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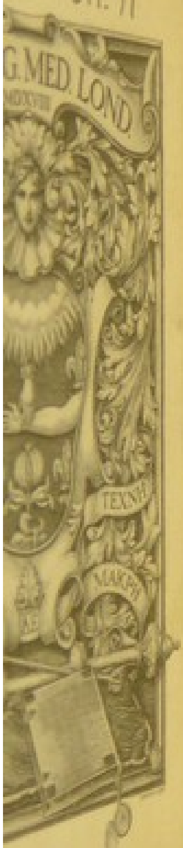

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HUMAN OSTEO

COMPRISING

A Description of the

WITH DELINEATIONS OF THE ATTACHMENT

THE GENERAL AND MICROSCOPIC STR

AND ITS DEVELOPMEN

TO WHICH IS ADDED

A BRIEF NOTICE OF THE UNITY OF TYPE IN THE

VERTEBRATE SKELETO

BY

LUTHER HOLDEN, F

DEMONSTRATOR OF ANATOMY AND OF OPERA

ST. BARTHOLOMEW'S HOSPIT

SECOND EDITION.

ILLUSTRATED BY NUMEROUS DRAWINGS ON

LONDON:

JOHN CHURCHILL, NEW BURL

MDCCCLVII.

HUMAN OSTEOLOGY:

COMPRISING

A Description of the Bones;

WITH DELINEATIONS OF THE ATTACHMENTS OF THE MUSCLES;

THE GENERAL AND MICROSCOPIC STRUCTURE OF BONE AND ITS DEVELOPMENT.

TO WHICH IS ADDED

A BRIEF NOTICE OF THE UNITY OF TYPE IN THE CONSTRUCTION OF THE VERTEBRATE SKELETON.

BY

LUTHER HOLDEN, F.R.C.S.

DEMONSTRATOR OF ANATOMY AND OF OPERATIVE SURGERY AT ST. BARTHOLOMEW'S HOSPITAL.

SECOND EDITION.

ILLUSTRATED BY NUMEROUS DRAWINGS ON STONE, AND WOODCUTS.

LONDON:

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TO THE

STUDENTS OF ST. BARTHOLOMEW'S HOSPITAL,

IN TESTIMONY OF HIS EARNEST REGARD, AND

IN REMEMBRANCE OF THE KIND AND CONSIDERATE FEELING
WHICH THEY HAVE EVER EVINCED TOWARDS HIM,

This Work is dedicated,

BY THEIR SINCERE WELL-WISHER AND FRIEND,

THE AUTHOR.

PREFACE

TO

THE SECOND EDITION.

In the Second Edition of this work the author has added the cartilages and muscles of the larynx, and the anatomy of the internal ear. These subjects are respectively illustrated by additional plates and numerous wood engravings.

Gower Street:
September 1857.

PREFACE

TO

THE FIRST EDITION.

This work is intended as an introduction to the *Manual of Anatomy* already published by the author. Its object is to teach the student the bones, and the accurate attachments of the muscles. Practical observations are here and there interspersed. The plan of the plates is novel, and speaks for itself; it is only necessary to explain that the red outlines denote the origins of muscles; the blue, the insertions.

The microscopic structure of bone has been introduced, because such knowledge is essential to a right understanding of its diseases. This part of the work has passed under the eye of Professor Quekett. The author is deeply indebted to that gentleman for his kindness in imparting information, and permitting access to his beautiful drawings and preparations, of which liberal use has been made.

To Professor Owen the gratitude of the author is especially due for his kindness in looking over the concluding part of the work, relating to the Unity of Type in the construction of the Vertebrate Skeleton.

The drawings have been executed on stone by Mr. Godart with his usual accuracy and spirit, deserving the author's best acknowledgments.

Gower Street:
September 1855.

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HUMAN OSTEOLOGY.

Importance and interest of Osteology.

Whoever would become a good surgeon, must make himself master of human osteology. It is not only his first, but his principal and constant professional study. During his dissections he is continually referring to the skeleton. He cannot reduce the simplest dislocation without a competent knowledge of the bones. The subject appears dry and tedious to a beginner — what study, indeed, does not? — but a little progress will convince him that, so far from being dry, it is full of interest, not only as conducive to professional success, but for its own sake. No part of creation displays more manifest design than the human skeleton. Undertaken in a right spirit, the study of it becomes, with many, a favourite pursuit, — leads us to look a little beyond "final purposes," and creates a natural longing to know something of the skeleton of the lower animals, that we may the better judge of the admirable construction of our own; for it is only by comparison that we can *judge*. When the great truth unfolds itself, that our own structure is but a modification of the "one common pattern" upon which all vertebrate animals are formed, we cannot but feel with the philosophic poet, that —

> "'Tis the sublime of man,
> Our noontide majesty, to know ourselves
> Parts and proportions of a wondrous whole."
>
> Coleridge.

Use of the bones.

The bones form a framework for the moulding and adequate support of the soft parts of the body; they form cavities for the lodgment and protection of delicate organs, — *e. g.*, the skull for the protection of the brain; the vertebral canal for the protection of the spinal cord; the orbit for the protection of the eye; the chambers in the temporal bone for the protection of the internal ear; the chest for the protection of the heart and lungs, &c.: they form the joints for the locomotion of the whole body, as well as for the movement of its individual parts: they form levers for the action of the muscles.

General composition of bone.— Its analysis.

Bone is composed of a basis of animal matter impregnated with "bone earth" or phosphate of lime. The first ingredient makes it tenacious and elastic; the second gives it the requisite hardness. The analysis is easily made. Place a bone in a solution of one part of dilute hydrochloric acid to five or six of distilled water; in a few days all the earthy part will be dissolved out by the acid, and the animal part will be left. The bone will be scarcely altered in shape or colour, but it can be bent and twisted in any direction. On the other hand, to get rid of the animal matter we have merely to boil the bone for a long time; or the bone may be calcined till all the animal matter is burnt out. In either of these ways the animal constituent of the bone will be removed, and nothing left but the earthy. The animal matter consists of gelatin (or glutin), which is nearly all soluble in boiling water. Everyone knows that soup may be made out of bones. Notwithstanding their antiquity, fossil bones are found to contain nearly as much animal matter as recent bones. Gimbernat made soup from the gelatin of the mastodon's tooth, as Dr. Buckland afterwards did from the fossil bones of the hyæna.

Relative proportions of the animal and earthy matter.

As to the relative proportions of the animal and earthy matter in bone, the best chemists agree that the animal part forms about *one third*, the earthy *two thirds*. Are these proportions constant? Do they vary at different periods of life, and in different bones of the skeleton? It is the generally received opinion that they *do* vary. It is believed that the animal element predominates in the bones at the beginning of life, and the earthy element at the decline. This is assigned as the reason why the bones of children are so elastic, so liable to indent, as in the case of the skullcap, and to bend like a green stick rather than break like the bones of the aged. Some recent investigators*, however, have impugned the correctness of this opinion. Their analyses go to prove that *equal weights* of bone tissue contain, at all ages, and in all bones, nearly the same relative proportions of animal and earthy matter. A particle of bone, they say, is a definite, not a variable compound. The hardness and compactness of bone depend, not upon the variations of its earthy ingredient, but upon the quantity of bone condensed in a given space. The peculiarity of the bones of children arises from the greater sponginess of their texture, and from the layers of cartilage introduced in appropriate parts to facilitate growth and to break shocks.

Lehman's analysis of bone.

The following is Lehman's† analysis of adult human bone:—

Animal matter	33 per cent.
Earthy matter, namely—	
Phosphate of lime . . .	57 „
Carbonate of lime . . .	8 „
Fluoride of calcium . . .	1 „
Phosphate of magnesia . .	1 „
	100

Dr. Bostock's analysis of ricketty bones.

In the disease of early life called "rickets," in which the bones bend and become distorted, from deficiency of earthy matter, Dr. Bostock found the proportions of animal and earthy matter to be—

Animal matter . . .	79·75 per cent.
Earthy matter . . .	20·25 „

* Dr. Stark, "Edinb. Med. and Surg. Journal," April, 1845; Nélaton, "Elements de Pathologie," t. i. p. 636.

Mr. R. Tuson, Demonstrator of Chemistry at St. Bartholomew's Hospital, has given me the subjoined analysis of 100 parts, by weight, of human long bones of different ages:—

	At Birth.	10 Years.	36 Years.	71 Years.
Organic matter . .	35·37	32·62	32·04	32·94
Inorganic matter . .	64·63	67·38	67·96	67·06
	100·00	100·00	100·00	100·00

† Physiological Chemistry, vol. iii. p. 18.

Of all animals, the bones of birds (especially of the predaceous kind) contain the largest proportion of earthy matter. Hence their great compactness and white colour. The bones of mammalia contain the next proportion: those of reptiles the next; and least of all those of fishes.

Importance of phosphate of lime.

Of the earthy ingredients of bone, the phosphate of lime holds by far the first rank; hence it is commonly called "bone earth." Adult bone contains 57 per cent. of it, and not more than 8 per cent. of the carbonate of lime. The latter is the principal ingredient in the hardening of shells. But the phosphate of lime is made use of to harden bone, because it forms a harder compound with animal matter than the carbonate. What can be harder than the enamel of the teeth? And this consists of a very large proportion of phosphate of lime combined with animal matter. According to Berzelius, there is only 2 per cent. of animal matter in the enamel, and of the remaining 98 parts, $88\frac{1}{2}$ consist of phosphate of lime.

Phosphate of lime enters not only as the principal earthy ingredient into the composition of bone, but is contained, more or less, in nearly all the tissues of the body. Of all inorganic materials it appears to be the most essential both for vegetable and animal life. Therefore it is not only a most important article of diet, but also a necessary manure. "Those parts of plants which experience has taught us to be the most nutritious, contain the largest proportion of the phosphates,—such as bread-corn, peas, beans, and lentils."* It has been ascertained by experiment, that if animals have their entire supply of phosphate of lime cut off, after some weeks of illness, they are attacked with diarrhœa, which soon kills them. Their bones are found very much softened; and it is not unlikely that the phosphate is absorbed from their bones to supply other more important structures, such as the nerves and muscles.

It is the quantity of phosphate of lime in the bones which makes them so valuable as manure. The bones are boiled to extract the gelatin or glue; afterwards they are crushed in a mill, and, as "bone dust," form an extensive article of commerce.

* Liebig's Letters on Chemistry, p. 522.

Strength of bone. From the experiments of Professor Robison, it appears that the strength of bone, as contrasted with other substances, is remarkable. He found that the following materials stood in point of strength to each other thus:—

Fine freestone, as	1·0
Lead	6·5
Elm and ash	8·5
Box, yew, oak	11·0
Bone	22·0

Hence bone is twice as strong as oak. Professor Robison found that a piece of bone an inch square would bear 5000 lbs. weight.* Besides this, we shall presently see that bone is constructed so as to give the greatest strength with the least expenditure of materials.

Elasticity of bone. In consequence of the animal matter they contain, bones possess a certain amount of elasticity. If a skull be thrown upon the ground, it will rebound. The degree of elasticity varies in different bones, according to their form and texture. The clavicle, for instance, owing to its curved form, is remarkably elastic,—a property which enables it to break the shock of a fall upon the hand. If one end of a clavicle be placed at right angles against a hard substance, and the other struck with a smart blow of a hammer, we shall find that the bone will rebound to a distance of nearly two feet. The ribs, too, are exceedingly elastic. The Arab children make excellent bows with the ribs of camels. Perhaps the best instance we can adduce of elasticity in bone is the clavicle (merry-thought) of the bird. It acts as a spring, and restores the base of the wings to their proper position after the action of the muscles of flight. All the long bones in the human body are more or less curved, that they may have the benefit of elasticity.

Division of bones into three classes. Though the bones present every variety of form and size, yet, for convenience of description, anatomists divide them into three classes — 1. The long and

* Gregory's Mechanics, vol. i. c. v.

round; 2. The broad and flat; 3. The short and square, or irregular. The long and round form the great levers of the limbs, and are adapted for motion. The broad and flat are found chiefly in the skull and pelvis, and are adapted for protection. The short and irregular are for limited motion combined with strength; as the bones of the spine, the carpal and tarsal bones.

NOMENCLATURE. In describing the different parts of a bone, we make use of terms,—Latin, Greek, or English, as the case may be,—which denote either the form of the part, or its fancied resemblance to some natural object, or the purpose it serves. We soon become familiar with such terms as "eminences," "depressions," "processes," "tuberosities," "spines," "foramina," "notches," "canals," "sinus," "fossæ," "trochanters," "condyles," &c. Again, there are parts of bones named after some celebrated anatomist, who may have first described them: for instance, the "aqueduct of Fallopius," the "antrum of Highmore," &c.

We come next to examine the structure of bone, so far as it can be seen with the naked eye. Afterwards we will examine its minute structure with the microscope. Lastly, we will give a concise account of the development and growth of bone.

