a small prominence corresponding to one of the turns of the cochlea. It has three grooves on its surface for the three tympanic branches of Jacobson's nerve.

4. The *fenestra rotunda* is an irregularly triangular opening below the fenestra ovalis, from which it is separated by the cochlea. It leads to the scala tympani of the cochlea, when examined in the dried bone; but in the perfect state of the parts is covered by the *membrana tympani secundaria* and by the lining membrane of both cavities.

5. The *eminentia pyramidalis* or pyramid, is a small conical prominence in the back of the tympanum and behind the fenestra ovalis. It is penetrated by a delicate canal that leads directly into the canal of Fallopius and also lodges the stapedius muscle.

6. The *mastoid foramen* is a medium of communication between the mastoid cells and the tympanum. It is a large opening in the upper and posterior part of the cavity near the membrana tympani.

7. *The apertura chordæ.*—There are two openings that bear this designation. The *posterior aperture* admits the chorda tympani, and is seen in parietes of the cavity near the root of the pyramid. The *anterior aperture*, that through which the chorda tympani escapes from the tympanum, is in the anterior parietes of the cavity and forms part of the fissura Glasseri (p. 44).

8. The opening for the laxator tympani muscle is also in the fissure of Glasser, while that for the tensor tympani is directly above the orifice of the Eustachian tube, on the inner parietes of the tympanum.

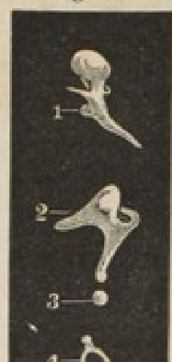
TYMPANIC OSSICULA.

Besides the complicated parts already noticed within the cavity of the tympanum, some others remain to be described, and first the *bones* of this cavity.

These little bones, *ossicula*, are the smallest that pertain to the human body, and are four in number, as follows:—

1. The MALLEUS, Fig. 381, 1, so named from its resemblance to a hammer, is attached to the membrana tympani in a nearly vertical position. It presents above a rounded extremity called the *head* with a surface behind for articulation with the incus. Fig. 382, 2.

Fig. 381.



Ossicles of the ear.

Fig. 381. Ossicles of the ear of the natural size; 1, malleus; 2, incus; 3, orbicularis; 4, stapes. From J. Bell.

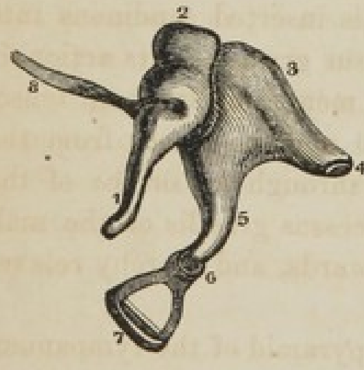
Below the head of this bone is a slight contraction called its neck; and from this point there is a curved prolongation downwards and forwards, terminating in a rounded point: this is the *manubrium* or handle. Fig. 382, 1. It forms an obtuse angle with the neck, and is received its whole length between the internal and central laminæ of the membrana tympani as far as the centre of the last named structure. Fig. 380, 4.

The malleus is also remarkable for two processes: the *processus brevis* comes from the origin of the manubrium, and presses the membrana tympani somewhat outwards in the direction of the meatus externus. The *processus longus* or *gracilis* is given off from the anterior part of the neck, long and extremely delicate in form, and penetrates into the fissure of Glasser. Fig. 382, 8.

2. The INCUS (from its resemblance to an anvil), consists of a body and two processes, lying behind and below the malleus in a vertical position. Figs. 381, 2, and 382, 3. Its body is irregularly squared, and presents in front a deep excavation for receiving the head of the malleus. Its longer process or *long crus* descends nearly parallel with the manubrium of the malleus, curves inwards and is joined at its end to the *os orbiculare*. Fig. 382, 5. Its *short crus* runs backwards and somewhat upwards to the orifice of the mastoid cells to which it has a ligamentous attachment. Fig. 382, 4.

3. The OS ORBICULARE, Fig. 381, 3, and Fig. 382, 6, is a small spheroidal bone the size of a pin's head, attached on one side to the terminus of the long crus of the incus, on the other to the head of the stapes. In the fœtus this tubercle is always distinct from the associated bones; and this distinction generally continues for some years after birth, and even to adult age; but since it eventually becomes anchylosed to the incus, it is often described as an appendage of that bone.