STRUCTURE OF BONE. Compact and cancellous tissue. The best way to obtain a rough idea of the structure of bone, is to make a vertical section through one of the long bones — say the femur — all the way down (Plate A). We shall then see that the outer part, or "wall" of the bone, is compact like ivory; the interior is hollow, forming the "medullary canal," or cavity containing the marrow. The ends, which expand to form the joints, are composed of a beautiful network of plates and columns of bone, forming what is called "cancellous or spongy tissue," which in the recent state is also filled with marrow.

Shaft of a bone, why hollow. Why is the shaft of a long bone hollow? Not only for lightness' sake, but also because, the amount of material being the same, a hollow cylinder is much stronger than a solid one. It is proved that the lateral strengths of two cylinders of equal weight and length, of which one is hollow and the other solid, are, respectively, as the diameters

PLATE A.

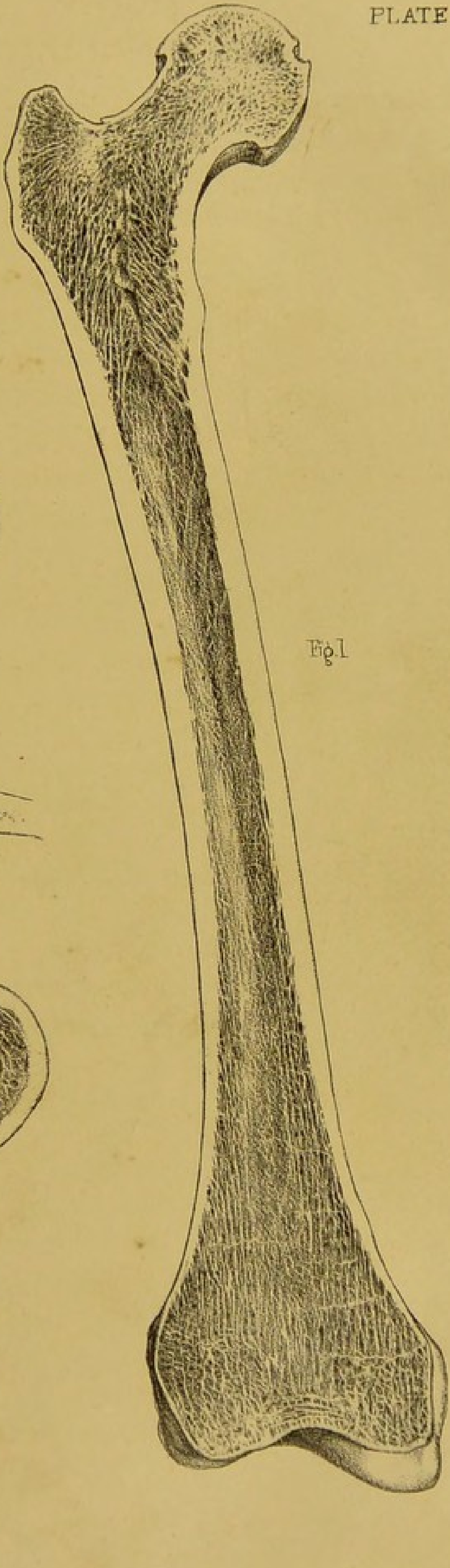


Fig. 1

Fig. 2.

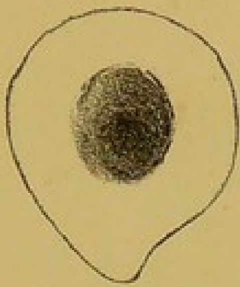


Fig. 4.

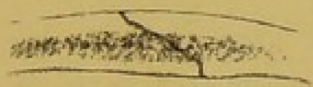
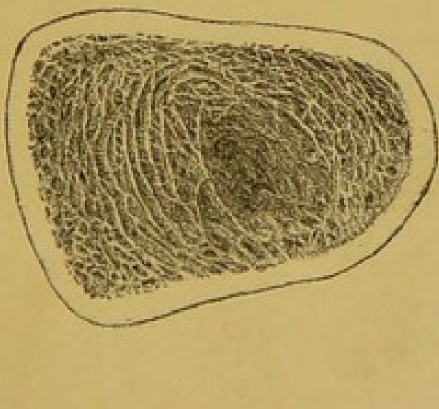


Fig. 3.



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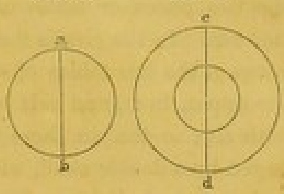
T. Godart. Lith.

of their transverse sections; provided always that the diameter of the tube be within certain dimensions. Thus, let *a b*, *c d* (figs. 1 and 2) represent the sections of two cylinders; then the strength of the tube *d c* is to that of the solid *a b* as the line *d c* is to *a b*.*

FIG. 1. FIG. 2.



In the early part of the 17th century, Galileo observed, that nature, on this principle, increases in a variety of instances the strength of bodies without adding to their weight. This most profound philosopher, when accused of atheistical opinions, and interrogated before the Inquisition as to his belief in a Supreme Being, picked up a straw from the floor of his prison, and replied, "If there were nothing else in nature to teach me the existence of a Deity, even this straw would be sufficient."

Air cells in bone.

Thus are strength and lightness combined in the economy of bones. This principle is carried to the extreme in the bones of birds, which are filled with air in place of marrow. There is a communication between their lungs and the cavities in their bones; and the air which fills the bones being warm, renders them still lighter. It is an interesting fact, that the extent to which air is admitted into the skeleton of birds, varies according to their powers of flight. The great beak of the hornbill forms one great air cell; even the thin columns of the cancellous tissue in the interior are hollow and filled with air. In this bird, in the swifts and the humming birds, every bone of the skeleton, down to the little bones of the claws, is filled with air. In the little apteryx which has no available wings, and in the penguin which never or rarely leaves the water, not any bone of the skeleton receives air. In the mammalian class, there are air cells in the bones, but nowhere except in the bones of the head. There are large air cells (sinuses) in the frontal, sphenoid, maxillary and mastoid bones in the human subject. But in animals these air cells are carried to a much greater extent. The most remarkable de-

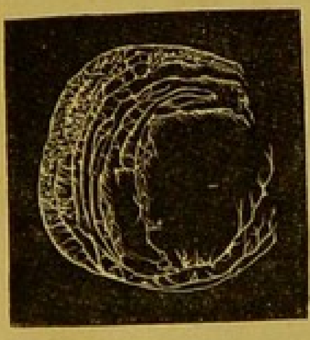
* Bishop on Deformities, 1852, p. 14.

velopment of air cells in the mammalia is seen in the skull of the elephant. His intellectual physiognomy is caused, not by the size of the brain case, but by the enormous size of the air cells between the two plates or tables of the skull. The same may be said of the owl. In the giraffe there is the same arrangement of air cells between the two tables of the skull. In the great extinct sloths the upper, back, and side walls of the cranium were thus inflated with air; so that in these instances the brain is, as it were, protected by a double skull, with air between the two. This modification not only lightens the skull, but protects the brain from the falling trees uprooted by these animals.

Bone divisible into layers.

Although the compact tissue of bone seems as hard and solid as stone, yet it is made up of layers placed so close together, that there is no apparent interval between them. Towards the articular ends (Plate A, fig. 3), the layers gradually separate to form the cancellous tissue, and the compact tissue becomes thinner in proportion. In bones that have been long weather-beaten in a church-yard, these layers may be peeled off one after another; or if the earthy matter be removed by acid, the animal matter admits of being stripped off like so many leaves. It is essential to bear this laminar structure of bone in mind, because it explains what is observed in cases of inflammation of bone — namely, that the enlargement of the blood-vessels and the inflammatory deposit separates the individual layers from each other, and thus causes the bone to expand and be very perceptibly increased in diameter, as seen in the adjoining wood-cut, taken from a specimen in the Museum of St. Bartholomew's Hospital.

Fig. 3.



Cancellous Tissue. Adaptation of its layers to the weight to be sustained.

Its great strength.

Its property of breaking shocks.

The cancellous tissue, as before remarked, occupies the interior of bones, and chiefly the articular ends. It is formed by the separation of the component layers of the bone, and these are connected by cross plates and fine columns, so as to form a kind of lattice-work with a most delicate and elegant arrangement. The direction of these component columns in all parts of bones is arranged upon this principle:—they always run exactly in the line of pressure which the bone has to bear. A beautiful example of this is seen in the section of the cancellous tissue of the thigh-bone (Plate A). At the lower part, towards the knee, the layers run vertically,—that is, in the direction of the axis of the shaft, this being the line of pressure when the body is erect. But in the neck of the thigh-bone the layers are arranged in decussating curves like the arches in Gothic architecture, one within the other, in order to sustain with the greatest mechanical advantage the weight transmitted on to the heads of the thigh-bones. Though so light and spongy, the cancellous tissue is able to support a great weight without giving way. We may form some idea of its strength from the following experiment*:—A cubic inch of cancellous texture was taken from the lower end of the femur, and placed with its principal layers upright. Four cwt. was then placed upon it, but it did not give way in the least. Six cwt. made it sink half an inch. Yet the cubic inch of bone itself did not weigh more than 54 grains. Not only is cancellous tissue strong as well as light, but it possesses also another advantage,—that of breaking shocks. When one ball of ivory strikes another, as in the game of billiards, the whole force of the shock is transmitted from one to the other: but let a ball made out of the cancellous tissue of bone be interposed, and then see how the shock will be broken. This property of breaking shocks is of course greater when the bone is in its natural state and filled with marrow.

The spaces formed by the cancellous tissue vary in size and shape, but freely communicate with each other, and also with the holes on the surface of the bones. This communication is easily proved by boring a hole at one end of a bone, and pouring quicksilver into it:—we shall find that the quicksilver will run out freely through the natural holes at the other end.

MARROW. Two kinds, yellow and red. Fœtal marrow cells.

The cancellous tissue, like the interior of the shaft of a long bone, is filled with yellow marrow. Marrow may be said to be composed almost entirely of fat (96 per cent.); that is, in bones that

* Outlines of Osteology, by T. Ward, p. 368.

are healthy. Like all other fat, it is removed in cases of great emaciation,—in general dropsy, for instance; and its place is supplied by an albuminous fluid. Hence the bones of a dropsical subject are always the least greasy, and the best adapted for skeletons. Besides the yellow marrow, there is another kind of marrow of a red colour. This red marrow differs from the yellow, in that it contains little or no fat, — not more than 1 per cent., according to Berzelius; it consists of albumen (22 per cent.) and water (75 per cent.) Marrow of this albuminous nature forms the red pulp in the bodies of the vertebræ, the sternum, the bones of the cranium, and the ribs. It is this kind of marrow which is found also in all the bones of the fœtus, and in infants. Hence it is sometimes called fœtal marrow. If it be examined with a high magnifying power, it will be found to contain a number of oval, many-nucleated cells (Plate D, fig. 9). We direct attention to these cells the more because they form one of the characteristics of a class of tumours termed "myeloid" (μυελώδης, marrow-like), from their being chiefly composed of them*; morbid growths being in the present day named and classified as much as possible after their likeness to natural parts.

How bones are supplied with blood.

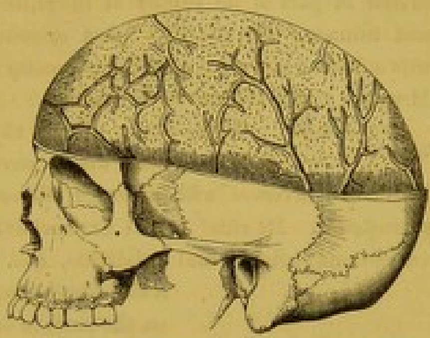
At the articular end of any long bone, or on the body of a vertebra, we observe a number of holes. For instance, near the lower end of the thigh-bone we might soon count as many as 150 or more. What are these holes for? The smaller are for the transmission of the articular arteries for the nutrition of the cancellous tissue, which is exceedingly vascular. The larger are for veins which return by themselves. These veins of the cancellous tissue are large and numerous. They traverse and ramify through this tissue in various directions in special canals with thin walls of bone. They are well seen in a section through a vertebra (Plate I., fig. 7), also in the cancellous tissue (termed "diploe") of the cranial bones. In a surgical point of view these "diploic" veins are interesting, on account of their liability to inflame after severe injuries of the head: such in-

Veins of the cancellous tissue.

* Lectures on Surgical Pathology, by J. Paget, F.R.S., vol. ii. p. 212.

flammation may lead to suppuration in the diploe, which is often fatal. The adjoining cut shows the large venous canals in the "diploe" of the skullcap.

FIG. 4.