Fig. 382.



Ossicles of the ear. After Arnold.

Fig. 382. Bones of the tympanum in their natural juxtaposition, magnified three diameters. 1, manubrium of the malleus; 2, head of the malleus; 3, body of the incus; 4, its short crus; 5, its long crus; 6, os orbiculare; 7, stapes; 8, processus gracilis of the malleus.

4. The STAPES, or stirrup, is not unlike the object from which it is named. Fig. 381, 4. It passes inwards and at a right angle from the incus, to which it is connected by the intervening os orbiculare. The stapes sends off two convex, divergent crura which are joined at opposite margins to a flat, oval plate, the base of the stapes. Fig. 382, 7. This basal plate is received into the fenestra ovalis which it covers and in which it moves, and the contiguous marginal surfaces are attached by a delicate ligament: but the basal surface lies in contact with the membrana vestibuli and is covered by the lining mucous membrane of the tympanum.*

INTER-OSSICULAR LIGAMENTS.—The several bones of the tympanum are con-

* Wilson. Anatomy, p. 488.

nected together by the apparatus common to other articulations, and among these are three ligaments.

1. The *ligamentum mallei* is a short fibrous cord, attaching the head of the malleus to the proximate face of the tympanic cavity.

2. The *ligamentum incudis* in like manner connects the short crus of the incus to the parietes of the tympanum, at the opening of the mastoid cells.

3. The *ligamentum stapedis* has some resemblance to a capsular ligament, placed between the margin of the base of the stapes and the corresponding margin of the fenestra ovalis.*

MUSCLES OF THE TYMPANUM.

The bones of the tympanum are moved by several muscles, small indeed, but proportioned to the parts on which they act. Anatomists differ as to the number of these muscles, which are usually described as four; Von Behr, however, states that true muscular fibres are found in the tensor tympani only; and the laxator tympani, in various systematic works, is excluded from the series. We shall adopt the whole four in accordance with the classification of Sœmmering.

1. The *tensor tympani* or internal muscle of the malleus, lies in the canal directly above the osseous portion of the Eustachian tube, from which it is separated by a thin bony septum. It arises from the posterior cartilaginous part of the Eustachian tube, from the contiguous margin of the petrous portion of the temporal bone, and from the spinous process of the sphenoid bone. It passes backwards, enters the cavity of the tympanum, and is inserted tendinous into the neck of the malleus directly beneath the processus gracilis. Its action is to draw the malleus inwards and thereby to make the membrana tympani tense.

2. The *laxator tympani* or external muscle of the malleus, arises from the spinous process of the sphenoid bone, and passing through an orifice of the fissure of Glasser, is inserted tendinous into the processus gracilis of the malleus. Its action draws the malleus forwards and outwards, and thereby relaxes the membrana tympani.

3. The *stapedius* arises from the depression in the pyramid of the tympanum, and passing from the summit of that body, is inserted into the head of the stapes. It draws the stapes backwards.

4. The *laxator tympani minor* consists of a few fibres arising from the upper and inner margin of the meatus externus, or, more strictly speaking, from the upper border of the tympanum contiguous to the meatus, and is inserted into the manubrium of the malleus near the processus brevis. Its supposed office, as its name imports, is to relax the membrana tympani.

The *lining membrane* of the tympanum is an extremely delicate and vascular tissue that covers its parietes throughout and is thence reflected upon the ossi-

* Wilson's Anatomy, Dr. Goddard's edit. p. 488. Von Behr, § 510. The latter author regards the laxator tympani, and laxator tympani minor muscles, as ligamentous structures.

cles. It appears to be divisible into two laminæ, of which the inner one is fibrous and possesses the characteristics of periosteum; but the exterior layer is analogous, in its structure and secretion, to the common mucous membrane with which it is continuous through the Eustachian tube.

THE LABYRINTH.

The *labyrinth* is a collective term for the various and singularly complex parts forming the internal ear. This structure is divided into three portions,—the *vestibule, semicircular canals* and *cochlea*, and of these the first two are again formed of an osseous basis and a membranous counterpart.

THE OSSEOUS LABYRINTH.

The VESTIBULE is a small and somewhat triangular cavity about the size of a grain of wheat. Fig. 383, 7. Its long diameter is nearly three lines, its greatest width the half of that measure, and the cavity is slightly compressed. It is placed almost vertically in the centre of the labyrinth, behind the cochlea and before the semicircular canals. Of the three angles or *cornua of the vestibule*, one is placed before, one behind, and the third above: the first of these contains the orifice of the scala vestibuli; into the second or posterior cornu are received the opening of the oblique semicircular canal, the common opening of the oblique and vertical canals, the termination of the horizontal canal and the orifice of the aqueduct of the vestibule; and the superior cornu contains the orifices of the superior and horizontal semicircular canals.

The foramina opening into the vestibule are usually classed into two series, one larger, the other smaller. The larger foramina are seven in number, viz.: five for the semicircular canals, as above stated; one, the *iter ad cochleam* below the fenestra ovalis; and another, the fenestra ovalis itself.

The smaller foramina are the orifice of the aqueduct of the vestibule; three others, the *maculæ cribrosæ*, at the base of the meatus auditorius internus, through which the nerves and vessels enter; besides some minute openings in the bottom of the fossa semielliptica and fossa hemispherica.*

There are two depressions in the vestibule. One of them, the *fossa semielliptica*, is placed at the posterior and outer part of the cavity, near the semicircular canals; Fig. 383, 5: the other, the *fossa hemispherica*, lies at the anterior inferior region of the vestibule contiguous to the cochlea. Fig. 383, 6. These depressions are separated by a slight elevation of the bone, the *crista pyramidalis*, having at its lower end another and smaller depression, the *fovea sulciformis* of Sœmmering.

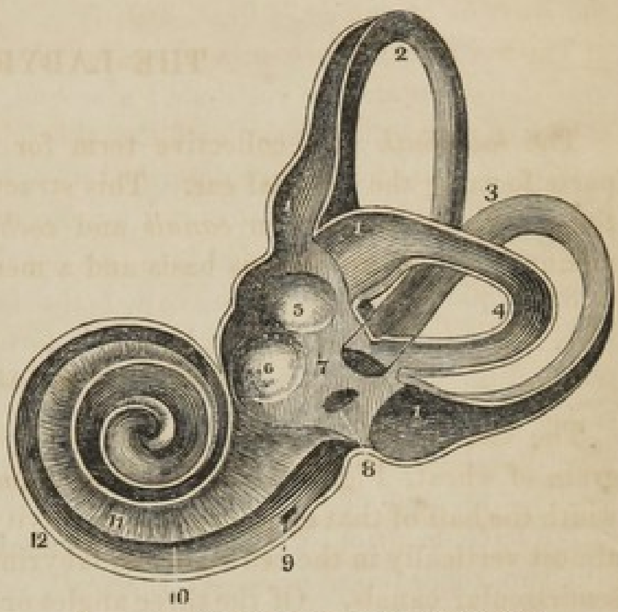
The SEMICIRCULAR CANALS are situated at the posterior end of and behind

* Von Behr. Hand Book of Anatomy, § 512.

the vestibule. They are three in number, describe more than half a circle and are about the twentieth of an inch in diameter. They are named from their relative positions, anterior, posterior and external.

1. The *anterior* or *superior canal*, Fig. 383, 2, is nearly vertical and about six lines long: its anterior extremity opens by a separate orifice in the vestibule; but its posterior crus joins that of the posterior canal, Fig. 383, 3, and a common orifice is thus formed.

Fig. 383.



Osseous labyrinth laid open. From Sœmmering.

Fig. 383. The osseous labyrinth, largely magnified and divided longitudinally. 7, the vestibule; 8, aqueduct of the vestibule; 5, fossa semielliptica; 6, fossa hemispherica; 2, 3, 4, semicircular canals; 2, superior semicircular canal; 3, posterior canal; 4, inferior canal; 1, 1, 1, ampullated extremity of each canal; 12, cochlea; 9, aqueduct of the cochlea; 11, osseous zone of the lamina spiralis, above which is the scala vestibuli communicating with the vestibule; 10, scala tympani, below the lamina spiralis.

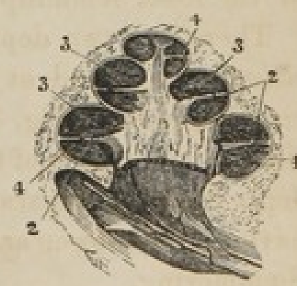
2. The *posterior* or *inferior canal*, Fig. 383, 3, describes the greater part of a circle and is the longest of these tubes. Its position is nearly vertical; its upper orifice opens, as just mentioned, by a common orifice with the anterior canal, but the lower opening communicates directly with the vestibular cavity.