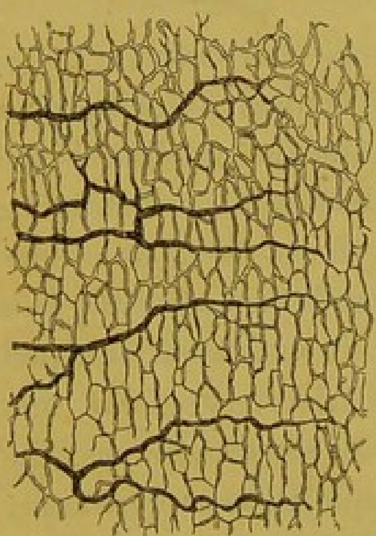
Again, on the outside of the shaft of a long bone there are a number of minute grooves, which run for the most part parallel to the shaft, and are for the lodgment of blood-vessels. At the bottom of these grooves lie a multitude of still more minute holes, barely visible to the naked eye, but easily seen through a small pocket glass. These holes transmit the blood-vessels for the nutrition of the compact tissue, which come from the "periosteum," or membrane covering the bone. The marrow in the interior of the bone is supplied with blood by the "medullary artery." This artery reaches the marrow through a very distinct canal (canal for the nutrient artery of the medulla), which runs obliquely through the shaft, somewhere near the middle of it. In a long bone like the femur there are generally two of these, situated at the back part of it. As soon as the artery reaches the medullary cavity, it divides into an ascending and a descending branch, which ramifies for the supply of the marrow, and finally communicates with the "articular" arteries already described.

Artery of the marrow.

Thus the several parts of a long bone are supplied with blood as follows: — The compact wall of the shaft by blood-vessels from the periosteum; the marrow in the interior by a special medullary artery; and the cancellous tissue of the ends by the articular arteries. The blood-vessels of these several parts are not exclusive, but communicate more or less with each other. Hence they readily reciprocate their morbid actions, and inflammation arising in the one part may spread to the other. Now although these three orders of blood-vessels do communicate in the bone, yet we cannot be surprised to find that when a bone is broken below the canal for the nutrient artery of the marrow, the lower fragment, being deprived of part of its supply of blood, is apt to become atrophied and thinner. Mr. Curling * has written an interesting paper on this subject: and a preparation is put up in illustration of it in the Museum of the College of Surgeons.†

PERIOSTEUM. Its use. Everywhere except at the insertion of strong tendons, and where covered with cartilage, the bones are invested with a tough fibrous membrane termed the periosteum. Its chief use is to provide a bed in which the blood-vessels may divide and subdivide, and so reduce themselves to a size small enough to penetrate the pores on the surface of the bones. The adjoining cut shows the arrangement of the blood-vessels of the periosteum. The periosteum likewise provides each of the vessels entering the bone with a fibrous covering. In early life it ministers to the growth of the bone in thickness, and ever afterwards to its nutrition. If therefore the periosteum be torn from the surface of a bone there is a risk that a layer of the subjacent bone will lose its vitality and be cast off.

FIG. 5.



MEDULLARY MEMBRANE. The medullary canal, as well as the cells (marrow spaces) of the cancellous tissue are lined by an extremely delicate membrane, termed the "medullary membrane." It is too delicate to be shown as a continuous membrane, like the periosteum; but so far as it goes, it supports the marrow, and serves the purpose of providing a stratum for the subdivisions of the medullary artery, before they penetrate the contiguous osseous substance.

NERVES of bone. Periosteum and bone unquestionably possess nerves. This is proved by absolute demonstration, and by disease. Nerves may be traced into some of the minute

* Medico-Chir. Transactions, vol. xx.

† Pathol. Cat. vol. ii., Prep. No. 382*a*.

foramina on the shaft of a long bone, but more easily into the articular ends. A nerve also enters the medullary canal with the nutrient artery of the medulla, and divides like the artery into an ascending and a descending branch. Of all the bones, the tibia presents the largest canal for the nutrient artery of the marrow; in this bone also it is easy to trace the entrance of the nerve with the artery. Though bone in health has but little sensibility, yet, when diseased, it becomes greatly exalted. Mr. Stanley * says he has "witnessed the manifestation of pain as acute from the penetration of an inflamed bone by a saw or trephine, as from incisions of the inflamed soft parts." The same author has likewise a chapter on "Neuralgia of Bone." Every surgeon must have witnessed how sensitive are granulations from bone. Indeed, it is probable that the severe pain attendant on the ulceration of articular cartilage is occasioned by the pressure of the cartilage on the bone granulations beneath it.

ABSORBENTS of bone.

The absorbents of bone have not hitherto been actually demonstrated. That bone does possess absorbents, is rendered highly probable from the fact that ivory pegs introduced into bones, for the purpose of consolidating ununited fractures, are in some instances absorbed.

MICROSCOPIC STRUCTURE OF BONE.

This is a most interesting and instructive study. It reveals to us that bones are as minutely provided with blood-vessels and nerves, and in all respects as much cared for, as the softer parts of the body. Being as fully organised as the other parts, we cannot wonder that they are subject to the same diseases. We shall have to investigate how the bones are formed in early life, how they grow to maturity, how their health is maintained, and how their injuries are repaired. Would anyone, looking at a solid bone, expect to find that even its hardest parts are tunnelled out by a network of minute canals for the passage of capillary blood-vessels;

* On Diseases of the Bones. Introduction, p. xi.

and that from these canals other tubes, infinitely more minute, and expanding here and there into reservoirs, radiate in all directions for the purpose of nutrition?

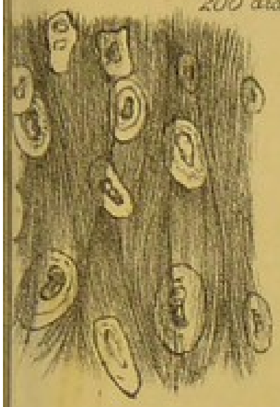
General idea of the subject.

Let us first get a general idea of the microscopic structure of bone, and go into details afterwards. If a transverse section from the shaft of a long bone be ground extremely thin, and examined with a power of about 20 diameters (Plate B, fig. 4), we shall see a number of holes, with dark spots grouped round them, in a series of tolerably concentric circles. These holes are sections of the canals (termed "Haversian," after their discoverer, Clopton Havers *) which transmit blood-vessels into the substance of the bone. The dark spots are minute reservoirs, called "bone corpuscles," "bone cells," or "lacunæ." One would imagine they were solid bodies, but they are really cavities; and their dark appearance in the dry bone is owing to the refraction of the light. As we examine the different parts of the section under the microscope, we notice that the Haversian canals vary considerably in size and shape. They are generally round or oval. Those nearest to the circumference of the bone are very small; but towards the medullary cavity they gradually grow larger, and at last open out into the cells of the cancellous texture.

Let us now examine the same section with a higher power (Plate B, fig. 6), and we shall find that the Haversian canals are surrounded by a series of concentric lines, reminding us of the tranverse section of the branch of a tree. These lines are termed the "laminæ:" they are in truth so many layers or rings of bone that have been developed within the Haversian canal. Understand that even the smallest Haversian canal was, when originally formed, a much wider space, and circumscribed by only a single layer of bone; but in process of growth the canal becomes gradually contracted by the deposit of successive layers of bone. We notice also that the dark spots, before alluded to as the "lacunæ," are situated between the laminæ, and that now, under a higher magnifying power, they look like spiders. The central part of the lacuna, representing the body of the spider, is hollow, and the dark fila-

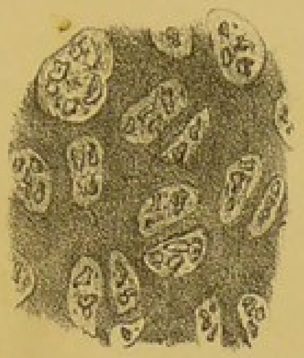
* An English physician of the 17th century.

Fig. 1. 200 dia^{s}



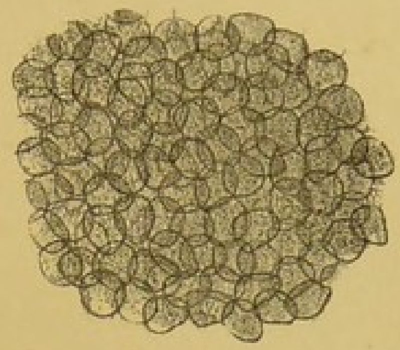
Fibro-cartilage.

Fig. 2. 250 dia^{s}



Hyaline cartilage.

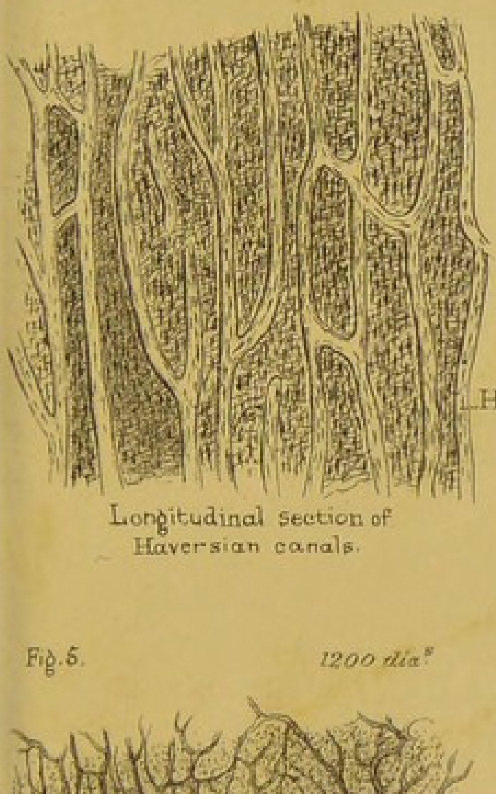
Fig. 3. 200 dia^{s}



Simple cartilage.

BONE

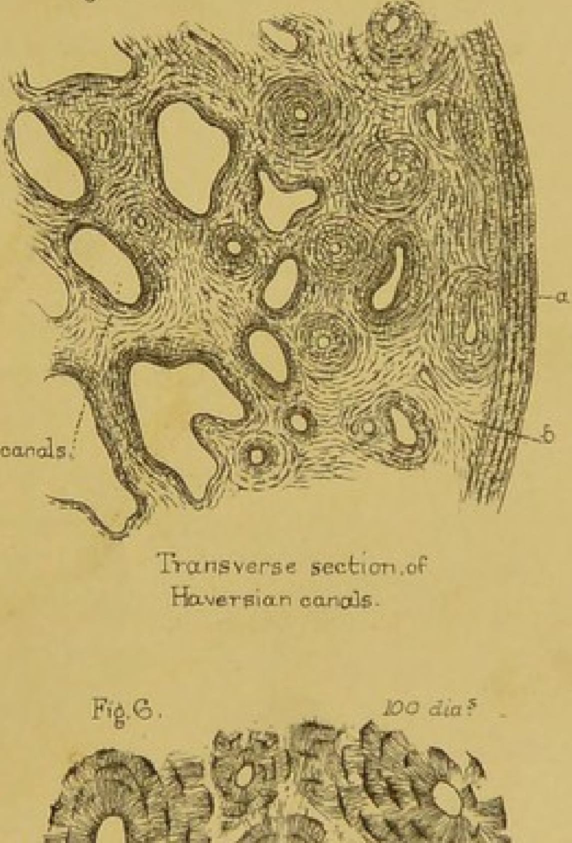
Fig. 3. 20 dia^{s}



Longitudinal section of Haversian canals.

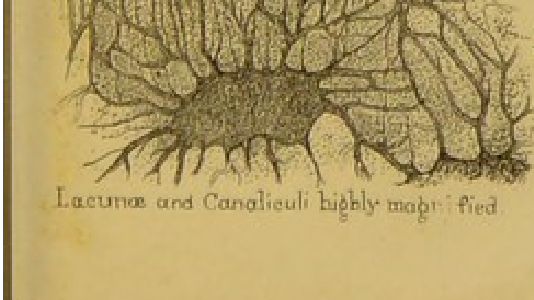
Haversian canals.

Fig. 4. 20 dia^{s}



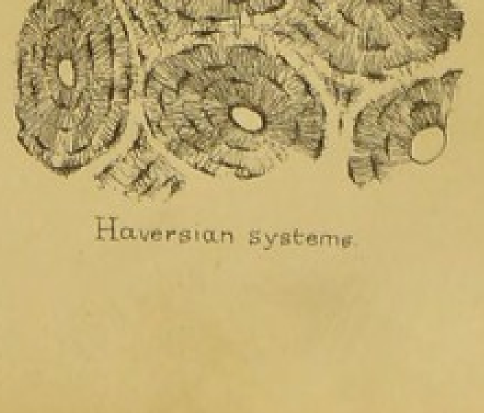
Transverse section of Haversian canals.

Fig. 5. 1200 dia^{s}



Lacunæ and Canaliculi highly magnified

Fig. 6. 100 dia^{s}



Haversian systems.

ments which pass off from it, representing the legs, are minute tubes termed "canaliculi:" these are exceedingly numerous, and radiate from all parts of the "lacuna," through the laminæ. Now since the canaliculi of one circle of lacunæ communicate most freely with those of the next circle, and the canaliculi nearest to the Haversian canal open directly into it, we see that by means of this system of radiating tubes a complete communication is established between the Haversian canal in the centre, and the successive circles of bone which surround it. The nutrient juice of the bone proceeds from the blood-vessels in the central canal, and is transmitted through the canaliculi from one lacuna to another.

What is an Haversian system?

Every Haversian canal taken in conjunction with its concentric layers of bone, lacunæ, and canaliculi, is termed an "Haversian system." It may be compared to the planetary system. As the sun is the centre of light and heat to the planets around it, so is the blood-vessel in the Haversian canal the centre of nutrition to the surrounding circles of bone.

Almost all the compact substance of bone is made up of a multitude of these "Haversian systems." Each system is, to a certain extent, independent of its neighbour, since the lacunæ of one system communicate very sparingly with those of another. In consequence of this isolation, we may sometimes find, in favourable sections, that each system is more or less circumscribed by a tolerably distinct white line, which is transparent bone with but few canaliculi.

Haversian interspaces.

As the Haversian systems are for the most part circular, and arranged like sticks in a faggot, it is clear they cannot touch each other in all parts of their circumference; so that here and there we may observe that triangular portions of bone fill up the gaps between them. Such portions are termed "Haversian interspaces" (Plate B, fig. 4*b*). These "outlying" portions of bone are also provided with lacunæ and canaliculi, and they derive their nourishment from the surrounding Haversian systems, of which they are, so to speak, dependencies.

The section we have all along been examining was a transverse one. We must now make an equally thin section in the longitudinal direction of the shaft, and we shall have quite a different appearance (Plate B, fig. 3). We shall cut in the course of the Haversian canals, not across them; and we shall find that, as a general rule, they run parallel to the surface of the bone (no matter whether long or flat), and that they communicate very frequently by transverse or more or less oblique canals. If the section be large enough for us to trace the Haversian canals near the circumference, we shall find that many open on the outer surface, in order to admit blood-vessels from the periosteum; others, again, will open out into the medullary canal, in order to admit blood-vessels from the interior. In this way the Haversian canals permeate the compact substance of the bone, and establish a free communication between the blood-vessels of the periosteum and those of the medulla. These canals may, in fact, be regarded as so many multiplications of surface for the ramifications of blood-vessels, in order that no part of the bone substance may be beyond the range of nutrition.

In this longitudinal section, the laminæ, in place of being arranged concentrically, will be seen running in lines parallel with the Haversian canals to which they belong.

Bone tissue.

At this stage of the investigation, a question naturally arises — Where is the earthy material, the phosphate and carbonate of lime? To see this, the transverse section must be magnified about 1200 diameters (Plate B, fig. 5). We shall then discover that the earthy ingredient consists of an infinite multitude of minute osseous granules, which are deposited in a "matrix" or bed of animal matter. This mixture of earthy granules and animal matter we call "bone tissue." It occupies all the space between the lacunæ and their canaliculi. If the specimen we are examining were steeped for a time in dilute muriatic acid, the osseous granules would be dissolved out of it, and the little pits in the matrix in which the granules were imbedded would become apparent.

So far we have acquired a general notion of the minute structure of bone; that is to say, of the "Haversian canals," the "lacunæ" and their "canaliculi," the "laminæ," and the "osseous granules." We must now proceed to speak of these several parts a little more in detail; and first, of the Haversian canals.

HAVERSIAN CANALS.

As was said before, the Haversian canals are tunnelled out of the compact substance of the bone, simply for the purpose of conveying blood-vessels for its nutrition. Observe, they form no part of the essential structure of bone. Wherever bone is so thin as to be able to derive its nutrition from the vascular membrane covering its surface, we do not find Haversian canals in it, nor does it require any. For instance, the delicate plates of bone composing cancellous tissue, the paper-like bones in the interior of the nose, have no Haversian canals in them: but they have plenty of lacunæ, which send out their canaliculi to open on the surface and imbibe the requisite nutrition. Bone so thin as to need no Haversian canals is called "non-vascular" bone. Such bone lives upon the blood which flows through the minute vessels of the mucous membrane. Bone has, therefore, like all other living structures, a *self-formative* power, and draws from the blood the materials for its own nutrition.

Their diameter.

The Haversian canals vary in diameter from $\frac{1}{200}$ to $\frac{1}{2000}$ of an inch, the average being about $\frac{1}{500}$. The smallest are found near the outer surface, where the bone is the most compact; but they gradually become larger towards the interior, where they open out into the cancellous tissue, or into the medullary cavity. All of them, whatever their direction may be, are surrounded by concentric laminæ of bone; but the number of the laminæ varies round different canals from 5 to 15 or more. All of them also are lined by a very delicate membrane, continuous with the periosteum on the exterior of the bone. The smallest

Their contents.

canals contain only a single capillary blood-vessel; the larger contain a network of vessels, while the largest, which gradually merge into the cancellous tissue, contain marrow as well as blood-vessels.

Their lining membrane.

Here it may be as well to mention a fact concerning the minute structure of bone, which should never be lost sight of. It is this: — that everywhere underneath the membrane in contact with the surface of bone, whether it be the periosteum covering the exterior, the prolongation of it lining the Haversian canals, or the medullary membrane lining the cancelli, there is a delicate layer of soft fibrous tissue, with a multitude of small oval cells in it, termed "osteal cells" (Plate C, fig. 3). Now, bone grows by additions to its surface, not by interstitial deposit, and it has been ascertained that these cells, and the soft tissue in which they are imbedded, are mainly concerned in the process, and that by the successive ossification of this tissue and cells, the concentric layers of bone are produced within the Haversian canal.

Dilatation of Haversian canals from inflammation.

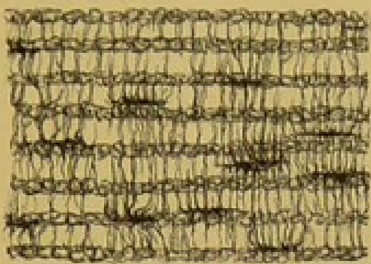
The knowledge of the free circulation of blood through the substance of bone gives us the key to some of the effects produced by inflammation in it. For example, as inflammation in soft parts is attended by dilatation of the blood-vessels, so also is it in the case of bone. When bone is acutely inflamed, the blood-vessels in the Haversian canals become greatly enlarged, and cause the canals themselves to become larger by absorption of the bone tissue,—so much so as to give the bone, sometimes, a reddish colour. In operations where the surgeon has to cut through inflamed bone, one may see the blood flowing from the cut surface of the bone, as it would from the soft parts. More than this, the distended blood-vessels may occasion not only a gradual enlargement of the Haversian canals, but their inflammatory deposit may cause even a general swelling of the compact substance of the bone, and a natural separation of its component layers, so that it becomes light and spongy, as seen in the adjoining cut.

FIG. 6.

Their obliteration in some cases.

On the other hand, under certain circumstances of long-standing disease, *e. g.* chronic inflammation, we sometimes find that bones become much harder and thicker than natural. They may become as hard as ivory. Here the Haversian canals are nearly filled up by successive layers of bone. Indurated bone is therefore less vascular than healthy bone. A good example of "eburnation" of bone is occasionally seen as the result of

Fig. 1. 440 dia^s



Laminæ under high power.

Fig. 2.

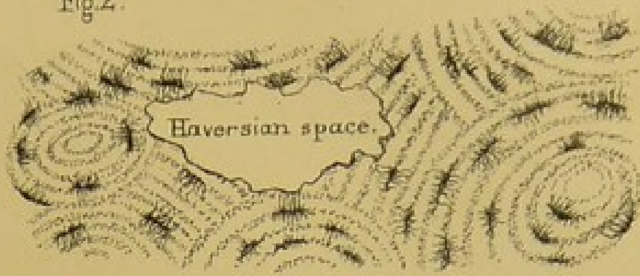
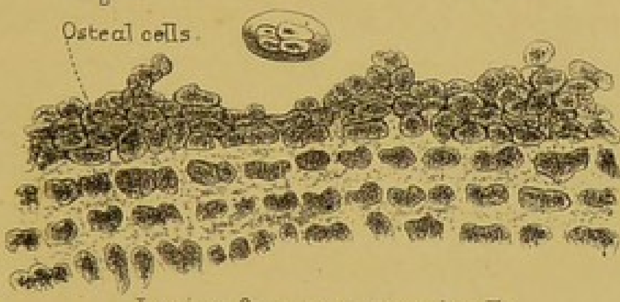
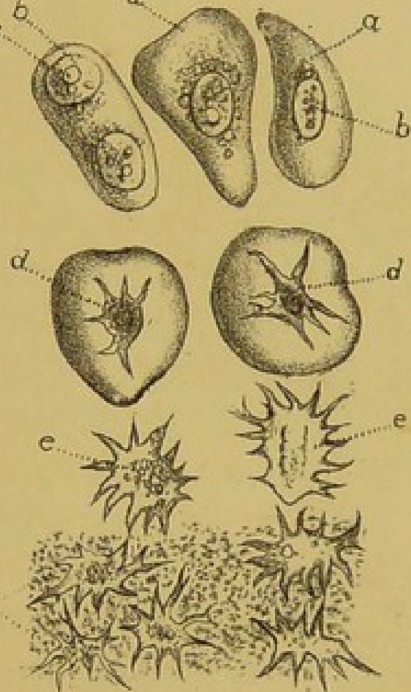


Fig. 3. 800 dia^s



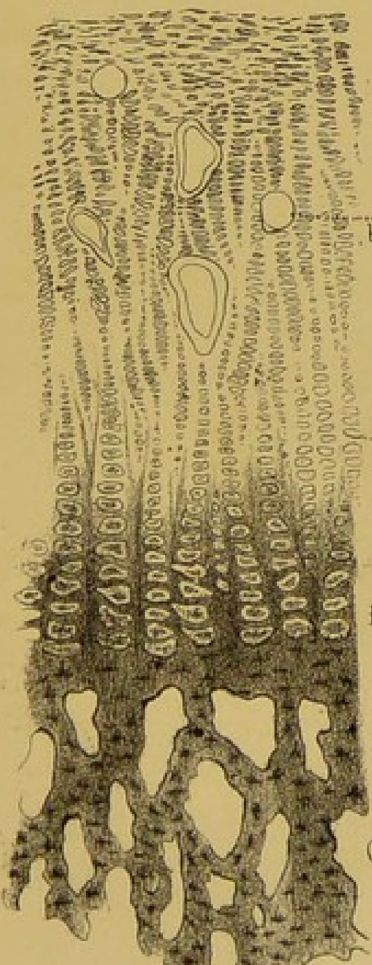
Laminæ formed by Osteal cells.

Fig. 4.



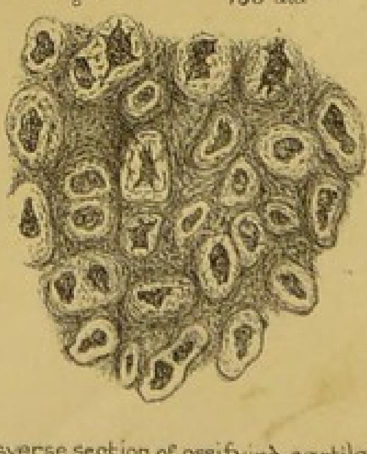
Development of Lacunæ

Fig. 5 50 dia^s



Vertical section of ossifying cartilage.

Fig. 6 130 dia^s



Transverse section of ossifying cartilage.

chronic rheumatism, where the articular ends of bone lose their cartilage and become hard and polished like ivory, owing to the blocking up of the Haversian canals by bone.

Lacunæ characteristic of true bone.

The "lacunæ" are the spider-like cavities which we find between the laminæ, arranged in concentric circles round the Haversian canals. They are characteristic of true bone, and distinguish it from accidental "ossifications," sometimes met with as products of disease. Formerly the lacunæ and canaliculi, in consequence of their dark colour, were considered to be solid; but subsequent observation has proved them to be hollow, since they can be filled with turpentine or Canada balsam. If, for example, a drop of oil of turpentine be applied to a section of dry bone under the microscope, capillary attraction will cause the fluid to enter the canaliculi, and its passage may be traced from one lacuna to another. It is a curious circumstance, that, in the bones of bodies that have been embalmed, the bone cells and canaliculi are filled with the bituminous material.

As a rule, the lacunæ are oval and flattened, so that one of their broad sides may be turned towards the Haversian canal. The first ring of lacunæ sends half of its canaliculi directly into the Haversian canal, while the other half communicate with the canaliculi of the second ring, and so on throughout the whole system. The nutrient fluid, or "plasma," of the blood, exuding through the coats of the blood-vessel in the Haversian canal, is imbibed by the nearest row of lacunæ, and passed on from them to all the others in the Haversian system. One may say then that the lacunæ are reservoirs of nutrition for the bone.

Their size and shape.

In man, the lacunæ measure about $\frac{1}{2000}$ of an inch in their long diameter, and about $\frac{1}{6000}$ in their short. It has been shown by Mr. Quekett that they vary in size and shape in the four great classes of animals, so that by means of this test it can be ascertained with certainty whether a given fragment of bone be part of a mammal, a bird, a reptile, or a fish. As this test is equally applicable in the case of fossil bones, it has an important bearing upon the study of geology. Another interesting fact discovered by Mr. Quekett is, that the size of the lacunæ bears very little relation to the size of the animal to which they belong. They are nearly as large in the bones of the little lizard, as they are in those of the enormous extinct lizard, the Iguanodon. But their size *does* bear an exact proportion to that of the blood cells in the several classes of animals. Therefore, as reptiles have the largest blood cells, so have they also the largest lacunæ.