3. The *external* or *horizontal canal*, Fig. 383, 4, is shorter but wider than either of the others, and has two openings into the vestibule.

Each of these canals has a dilatation at its vestibular end called its *ampulla*, which is about twice the diameter of the canal itself. Fig. 383, 1, 1, 1.

4. The COCHLEA, so named from its resemblance to the shell of the garden-snail, lies in front of the tympanum and forms the anterior section of the labyrinth. Fig. 383, 12. Its base is seen at the bottom of the meatus internus, on which it is marked "by a depression exhibiting a spiral arrangement of pores for the reception of the cochlear division of the auditory nerve." The apex of the cochlea is turned towards the Eustachian tube; and its axis, which is about four lines in length, is directed downwards and outwards, widening rapidly in its course.

Fig. 384.



The cochlea. From Arnold.

Fig. 384. Section of the cochlea through the axis or modiolus. 1, modiolus; 2, 2, 2, lamina spiralis; 3, 3, 3, scala vestibuli; 4, 4, 4, scala tympani.

This axis is the *modiolus*, of a conical form and extending between the base

and apex of the cochlea. It is perforated from end to end by a minute canal, and this is surrounded by several similar but smaller canals, all terminating by corresponding foramina on the lamina spiralis. Fig. 384, 1.

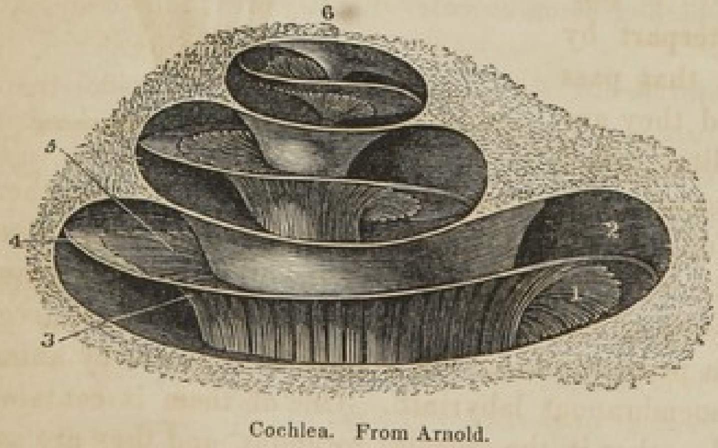
An osseous tube, the *canalis spiralis*, makes two and a half turns round the modiolus; it is an inch and a half in length, gradually diminishing in diameter as it approaches the apex of the cochlea, where it ends in a funnel-shaped cavity, the *scyphus* or *cupola*. Figs. 384, 385, 6.

The spiral canal presents three openings near its base: one of these, of an oval shape, enters the vestibule; a second, the fenestra rotunda, looks into the cavity of the tympanum; and the third is the orifice of the *aqueduct of the cochlea*, a canal heretofore described as opening by its other end into the jugular fossa, and supposed to transmit a minute vein.* Fig. 383, 9.

The spiral canal is divided into two nearly equal passages by a septum, partly osseous, partly membranous, called the *lamina spiralis*. Figs. 384, 2, 2, and 385. The inner half of this lamina is formed of bone, whence its name,—*zona ossea*, Fig. 383, 11; the outer half has a fibro-cartilaginous structure, and is called *zona Valsalvæ*, or *zona membranacea*.† Fig. 385. The osseous zone is constituted of a double lamina with interposed canaliculi for transmitting the cochlear nervous filaments.

We have mentioned that the spiral canal is separated by the lamina spiralis into two subordinate passages, the scala vestibuli and the scala tympani. The *scala vestibuli* is the larger of the two, and communicates with the vestibule at the *iter ad cochleam* of the vestibular cavity. Figs. 384, 3, 3, and 385. The *scala tympani* lies nearer the base of the cochlea, and communicates with the tympanum through the fenestra rotunda. Figs. 384, 4, 4, and 385, 1.

Fig. 385.



Cochlea. From Arnold.

Fig. 385. Magnified view of the cochlea of a new-born infant, opened on the side towards the apex of the petrous portion of the temporal bone. 1, scala tympani; 2, scala vestibuli; 3, lamina spiralis; 4, zona Valsalvæ vel membranacea; 5, zona ossea; 6, cupola.