CANALICULI: their size and office. Respecting the "canaliculi" (Plate B. fig. 5), observe how exceedingly minute they are; that they run off from all parts of the circumference of the lacunæ, and communicate most freely with the canaliculi of the adjoining lacunæ. Their diameter ranges from $\frac{1}{14000}$ of an inch to $\frac{1}{20000}$ of an inch; but there are some even smaller. They are far too small to allow the entrance of blood cells. They admit the passage of nothing but a thin juice from the blood, the "plasma," destined to nourish the bone and keep it in a state fit for self-repair when injured by disease or violence.

LAMINÆ. In man, and almost all mammalian animals, bone grows by the deposit of fresh layers. In all cases the new layer is deposited on that surface of the old layer which is next to the blood-vessel. Therefore, in a fully formed Haversian system, we get the appearance of "concentric" rings. They vary in thickness from $\frac{1}{3000}$ to $\frac{1}{5000}$ of an inch. Those around the Haversian canals vary from five to fifteen in number, and are called the "Haversian laminæ." Those surrounding the circumference of a long bone which has reached its full growth, are termed "circumferential laminæ" (Plate B, fig. 4 *a*). The ill-defined and broken layers apparent here and there in the Haversian interspaces are termed "interstitial laminæ" (Plate B, fig. 4 *b*). It seems doubtful how these interstitial laminæ were originally formed; but the recent investigations of Messrs. Tomes and De Morgan lead them to believe that they are the remnants of Haversian systems that have been partially removed by absorption.

Structure of a lamina. If a well-marked lamina be examined with a power of 440 diameters, we shall find that it consists of two portions—an inner, apparently structureless and clear; and an outer, granular and opaque (Plate C, fig. 1). This difference of structure arises from the manner in which the several ingredients of bone are originally laid down. Here we must bear in mind that the animal matter of the bone, in its nascent state, consists of a soft, fibrous tissue, which we call "intercellular," and of a number of cells called "osteal cells." The animal matter is laid down first; the earthy part, consisting of granules, is added afterwards; and both intercellular substance and cells become ossified. Now the cells, when ossified, present a much more granular and opaque appearance than the ossified intercellular substance. Therefore, if the cells, in place of being scattered here and there promiscuously, arrange themselves in a row close together, leaving the intercellular matrix clear, the new layer of bone will present a linear appearance, there will be a layer of opaque or granular bone, and a layer of more transparent bone.

Lamination: what is it?

To use the words of Messrs. Tomes and De Morgan*, "Lamination is but a definite linear arrangement of the osteal cells with their outlines permanently retained in the perfected bone."

Osseous Granules.

The earthy salts are deposited in the animal matrix in the form of exceedingly minute granules. The Germans call them "bone crumbs." We cannot see them, however, without a magnifying power of 1200 diameters (Plate B, fig. 5). They vary in size in different specimens of bone. In man their size ranges from $\frac{1}{6000}$ to $\frac{1}{14000}$ of an inch. They can be very distinctly seen in the skulls of small birds—the canary, for instance—and also in the skull of the bat, where they are so much larger than in the human subject. After a section of bone has been steeped for some time in dilute hydrochloric acid, these earthy particles will be dissolved out of the animal matrix, and the little cavities in which they are imbedded can then be distinctly seen.

Present in pus coming from dead bone.

It is an interesting and valuable practical fact, that these earthy granules are generally present in the pus which comes from dead bone. If a specimen of pus under such circumstances be examined with a

* Philosophical Transactions, 1853.

power of 500 diameters, a number of earth granules may be detected among the pus cells,—proving that there is dead bone somewhere. Mr. Quekett noticed this fact many years ago. Mr. Bransby Cooper has also ascertained that in pus coming from diseased bone there is as much as two and a half per cent. of phosphate of lime.

HAVERSIAN SPACES. This name has been given by Messrs. Tomes and De Morgan to certain spaces which they have lately discovered in bone (Plate C, fig. 2). The spaces are produced by absorption of old bone, and in process of time are again filled up with deposits of new laminated bone. This discovery is important, since it shows that bone is not a stationary structure; on the contrary, it is subject to a kind of absorption and reproduction of its tissue, throughout life, the activity of the process diminishing with advancing age. How are we to distinguish these "Haversian spaces" from "Haversian canals?" As follows:—

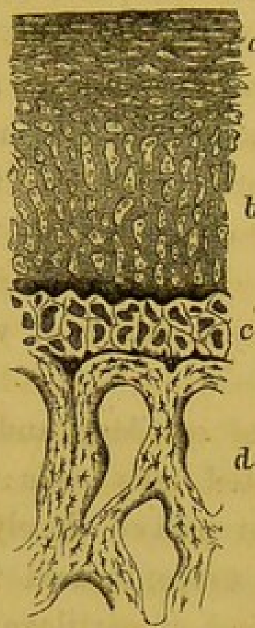
How distinguished from Haversian canals. The walls of the Haversian canals have a smooth regular outline; on the other hand, the Haversian spaces have a festooned irregular boundary, apparently produced by the absorption of parts of several Haversian systems. Indeed, the authors just mentioned consider that the "interstitial laminæ" are but the remains of Haversian systems nearly all absorbed.

"Haversian spaces" may be found in various conditions. In some the process of absorption is still going on; in others the deposit of new bone has commenced. Thus, then, it would seem that portions of the circumference of three or four Haversian systems, having lived a certain time, are gradually removed, and presently a new Haversian system is set up in their place.

ARTICULAR BONE: Its peculiarities. By this we understand a thin layer of bone situated immediately under articular cartilage; and since there is a peculiarity about the structure of it, we will allude to it here. If a perpendicular section be made through the articular surface of any fresh bone with the cartilage attached, it will be observed, (as seen in the cut,) that the cartilage does not rest immediately upon the cancellous tissue of the bone, but upon a thin compact crust of bone which closes the cancelli.

This crust, which we call "articular bone," varies in thickness, and is of a remarkably white colour. But its chief peculiarity consists in this, — that it has no Haversian canals in it, and and therefore is not vascular. The blood-vessels of the cancellous tissue run up only as high as its under surface, and then turn back in loops. Moreover, its "bone cells" are three or four times larger than in ordinary bone, and are destitute of canaliculi. Here is a striking instance of design. This layer of bone, having no Haversian canals, is much less porous than common bone, and in consequence of its closer texture is all the stronger, and more adapted to form an unyielding surface for the support of the articular cartilage.

Fig. 7.



Although articular bone and adult articular cartilage have no blood-vessels in health, yet they both become vascular in some cases of disease of the cartilage. Blood-vessels may be seen, when successfully injected, shooting up through the heretofore non-vascular layer of bone into the cartilage on its surface.

FORMATION OF BONE IN THE EMBRYO.

Bone may be formed in cartilage or in membrane.

Remember what bone is: — A matrix or bed of animal matter, hardened by a deposit of earthy salts. The animal matter may be cartilage, or membrane. Hence we have formation of bone in cartilage, and formation of bone in membrane. These subjects must be considered separately; and in order to a right understanding of the first of the two, it is essential to know something of the nature of cartilage.

Nature of cartilage.

Cartilage, commonly called gristle, is tough, flexible, very elastic, of a greyish-white colour, and used for various purposes in the animal body. There are many kinds of it. The simplest kind, when examined with the microscope, is found to consist of a mass of nucleated cells, closely packed and variously shaped from mutual pressure.

Simple cartilage.

Such cartilage as this may be seen in a tadpole, or in the spinal cord of a lampern, or in the ear of a bat or mouse (Plate B, fig. 3). Under the microscope, though not to the naked eye, it is just like some kinds of vegetable tissue, for instance, the pith of the elder.

Another kind of cartilage, and that which chiefly concerns us, consists of nucleated cells (cells with nuclei in their interior) of various shapes, not packed closely, but imbedded in a matrix of a homogeneous substance, termed "intercellular." It is altogether a much firmer kind of cartilage. Now the nature of this intercellular substance varies. It may be clear and transparent like glass: then we call it "hyaline cartilage" (fig. 2). Of this kind is the fœtal skeleton, and the cartilage of the joints throughout life. Or the intercellular substance may contain more or less of fibrous tissue: then we call it "fibro-cartilage" (fig. 1). This kind of cartilage constitutes the gristle of the nose and the ear; and since it never ossifies, it is sometimes called "permanent" cartilage, as opposed to hyaline or fœtal cartilage, which does ossify, and is therefore only "temporary."

Hyaline cartilage.

Fibro-cartilage.

Perichondrium.

All kinds of cartilage, with the exception of that which covers the ends of the bones (articular cartilage), are invested with a white fibrous membrane, termed "perichondrium." This, like the periosteum of the bones, serves to support the nutrient blood-vessels of the cartilage. When the cartilage is thin, the vessels proceed no further than the surface: but when it is thick, they are prolonged into its substance by means of canals, carrying with them a sheath of perichondrium. When cartilage is about to ossify, these canals increase in number and size, in order to provide a free supply of blood from which the bone earth is deposited.

Articular cartilage has no perichondrium, neither has its blood-vessels, except in the young condition. But when diseased, it has been proved by injection* that blood-vessels do shoot into the cartilage through the layer of articular bone beneath it.

Development of bone in cartilage.

The parts of the embryo animal destined to become bone, may be detected as early as the seventh week after conception, in the shape of a gelatinous pulp without trace of organisation, contained in a delicate membrane. Presently this pulp becomes converted into the simplest form of cartilage,—that is, an aggregation of closely-packed nucleated cells. But since a mere aggregation of soft cells would not be a sufficient basis of support to the surrounding parts in progress of development, intercellular substance is added to give it greater solidity, and this "simple" cartilage becomes "hyaline" cartilage. Thus the entire skeleton of the fœtus, with the exception of the skull-cap and the bones of the face, consists at first of hyaline cartilage.

Cartilage becomes more vascular previous to ossification.

When the proper time for ossification arrives, that part of the cartilage which is about to ossify becomes permeated by larger and more numerous canals for the passage of the blood-vessels which carry the bone earth in solution. Presently, minute specks of bone are deposited in the hyaline substance; and for every particle of bone laid down, a particle of animal matter is removed to make place for it, otherwise there would be a redundancy of bulk. The deposition of bone does not take place at once in all parts of the cartilage, but at certain points, which are called "centres of ossification." Every bone has a definite number of these centres, which always appear in the same place; and from these centres the ossification extends according to a regular plan. The number of centres varies in different bones. Some bones have only a single centre; others two, three, five, seven, &c.; and the bone called the "sacrum" has as many as thirty-three centres before its ossification is complete.

Centres of ossification.

* See Catalogue of the Histological Series in the Museum of the R. C. S. E., vol. i. plate viii. fig. 11.

Observe, the centres of any given bone do not all appear at once: some appear before birth, others after it, but all in regular succession, and at stated periods, according to the degree of importance of the bone, and the function which it has to perform; *e. g.* the lower jaw and the ribs ossify early, because suction and respiration are brought into play at birth. As a general rule, each centre appears first in the middle of the portion of cartilage which it will subsequently ossify; and thence the ossification extends towards the circumference in the flat bones, and towards the extremities in the long bones. Almost all the bones, then, in infancy and childhood, are made up of so many distinct bony pieces united together by cartilage: and these several pieces remain distinct until the stature of the individual is complete, at which time they are all consolidated.

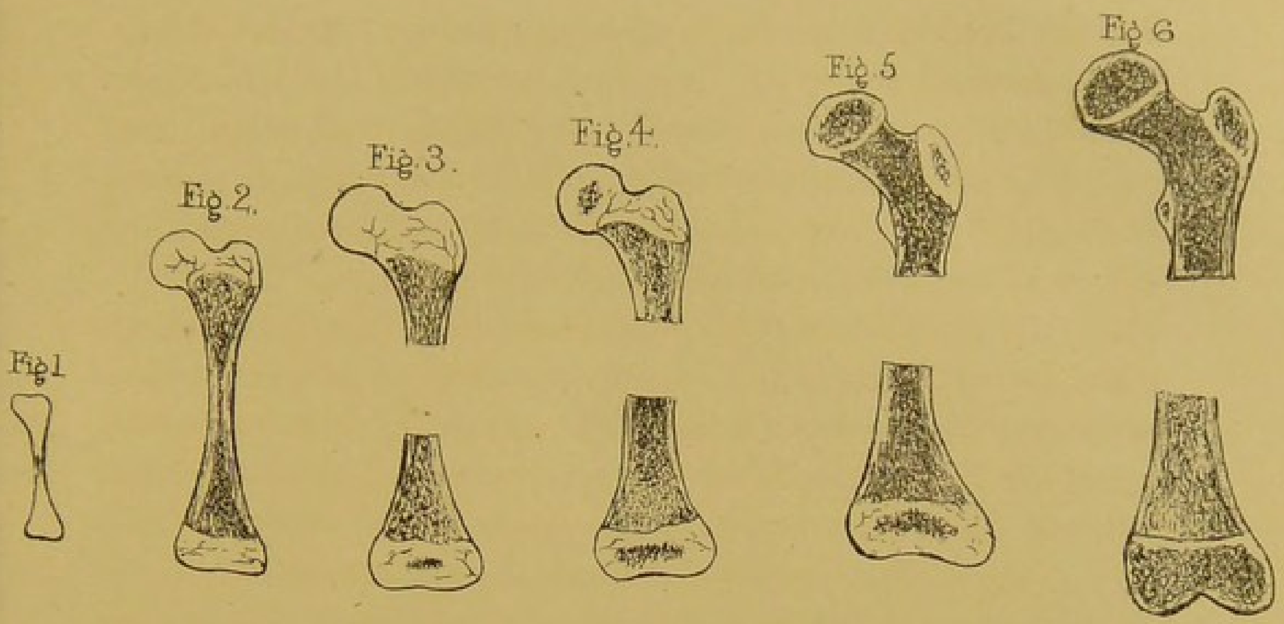
Ossification of the thigh-bone selected as an example.

As a good example of what can be seen of the process of ossification with the naked eye, let us follow out that of the thigh-bone (Plate D, figs. 1 to 6). The future bone is at first sketched out in hyaline cartilage. About the beginning of the third month after conception, the first centre of ossification appears in the middle of the shaft;—and this, by the way, is the case in all the long bones (fig. 1). From this point ossification gradually extends up and down the shaft, which is all ossified before the other centres appear. About the last month of fœtal life, a second centre appears in the lower end, which forms the knee (fig. 3). About the end of the first year after birth, a third centre appears at the upper end or head of the bone (fig. 4). In the course of the fourth year a fourth centre appears in the projection termed the "trochanter major" (fig. 5). In the course of the fourteenth or fifteenth year a fifth and last centre appears in the "trochanter minor" (fig. 6).

Meaning of "diaphysis" and "epiphysis."

Thus, then, the thigh-bone has five centres of ossification. The shaft or body of the bone, which ossifies first, is called the "diaphysis;" the other parts are termed "epiphyses." As these epiphyses, during the period of growth, are only united to the shaft by a layer of cartilage, the separation of an epiphysis by violence is not an infrequent accident in childhood. When growth is complete,

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6



Diagrams showing the formation of the Thigh bone.

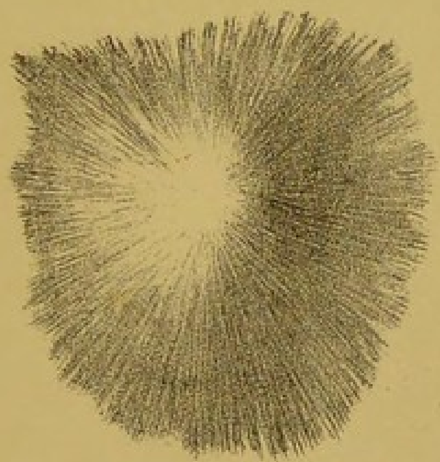


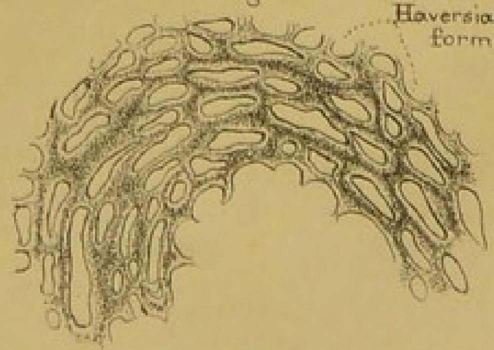
Fig. 7.

Parietal bone of a Fœtus.

Fig. 9.

Cells from Fœtal marrow.

Fig. 8



Section of fœtal bone.

all the epiphyses are consolidated with the rest of the bone, and no cartilage remains except at the articular surfaces, where there is a thin layer of it to break the shocks at the joints.

Order in which the epiphyses unite to the shaft.

It is worth observing, concerning the union of the articular epiphyses at the ends of the long bones, that the epiphysis of that end towards which the canal for the medullary artery runs, always unites to the shaft before the epiphysis at the other end does.

It is a curious fact, also, that the order in which the epiphyses unite to the shaft of a bone is just the reverse of that in which they begin to ossify. Thus, the trochanter minor unites first; afterwards, the trochanter major; then, the head of the femur; lastly, the lower end. At the age of twenty-one, or near it, they have all united to form a single bone.

Final purpose of development from several centres.

The fact that bones are developed from several ossific centres, separated by layers of cartilage, has for its final purpose the well-being of the growing animal. For example, it is necessary to have one part of a bone ossified to support weight, while other parts remain cartilage to take off concussion. "The young lamb or foal," to use the words of Professor Owen, "can stand on its four legs as soon as it is born; it lifts its body well above the ground, and quickly begins to run and bound. The shock to the limbs themselves is broken and diminished at this tender age by the division of the supporting long bones,—by the interposition of the cushions of cartilage between the diaphyses and the epiphyses." The nervous system of slow and cold-blooded animals, whose limbs sprawl outwards, and whose body trails upon the ground, does not demand such protection. Therefore we do not find epiphyses, with cushions of cartilage, at the ends of the shafts of the long bones of saurians and tortoises. But when the reptile moves by leaps, then the principle of ossifying the long bones by distinct centres again prevails, and the extremities of the humeri and femora long remain epiphyses in frogs.

We recognise also a definite purpose in separate centres of ossification in the bones of the head of the human fœtus, in relation to facilitating birth. The bones of the skull-cap, being connected only by membrane, are permitted to overlap each other a little during parturition.

However, in some instances, no satisfactory explanation, so far as purpose is concerned, can be given why a bone should have a certain number of centres from which it ossifies. We must then fall back upon the general plan of organisation, the "unity of type" which pervades the construction of animals; and then we shall find that in our own skeleton many such separate centres of ossification represent permanently distinct bones in some of the lower animals.

Microscopic examination of ossifying cartilage.

Let us now pass on to examine what the microscope reveals to us concerning the ossification of cartilage. For this purpose it is necessary to procure the fresh fœtus of any mammalian animal, and to make thin sections through the bone and the cartilage at the point where ossification is going on. It requires much dexterity and practice to make the sections thin enough to be transparent, and without severing the connection between the cartilage and the bone shooting into it. It is to this precise spot, where the cartilage and bone meet, that we are to direct our attention. We will anticipate the subject by stating the general belief, that *the hyaline or basis substance of cartilage becomes converted into the basis substance of bone, while the granular nuclei of the cartilage cells form the lacunæ and canaliculi.*

When all is ready for ossification, the cartilage is permeated by larger and more numerous channels for the blood-vessels which carry the bone earth in a state of solution in the blood. The earth itself is then laid down, in the form of extremely minute granules, in the hyaline substance of the cartilage.

Changes in the cartilage cells.

Meantime this deposit is preceded and attended by remarkable changes in the cartilage cells. All is life and activity with them to make ready for the coming change. The cells multiply again and again by subdivision, so as to arrange themselves in slightly undulating rows, perpendicular to the advancing bone. But this is not all: some of the cells which are nearest to the bone become enlarged to five or six times their original size, and invest themselves with a thick cell wall at the expense of the hyaline substance, which is thus reduced to a thin film between the cells. These enlarged cells have been termed by Messrs. Tomes and De Morgan "lacunal cells," since it is from the granular cells in their interior that the lacunæ of bone are developed. And here observe, that, although the bulk of the hyaline substance of the cartilage is diminished by this enlargement of the cells, nevertheless the strength of what remains is actually increased by its being impregnated with earthy salts.

As the deposit of bone advances, not only between the rows of cells, but also between the cells themselves, we can understand that these become gradually surrounded on all sides by ossified hyaline substance, so as to be buried, as it were, in osseous crypts. Contemporaneously with this process, the cells themselves undergo a strange metamorphosis. Their outer cell wall is gradually ossified by the deposition of earth granules, while the granular cell in the interior concurrently moulds itself into a lacuna, and shoots out its canaliculi into the young bone of the cell wall. When fully ossified, the cell wall disappears, and cannot be distinguished from the ossified hyaline tissue. How the canaliculi of the young lacunæ establish a communication with each other, is not exactly ascertained.

In plate C, fig. 5, there is a diagram of a perpendicular section of ossifying cartilage. It shows the spicula of bone advancing into the hyaline tissue between the rows of the cartilage cells, and also between the cells themselves.

Fig. 6 shows a transverse section through the ossifying surface. We see the cartilage cells enclosed in their little crypts of bone, forming a kind of uniform pattern. The cells themselves appear in various stages of transformation into lacunæ.

Development of lacunæ from the cells of cartilage.

For a long time it was a puzzle in physiology how the lacunæ and canaliculi of bone were formed. Some observers contended that they were nothing more than spaces left between the layers of bone, like gaps in the weaving of an artificial fabric. Others maintained that they were transformations of the cells pre-existing in the cartilage, and supported their opinion by appealing to the successive steps of the process by which a vegetable cell is lignified. It is no easy matter to follow up such investigations as these. All is straightforward enough as long as the sections are transparent; but as ossification advances, the bone granules laid down in the hyaline tissue cloud the field at the critical moment where the chief point of interest lies, and render further observation almost impossible.

At present, however, there appears to be no reasonable doubt that the lacunæ of bone are developed from cartilage cells, and on the following grounds:—1. While examining the ossifying shaft of a bone affected with rickets, Kölliker* accidentally discovered that in this disease the hyaline substance of the cartilage remains unossified,—or all events ossifies very slowly,—while the cartilage cells do ossify just as under ordinary circumstances. Here, then, he had an excellent opportunity of seeing the gradual conversion of the cartilage cells into lacunæ with canaliculi, and of tracing the successive steps of the transformation, from beginning to end. 2. In certain parts of the body—for instance, at the symphysis pubis, in the intervertebral substances, in the articulation between the ilium and the sacrum, and, generally, wherever fibro-cartilage or tendon is attached to the bone—we find cartilage cells lying free in the matrix, and presenting various degrees of transformation into lacunæ: so that the conditions in normal tissue also favour the present belief as to the mode of origin of the lacunæ. 3. Another argument is derived from the phenomena attending the occasional ossification of cartilaginous tumours.† When such tumours ossify, it is not the intercellular matrix, but the cartilage cell, which ossifies: one can see the cell wall gradually filling with successive layers of bone, while the nucleus remains a lacuna, and shoots forth canaliculi.

Messrs. Tomes and De Morgan‡ have succeeded in tracing the development of lacunæ from the cells of cartilage (Plate C, fig. 4). Previous to ossification, the enlarged cartilage cell, which they call a "lacunal" cell, consists of an outer pellucid cell wall (a), a

* Ueber Verknöcherung bei Rachitis und s. w. in Mittheil. der Zürich nat. Gesellsch. 1847, p. 93.

† See Professor Quekett's Lectures, vol. ii. page 165.

‡ Philosophical Transactions for 1853.

granular cell (*b*), and a nucleolus (*c*). The outer cell wall ossifies, and disappears in the surrounding bony deposit (*f*). The granular cell decomes a lacuna by gradually throwing out canaliculi (*d*, *e*).

Formation of cancellous tissue.

The ossified hyaline tissue, and the ossified cell wall of the fœtal cartilage, are not destined to a long existence. No sooner is the bone laid down, than large spaces are formed in it by absorption, below the line of ossification (fig. 5). These spaces are irregular in form and size, open freely into each other, and are filled with a reddish-coloured marrow, and blood-vessels. Some of them remain to form the temporary cancellous tissue of the young bone. Others, to form the more compact substance, are gradually filled up by a deposit of laminated bone, precisely in the same way as the Haversian canals. In this process of filling up, no fresh cartilage is formed: none is required, for the bone at this stage can support itself, and needs not the mechanical aid of cartilage. The process which takes place in the formation of this "secondary bone," as it is called, is as follows:—A layer of osteal cells, connected by a soft intermediate tissue, is laid down on the inner surface of the cancellous space; cells and intermediate tissue become ossified, and form a thin layer of bone. The same process is repeated again and again, until the cancellous space is filled up to the extent desirable, and has become, in fact, an Haversian system. But how, it may be asked, are the lacunæ formed in this "secondary" bone? Simply by the transformation of some of the osteal cells into lacunæ.

In brief, the ossification of fœtal cartilage may be thus summed up:—The cartilage becomes more vascular; its cells multiply, arrange themselves in rows, and those nearest to the line of ossification increase greatly in size. The hyaline substance of the cartilage ossifies; so does the cell wall; but the granular nucleus of the cell remains to form the lacuna and canaliculi. In the "primary" bone thus formed, large spaces are produced by absorption, and are occupied at first by fœtal marrow and blood-vessels. Of these, some remain as cancellous tissue, others are filled up by layers of new laminated bone ("secondary bone"), and form the more compact tissue: they become, in short, Haversian systems.

What bones are developed from cartilage, and what from membrane.