THE MEMBRANOUS LABYRINTH.

Independently of the delicate periosteal membrane that lines the labyrinth and

* Whence it was called by Wildberg, *canalis venosus cochleæ*.

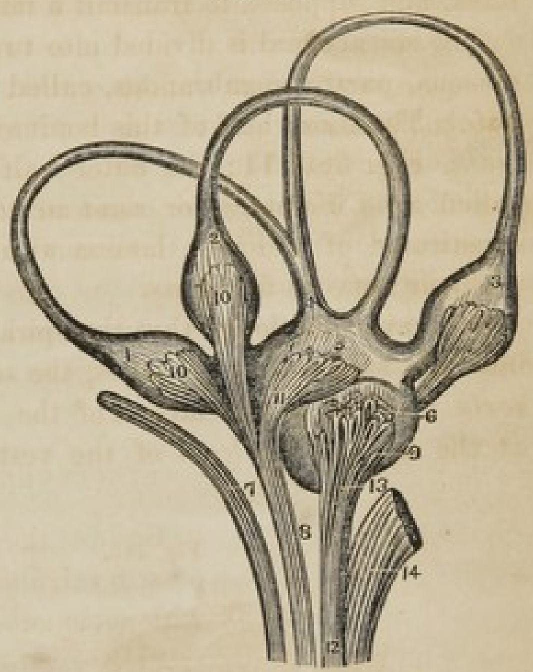
† These parts are sometimes more appropriately called, *lamina spiralis ossea* and *lamina spiralis membranacea*.

closes the fenestra ovalis and fenestra rotunda, the vestibule and semicircular canals possess within themselves a membranous labyrinth that corresponds in every particular to the osseous one. Fig. 386.

The *membranous canals* are much smaller in diameter than the bony tubes; but they have the same ampullated enlargements, and open also into the membranous vestibule by five orifices. The *membranous vestibule* consists of two parts, of which the larger is the *sacculus communis* or *ellipticus*. Fig. 386, 5, 2, 3. It lies in the fossa elliptica, and receives the five semicircular canals. Fig. 386, 5.

The other vestibular sac is the *sacculus rotundus* or *sphericus*, occupying the fossa hemispherica; and though it is in contact with the sacculus communis, is said to have no communication with it.* Fig. 386, 6.

Fig. 386.



Membranous labyrinth. From Sœmmering.

Fig. 386. The membranous labyrinth with its vestibule, semicircular canals and nerves. 1, the superior semicircular canal; 2, the external semicircular canal; 3, the inferior semicircular canal; 4, union of the superior and inferior canals; 5, the sacculus ellipticus; 6, the sacculus sphericus; 7, the facial nerve; 8, the anterior fasciculus of the auditory nerve; 9, the nerve of the sacculus sphericus; 10, 10, the nervous fasciculi of the superior and external ampullæ; 11, the nerve of the sacculus ellipticus; 12 posterior fasciculus of the auditory nerve, furnishing 13, the filaments to the sacculus sphericus, and 14, filaments to the cochlea.

The membranous labyrinth is connected to its osseous counterpart by means of nervous filaments that pass from one to the other; and they are separated by a delicate halitus called the *perilymph*, or *aqua Cotunnii*. The membranous canals and sacs are themselves also filled with a fluid of greater consistence than the perilymph, the *liquor Scarpæ*, or *endolymph*. The endolymph is moreover the nidus of two minute calcareous bodies,—the *otoconia* of some anatomists,—composed of an aggregation of smaller particles of a prismatic form, and connected together by animal substance derived from the membranous labyrinth. One of them is contained in the sacculus communis, the other in the sacculus rotundus, and they are supposed to serve in some way for strengthening or protracting sounds.

The *arteries* of the labyrinth are derived from the internal auditory.

The nerves.—The auditory nerve (p. 585) separates at the bottom of the internal meatus into two branches; the anterior or larger branch, the *cochlear nerve*, enters the basis of the modiolus by many filaments, which run chiefly between the layers of the lamina spiralis, and anastomose in loops at its outer border. Fig. 386, 14.

* Von Behr. Hand-Book, § 545.

The posterior or *vestibular* division of the auditory nerve separates at the bottom of the internal auditory meatus into three branches: one of these, and the largest, is given to the sacculus ellipticus of the membranous labyrinth, and to the ampullæ of the superior vertical and horizontal canals; the second filament is spent upon the sacculus sphericus, and the third upon the inferior vertical canal.* Fig. 386, 13.

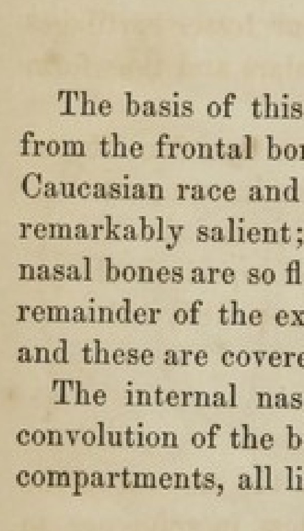
THE NOSE.

The basis of this structure is formed of the ossa nasi (p. 53), which project from the frontal bone at a variable angle in the different races of men. In the Caucasian race and in the Aboriginal Americans, the nose is for the most part remarkably salient; but in many Negroes, and in some Mongolian tribes, the nasal bones are so flat as not to be visible in a profile view of the cranium. The remainder of the external organ of smell is made up of a series of cartilages, and these are covered by the common integuments.

The internal nasal apparatus consists, on the other hand, of an elaborate convolution of the bony structure and separation into numerous and very varied compartments, all lined by the pituitary or mucous membrane.

STRUCTURE OF THE NOSE.

Fig. 387.



Nasal cartilages. After Sœmmering.

Besides the osseous basis, the external nose is formed of several fibro-cartilages, muscles and skin, together with some subordinate parts.

Fibro-cartilages.—These are five in number; one constitutes the septum, two are lateral, and two others, called *alar cartilages*, are both terminal and lateral.

Fig. 387. The nasal cartilages, showing their connection with each other and with the ossi nasi; 1, cartilage of the septum; 2, 2, lateral cartilages; 3, alar cartilage; 4, cornua or appendices of the alar cartilage; 5, nostril.

The *septal* or *vertical cartilage* fills up the triangular space between the nasal lamella of the ethmoid bone and the vomer. It is attached also above to the nasal bones and the lateral cartilages, presenting on this exterior surface a triangular plane with the base upwards. The inferior margin is attached behind to the intermaxillary suture. This cartilage, therefore, completes the septum of the nose. The other cartilages are connected to it by means of a common perichondrical envelope, and they are all capable of a certain degree of motion upon each other. Fig. 387, 1.

* Von Behr; Hand-Book, § 515. Cruveilhier, p. 907.

The *lateral cartilages* are two pyramidal structures forming a part of the dorsal surface of the nose. They are attached below to the alar cartilages, whence each one tapers to a point in the upward direction to be connected with the corresponding nasal bone. The diverging interval between these pyramids is occupied by the septal cartilage; behind they join the nasal processes of the superior maxillary bones. Fig. 387, 2.

The *alar* or *oval cartilages*, Fig. 387, 3, form the lower dilated portion of the nose and consequently the parietes of the nostril. Their rounded surface in front constitutes the *lobe*, or tip of the nose; and the central junction of these cartilages between the nostrils is the *columna*. Three or four lesser cartilages (sesamoids) curve first outwards and then inwards from the alars and thus form the *alæ nasi*. Fig. 387, 4.

These several cartilages are covered and connected together by a firm fibrous membrane or perichondrium, over which is placed the common integument.

Several muscles also enter into the structure of the nose, viz.: the levator labii superioris alæque nasi, compressor naris, depressor labii superioris alæque nasi and pyramidalis nasi. These have been fully described—p. 180, 181.

INTERNAL STRUCTURE OF THE NOSE.