Almost all the bones in the human body pre-exist in the shape of cartilage, and form what is called the "cartilaginous skeleton," for the support of the embryo. But there are some bones which never were cartilaginous; namely, the bones of the skull-cap (the frontal bone, the parietal, the upper half of the occipital, the squamous and tympanic parts of the temporal); also, the bones of the face; and lastly, the inner plate of the pterygoid process of the sphenoid. In fact, none of the bones of the skull pre-exist as cartilage, except those which form the base of the skull. This is sketched out in cartilage at a very early period of fœtal existence, in order to form a support for the important parts at the base of the young brain. The cap of the skull, at the time we are speaking of, is simply membranous. Our present object being to examine the formation of bone in membrane, we cannot do better than follow out the process in one of the cranial bones. We shall find that there is no essential difference between the formation of bone in cartilage, and its formation in membrane. In the one case the animal matrix is cartilage and cells, in the other, a soft fibrous tissue and cells.

Ossification in membrane. Parietal bone taken as an example.

We will speak first of what can be seen of the formation of bone in membrane with the naked eye, taking the parietal bone as our example. In the early embryo, the covering of the brain is composed of two closely united membranes — an outer, termed the "pericranium;" and an inner, termed the "dura mater:" between these the bone is laid down. About the end of the second month after conception, a centre of ossification appears in the middle of the space which is eventually to be occupied by the parietal bone. From this centre the deposition of bony matter radiates in the form of fibres (Plate D, fig. 7). Similar centres of ossification, appearing simultaneously in other parts of the soft covering of the brain, and radiating in the same manner, sketch out the rudiments of the several bones of the skull-cap. For some time the individual bones are connected simply by membrane; and even at birth they can overlap each other a little, in order to facilitate parturition. Long after birth, indeed, there are parts of the skull-cap closed in by membrane only, as everyone knows who has felt the head of an infant (Plate XX. *a*, fig. 4). These unossified parts are called the "fontanelles," from the rising and falling of the brain beneath them, like the bubbling of a spring. As the child grows, the rays from the edges of the bones meet and dovetail so as to form what are called the "sutures." For a long period of life the sutures may be separated; indeed, a thin film of animal matter is left unossified between the interlocking teeth of the bone, of which the manifest design is to break the shock of a blow on the cranium. As old age creeps on, even this film of animal matter ossifies, and the cap of the skull becomes a solid dome of bone, with all trace of the sutures lost.

Microscopic examination of ossifying membrane.

So much can be seen with the naked eye concerning the process of ossification in membrane. Let us now examine it with the microscope. We find that the membrane is richly provided with blood-vessels which pour out the animal matter or "matrix" for the bone. A careful examination of this animal matter, with a high power, shows it to consist of a multitude of oval cells (osteal cells)* closely packed, and held together by an almost structureless tissue ("blastema") (Plate C, fig. 3). The "bone crumbs" are laid down in this animal matrix, not only in the intervening tissue, but also in the osteal cells, and both become blended as they ossify. The intervening tissue, when ossified, is more transparent than the cells, owing to the latter having so much more bone earth in them. Observe, however, that all the osteal cells do not ossify; some of them, here and there, develope themselves into lacunal cells, which form "lacunæ," and shoot out canaliculi. These canaliculi do not stop at the surface of the cell wall, but extend their arms in all directions, passing through or between the ossified cells, and establishing the freest communication with each other.

Whoever desires to examine this for himself should procure the skull of a three-months fœtus, or a fœtal lamb of the same date. The dura mater and the periosteum should be stripped off the

* See Tomes and De Morgan, loc. cit.

rudimental parietal bone. If done carefully, he will find that not only on both surfaces of the young bone, but also along its free edge, there is a thin film of the soft animal matrix we have been speaking of. The best place to examine the matrix is at the edge of the bone, from which it is seen gradually passing off in thin fibre-like lines. Here it is quite transparent. The dark rays of bone may be seen advancing amongst the osteal cells, and the cells themselves may be seen in all states and stages of development. The more distant are still transparent, and without bone granules; some, nearer the bone, are gradually filling with bone granules; others are full of them, and imbedded in the ossifying intercellular tissue; lastly, some may be detected in process of transformation into lacunæ. Of course the investigation of nice points like these requires a practised eye and a first-rate microscope, with the accessory apparatus for modifying the light.

Such and so simple is the formation of bone in membrane. The process is the same in all cases, whether it take place between two membranes, as in the case of the flat bones of the skull; or beneath the periosteum, in the long bones growing in circumference. The relative amount of the osteal cells, as compared with the intervening tissue, may and does vary in different bones and at different ages. But in all cases, no matter what the age or what the bone, the cells and intermediate tissue become blended as they ossify. If the ossified cells are scattered indiscriminately, the whole will present a tolerably uniform granular appearance. But if it so happen, as it does in adult bone, that the ossified cells keep close together, and arrange themselves in single file, then we shall have alternate layers of granular and transparent bone. The appearance of "lamination" will be strongly marked (Plate C, fig. 3).

Haversian canals: how formed in bone growing from membrane.

We have, in the next place, to explain how the Haversian canals are formed in bone growing from membrane. Remember that the blood-vessels always precede the process of ossification. They are the agents which map out, and preside over, the direction in which the bone is to grow. The bone will grow gradually round them. Suppose, for instance, one or more arteries to run in a given direction: they first pour out the animal matrix, and then deposit in it the bone earth: thus by degrees they come to be surrounded by their own work. At first (Plate D, fig. 8) they lie in grooves on the growing bone, so that its surface presents a kind of fluted appearance. Presently the grooves become deeper by the uprising of the edges round the vessels: at last the edges approach each other, and completely enclose the vessels. Thus is sketched out the circumference of large Haversian canals. Within these canals a layer of matrix is laid down and ossified, then another, and so on until they become Haversian systems.

How bones increase in thickness.

The long bones increase in circumference, and the flat bones in thickness, not by interstitial deposit, but by the successive formation of fresh Haversian canals beneath the periosteum. Observe, no layer of cartilage is laid down previously. It is simply ossification in membrane. The periosteum is composed of two strata—an outer, strong and fibrous, in which the blood-vessels break up before they enter the bone; and an inner, consisting of a softer tissue full of osteal cells, in immediate contact with the bone. The softer stratum of the periosteum is continually renewed, so as to present a basis of animal matrix, which ossifies round the blood-vessels, and forms a succession of Haversian canals. These, by endogenous deposit, become Haversian systems. The process goes on year after year, until the bone has reached the size it is destined to attain. The formation of Haversian canals is then arrested, and the periosteum puts the last finish to the work by girding the entire shaft of the bone with a number of circumferential laminæ (Plate B, fig. 4 *a*).

Interesting experiments with madder.

That bones grow in thickness by additions to their surface, and not by interstitial deposit, is proved from the interesting experiments made with madder. It was accidentally discovered by Mr. Belchier, that madder tinges the bones a red colour. He gives the following account of the circumstances under which the discovery was made.* He happened to be dining with a calico-

* Philosophical Transactions for 1736, vol. xxxix.

printer on a leg of fresh pork, and was surprised to observe that the bones, instead of being white, as usual, were red. On making inquiry, he found that the pig had been fed on the refuse of the dyeing vats, which contained a large quantity of the colouring substance of madder. This fact naturally attracted the attention of physiologists. The red tinge was found to be communicated much more quickly to the bones of growing animals, than to those full grown. The bones of a young pigeon were tinged a rose colour in twenty-four hours. In the adult bird it took fifteen days to do it. The effect of madder upon bones depends upon this:—The colouring principle of the madder (rubia tinctorum) has a strong affinity for phosphate of lime. It appears, however, that the vegetable dye does not combine with the phosphate of lime already formed, but only with that which is actually forming and being deposited in the bones. Therefore, since the dye tinges only the most recent deposit of bone, it is possible to produce alternate rings of white and red bone, by periodically administering and withholding the madder as an article of diet. These rings will be observed not only at the circumference of the bone, but also within the Haversian systems.*

How bones increase in length.

Bones increase in length, not so much by interstitial deposit, as by addition to their ends, that is, by progressive ossification of the layers of cartilage which intervene between the ends of the shaft and the epiphyses. These layers of cartilage furnish the animal basis of ossification, by constantly growing on the one surface while they ossify on the other. When the cartilage ceases to grow, ossification still goes on till the component parts of the bone are all united by bony matter; and thus the stature of the individual is determined. If from inflammation or other cause the epiphyses unite sooner than they ought to do, then one limb may be shorter than the other. That bones grow chiefly by addition to their ends was proved by Hunter. He introduced shots at definite distances into the shaft of a growing bone of a common fowl, and examined them a

* The preparations of bones coloured with madder in the Hunterian Museum are Nos. 190 to 201. The artificial perforations are Nos. 188, 189, Physiolog. Series.

fortnight or three weeks afterwards. The distance between the two shots was found only half as much increased as the distance between a given shot and the end of the bone.

Progressive deposition and absorption of bone.

The shaft of the fœtal bone consists at first entirely of cancellous tissue, full of a reddish-coloured marrow. But soon the cancelli towards the circumference are gradually filled by successive layers of bone. They become Haversian systems, and form the compact tissue of the shaft; while the cancelli in the interior are absorbed to form the medullary canal. Thus the perfect bone is sketched out in miniature. Henceforward, as each succeeding layer is laid on the circumference by the periosteum, so is the medullary cavity duly widened by absorption. This progressive deposition on the one hand, and absorption on the other, goes on modelling the shaft into its requisite proportions during the successive stages of growth. In a rapidly-growing bone there is nothing permanent. It is the very type of activity and change. No sooner is a part laid down than it is removed to make way for the development of another on a more extended scale. The bone of to-day is not the bone of yesterday. These two processes of absorption and deposition are so combined and harmonised, that during the long period of growth any given bone is regenerated, as it were, several times. For instance, the thigh-bone of an infant at birth does not contain an atom of the osseous tissue which existed three months after conception; nor does the femur of an adult contain an atom of the tissue which made up his bone when he was six months old.

Practical remarks on the value of the periosteum.

Such is an outline of the structure and formation of bone. It is a subject interesting not only for its own sake, but because it helps us towards the explanation of what we are every day seeing of the processes of disease, and the repair of injuries, in bone; and what is more, it helps us towards a rational treatment of them. To give a few examples. Look at the value of the periosteum. Suppose a portion of periosteum to be detached by injury or disease from the surface of a bone, a part of the thickness of the subjacent bone will run great risk of dying. It will not *necessarily* die, because its blood-vessels may still be filled from within, owing to the free communication between the blood-vessels of the periosteum and those of the marrow. In a case of compound fracture, where there are loose fragments of bone, we ought not to remove any that are still connected to their periosteum. Or, when a portion of the skull-cap is sliced off with the scalp by a sabre cut, and adheres to it firmly, the scalp and bone should be re-applied, and the cure will often be effected without difficulty. In the Hunterian Museum, there are ten skulls which have suffered from very severe sabre cuts. The portions of bone thus sliced off, were once detached, and afterwards re-united a little out of their proper place, so that the line of separation can be distinctly seen.* Again, there are cases in which, either from exposure to cold or from direct injury, acute inflammation of the periosteum of the shaft of a bone ensues, effusion of fluid takes place beneath it, and severs the connection between it and the bone. The death (necrosis) of the entire shaft may be the consequence. Then, what happens? As the inflammation subsides, the bone-secreting layer of the periosteum sets about forming new bone round that which is dead, so as by degrees to enclose it in a bony case. The dead bone lies loose in this new case, having been detached from the articular ends, which (observe) do not die like the shaft: and for this reason,—that they are less compact, and largely supplied with blood by the articular arteries. The articular ends of the old bone become in time the articular ends of the new bone. Thus the periosteum has formed a new shaft with a capacious cavity in its interior, in which the old bone is enclosed, and will remain so, and be a source of irritation for years, unless removed by a surgical operation.

Although the periosteum holds the first rank of all the structures which minister to the repair of bone, still we are not to suppose that it is absolutely essential to the process. Where nature finds it necessary that bone should exist, she can form it out of almost any tissue. For example: In a case of compound frac-

* Mr. O'Haloran, who practised in Dublin, the metropolis of cut heads, and very naturally wrote on injuries of these parts, gives many curious cases of injuries to the head, where pieces of bone cut off by a sword have readily healed.

ture of the leg, where a portion of the entire circumference of the tibia, including its periosteum, was taken away, the vacancy in the bone was filled up by new osseous substance secreted by the surrounding soft tissues, and there was no shortening of the limb.* Again, we occasionally see the intervening soft tissues forming bridges of bone, to repair a fracture where the broken ends themselves are widely apart.

Material for the repair of fractures.