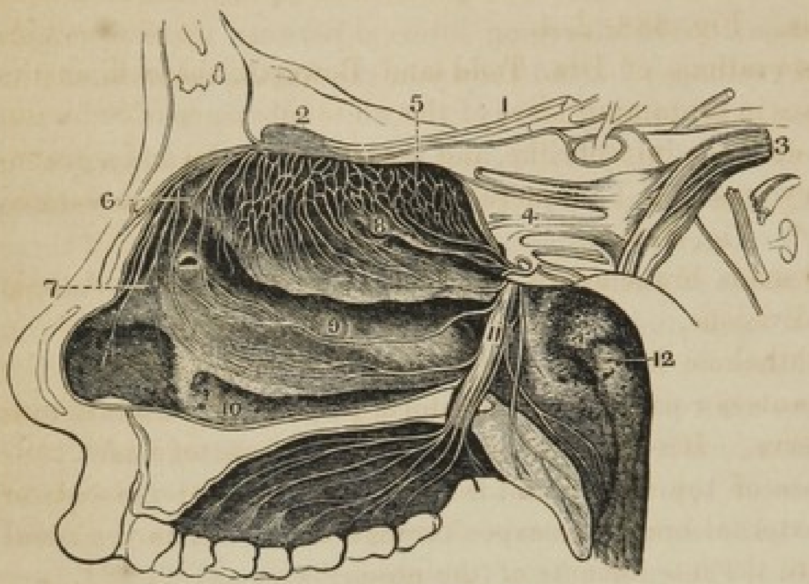
The configuration of the nasal fossa has been explained in the account of the bones of these parts (p. 68), and it remains to consider them in reference to their membranous covering and nerves. The osseous structure, in all its cavernous ramifications, is provided with periosteum in the usual way; but over this is laid the mucous or Schneiderian membrane, which is continuous with the skin at the entrance of the nostrils, with the mucous membrane of the eye through the lachrymal passages, and with that of the pharynx and internal ear through the posterior nares. The pituitary membrane is more dense and more vascular on the septum narium and spongy bones, where also it embraces an infinitude of minute glands; in other localities, and especially in the sinuses, it possesses an extreme tenuity, and can with difficulty be detached from the subjacent periosteum. Besides an extreme vascularity, this membrane is furnished with the usual apparatus of epithelial cells: these are of the tesselated variety in the vicinity of the nostrils; but in the sinuses and lower region of the nose, they assume the columnar form and are clothed with vibratile cilia.* Fig. 6.

The mucous membrane enters the foramen incisivum in the floor of the nostril, and sometimes forms an open duct into the mouth. From the middle meatus of the nose it penetrates into the antrum Highmorianum by an orifice the size of a pipe-stem, which, however, is variable in its position. It is continued above into the frontal sinuses, and behind into the sphenoidal cells; and just beneath the anterior margin of the lower spongy bone, is an orifice leading into the ductus ad nasum, which last, together with the lachrymal sac, is also lined by the same pituitary membrane.

* Todd and Bowman. Physiology, ii. p. 3.

Fig. 388. The three turbinated bones and associated parts of the nasal fossæ, covered by the Schneiderian membrane, with the nasal nerves. 1, olfactory nerve; 2, its bulb, below which is seen the plexiform distribution of the olfactory filaments on the upper and middle turbinated bones; 3, trigeminus nerve with the ganglion of Gasser; 4, its superior maxillary division, showing its connection with Meckel's ganglion, from which filaments are given off to anastomose with those of the olfactory nerve, 5, and with branches of the nasal division of the ophthalmic nerve, 6, 7; these figures, 5, 6 and 7, also mark the upper, middle and lower turbinated bones; 8, superior meatus; 9, middle meatus; 10, lower meatus; 11, posterior palatine nerves from Meckel's ganglion, distributed to the hard and soft palate; 12, cartilaginous orifice of the Eustachian tube.

Fig. 388.



Pituitary membrane and nerves of the nasal fossæ. From Sœmmering.

We take this occasion more fully to show the position and course of those passages called the *meatuses of the nose*, of which the size and points of communication with the proximate cavities are sensibly reduced by the presence of the mucous membrane. The *upper meatus* is the smallest of the three, and receives the secretions of the sphenoidal and posterior ethmoidal cells. Fig. 388, 8.

The *middle meatus* communicates directly with the antrum, the frontal sinuses and the anterior ethmoidal cells, Fig. 388, 9; and we may repeat, that the orifice of the Eustachian tube is in the pharynx, on a line with the lower margin of the middle spongy bone, so that the most direct course to that canal is through the middle meatus. Fig. 388, 12.

The *lower meatus*, the longest of the three, receives only the ductus ad nasum in the manner above stated. Fig. 388, 10.

Blood-vessels.—These are in part derived from the ophthalmic artery, which sends from the orbit the anterior and posterior ethmoidals; and in part from the internal maxillary artery. One branch of this vessel, the spheno-palatine, descends through the foramen of that name, and is distributed upon the turbinated bones and septum; and the pterygo-palatine branch of the same artery has a similar destination.

Nerves.—These are numerous, being chiefly derived from the olfactory and trigeminus, of which the ultimate distribution may now be more circumstantially given than on the former occasion, at least so far as relates to the nose.

The filaments of the olfactory bulb, fifteen or twenty in number, after penetrating the foramina of the cribriform plate of the ethmoid bone, are at once

received into the nasal cavity, whence they are distributed to the Schneiderian membrane. They form a beautiful plexiform arrangement on the upper and middle spongy bones, and anastomose posteriorly with filaments from the second branch of the trigeminus. Fig. 388, 2, 4.

According to the observations of Drs. Todd and Bowman, these filaments differ from ordinary nerves in containing more of the white substance of Schwann (Fig. 485), in not being divisible into fibrillæ, and possessing nuclei and a granular structure; in fact they appear to be a merely continuous structure prolonged from the olfactory bulb.* Fig. 388, 2.

The trigeminus nerve sends branches to the nose both from its ophthalmic and superior maxillary divisions.

The twig from the ophthalmic is the internal nasal nerve which enters the nasal fossa through the anterior part of the cribriform plate and in contact with fibrils of the olfactory nerve. It separates into two branches, one of which runs along the posterior surface of the os nasi and is spent upon the integuments of the nose; the other or external branch, escapes through a foramen in the nasal bone, and is distributed to the integuments of the nose.

The superior maxillary nerve gives many filaments to the Schneiderian membrane. These posterior palatine nerves enter the nose through the spheno-palatine foramen, or by pores between this and the posterior palatine canal, and then spread over the three turbinated bones and the septum nasi, anastomosing at several points with the olfactory filaments, and with the nasal branch of the ophthalmic.† Fig. 388, 11.

Sense of smell.—That this faculty resides in the olfactory nerve is conceded by most physiologists. Its perfection requires a certain normal secretion from the Schneiderian membrane, but its excess or deficiency impairs the integrity of the function. The real olfactory region is limited to the upper and middle spongy bones, the upper half of the septum narium and the roof of the nasal fossa, the latter part possessing the function in the greatest degree. Its variations, however, even in the healthy state, are very remarkable.

The branches of the trigeminus appear to influence the olfactory sense only by imparting common sensibility to the mucous membrane; although Magendie, as the result of experiment, regards the branches of this nerve as mainly possessing the function of smell. But the prevalent opinion is, that the fifth pair receives the impression of acrid or pungent substances, which act upon it as they do upon the tongue. They are *felt* upon the mucous membrane, rather than smelt by it, whence arises the act of sneezing for the purpose of expelling the irritating substance.‡

ORGANS OF TOUCH AND TASTE.

On these subjects we have nothing to add to the remarks heretofore made. See pp. 146 and 295.

* Physiological Anatomy, p. ii. 9. † Ibid.

‡ Dunglison; Human Physiology, i. p. 130. Carpenter; Elements of Physiology, § 948.

ADDENDUM.

THE OS HYOIDES.*

THIS, the most isolated bone of the skeleton, is situated at the base of the tongue (for which it forms a medium of attachment), and above the thyroid cartilage, being so superficial as to be distinctly felt beneath the integuments. Fig. 255.

It consists of a body, cornua and appendices. The *body* or *base* is of an elongated elliptical form, concave behind and convex in front, and attached to the thyroid cartilage by means of the middle thyroid membrane. Fig. 255, 8.

The *cornua*, one on each side, curve backwards, giving the bone a lunated or semicircular form. Fig. 255, 2. They are connected to the body by a distinct movable articulation, which, however, generally becomes anchylosed late in life. These cornua are connected with the corresponding projections of the thyroid cartilage by the lateral thyro-hyoid ligaments. Fig. 255, 4.

The *lesser cornua* or appendices, also one on each side, are situated at the junction of the base with the greater cornua. They present upwards and outwards, and are united to the styloid process by the stylo-hyoid ligament, which sometimes ossifies. Fig. 255, 3.

The body of the os hyoides serves for the attachment of a number of muscles, viz., the sterno-hyoideus, thyro-hyoideus, omo-hyoideus, stylo-hyoideus, mylo-hyoideus, genio-hyoideus, genio-hyo-glossus, lingualis, middle constrictor of the pharynx, and the tendinous pulley of the digastricus.

* The description of this bone was inadvertently omitted in its proper place, p. 105.

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THE END.

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