In the repair of fractures, nature makes use of the same material as that out of which bone was originally formed. She lays down the animal matter first, which is of a fibrous nature or cartilaginous,—or perhaps a mixture of both, as the case may be,—and then deposits in it the earthy salts. In the case of a simple fracture, where the broken ends are kept in contact and perfectly immoveable by artificial splints, the bones unite almost like an incised wound of soft parts. After all the effused blood is absorbed between the broken ends, a soft fibrous substance (blastema) full of osteal cells is thrown out from the ends of the broken bone, so as to form a thin layer of animal matter (intermediate callus) between them. This gradually hardens, and the bone earth is then deposited in the blastema and cells. Thus the ends are united. It occupies a period varying from four to ten weeks, according to the bone broken; *e.g.* the clavicle and the ribs unite more quickly than other bones, probably from their great vascularity. The process is simply an excess of nutrition. Apparently, more new bone than is wanted is formed. The excess fills up the medullary cavity at the seat of fracture, and rounds off corners and angles if there be any. But when the *permanent* uniting medium is strong enough, nature removes all that is seemingly superfluous, and the medullary canal is restored as it was before, after a period varying from six to twelve months. On the other hand, suppose the fracture cannot be kept steady—as, for instance, in the case of animals—then nature provides a kind of temporary splint, in the shape of a broad and thick ferrule of cartilage, which ossifies round the ends of the broken bone, in order

* Stanley, Diseases of the Bones, p. 108.

to keep them as immoveable as possible, while the permanent process of repair is going on between them. This ferrule, termed the provisional callus* is not removed until the fracture has been thoroughly repaired.

* "Callus" is the term applied by the old surgeons to the material by which fractures were repaired.

THE VERTEBRAL COLUMN.

(Plates I. and II.)

The vertebral column or spine, (Plate II.), consists of a series of bones articulated together so as to describe three slight and graceful curves, the bend being forward in the loins, backward in the chest, and again forward in the neck. These bones are called the "vertebræ" because they permit the bending and rotation of the body (*verto*, I turn). They are 24 in number; of which seven* constitute the cervical region, twelve the dorsal, and five the lumbar. Below the lumbar vertebræ, the spine is supported upon a bone termed the "os sacrum," which consists of five vertebræ firmly coalesced into a single bone. Below the sacrum is the little bone termed the "coccyx," from its resemblance to the beak of a cuckoo (*κοκκυξ*). This also contains the rudiments of three and sometimes four vertebræ. The vertebral formula of man, therefore, is—7 cervical, 12 dorsal, 5 lumbar, 5 sacral, and 4 coccygeal or caudal, in all 33.

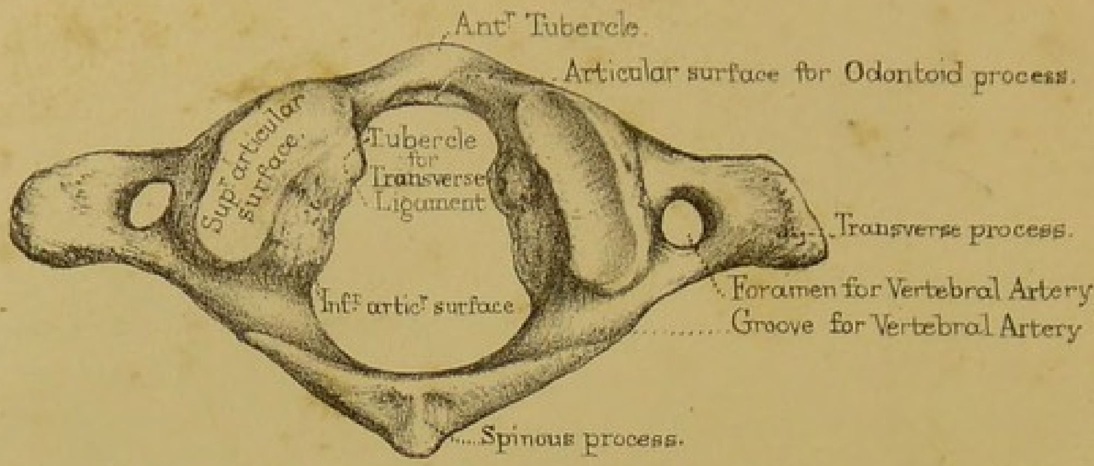
General description of a vertebra.

All the vertebræ are constructed upon one plan, and have certain common characters. These are modified in each region of the spine, to suit its special requirements. Let us, therefore, first obtain a general knowledge of a vertebra, and of the names given to its several parts; and afterwards examine the characteristics of the vertebræ in each region.

Taking a lumbar vertebra as a pattern, we find it consists of a "body," or "centrum," which forms the columnar part, and supports the weight of the spine. The body is convex in front,

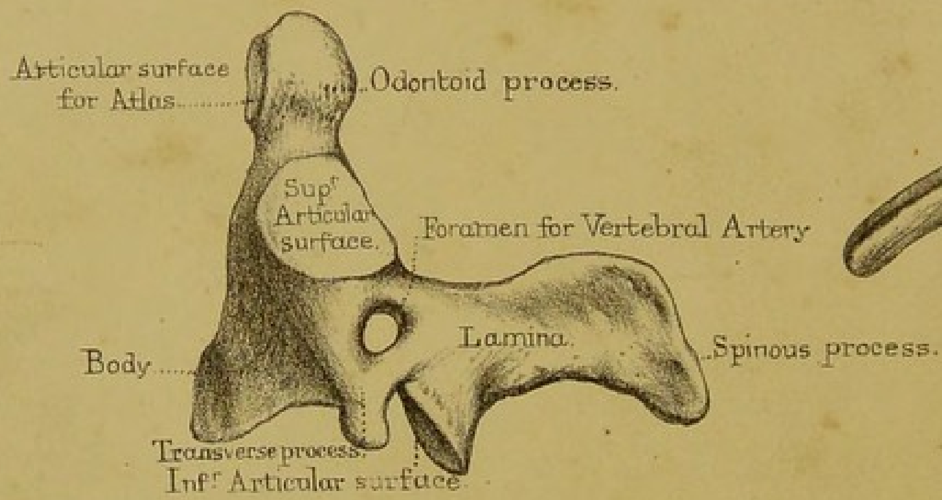
* In all known "mammalia" there are seven cervical vertebræ, with the exception of the three-toed sloth (bradypus tridactylus), which has two more than seven, and the manatee, or sea-cow, which has less than seven. In the skeleton of the whale, which to outward appearance seems to have no neck, there are as many cervical vertebræ as in the giraffe. Is not this a striking instance of "unity of type" within the limits of a class? True, the vertebræ in the neck of the whale are not moveable one upon another, because they are required to give a firm and unyielding support to the head as it moves through the water. Still, seven vertebræ are substantially there.

Fig. 5.

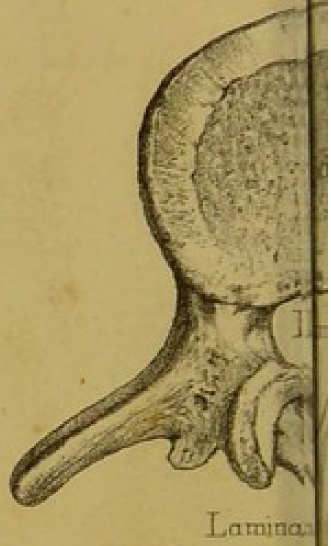


First Cervical Vertebra or Atlas.

Fig. 6.

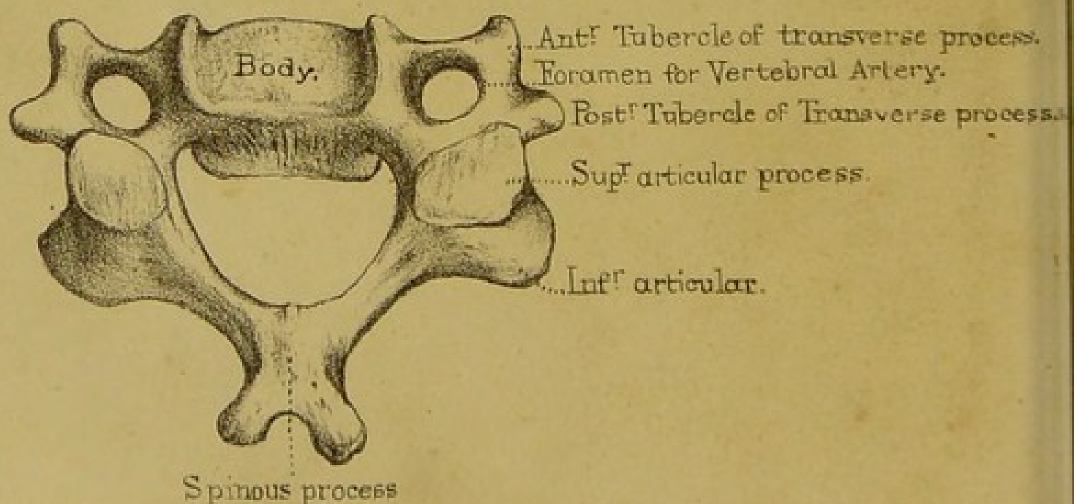


Second Cervical Vertebra or Axis.



Lumbar

Fig. 4.



Cervical Vertebra.

L. Holden ad natur del.

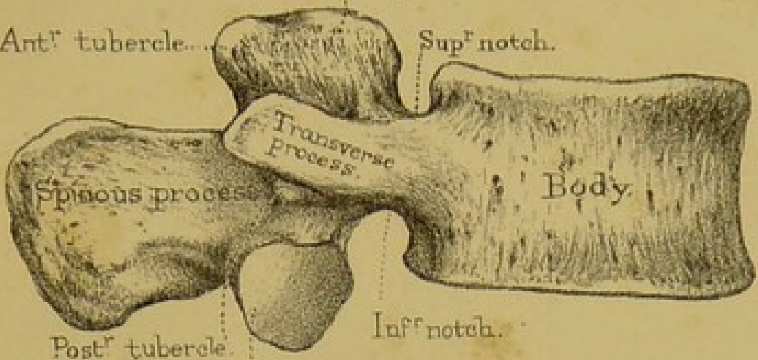
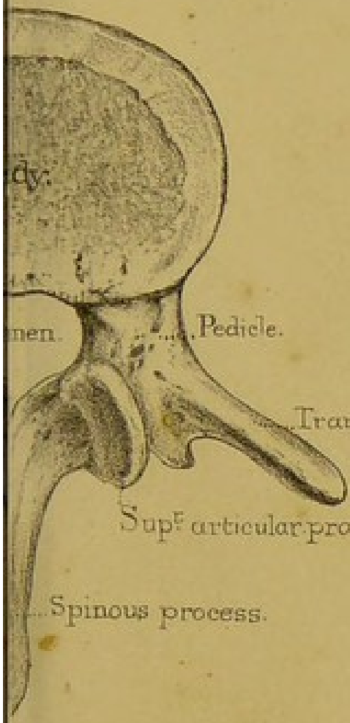


Fig. 1.

Lumbar Vertebra.

ġ. 2.



rtebra.

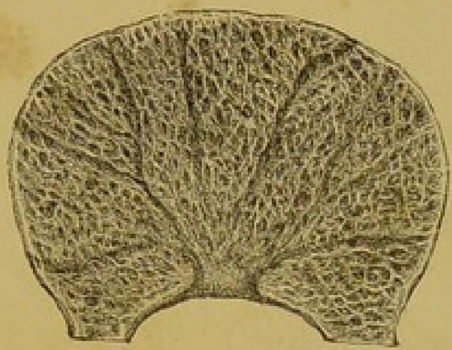


Fig. 7.

Section showing Venous canals.

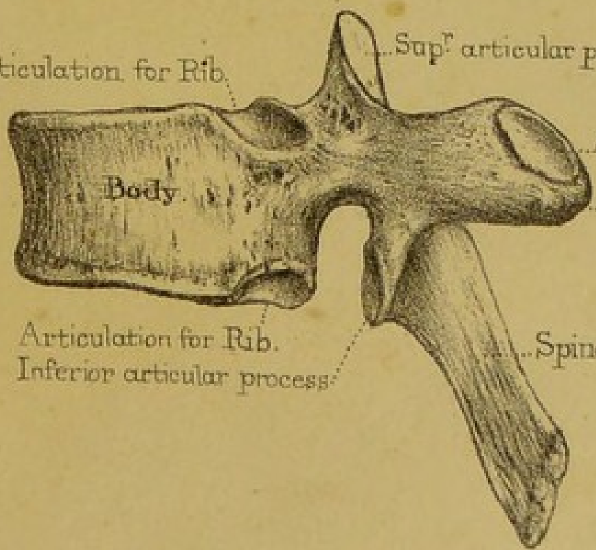


Fig. 3.

Dorsal Vertebra.

Drawn on Stone by T. Godart.

Such, then, are the constituent parts of a vertebra: namely, a body, an arch, a vertebral foramen; seven outstanding processes, of which four are for articulation, and three for the attachment of muscles; lastly, the notches for the transmission of the spinal nerves.

We must next examine the peculiarities of the different vertebræ; selecting in each case a well-marked example, since the peculiarities of one region gradually merge into those of the next.

Characters of LUMBAR VERTEBRÆ.

The general characters of the lumbar vertebræ are as follows:—The "bodies" are large and oval, with their broad diameters from side to side, for the better support of the trunk. The vertical measurement of the bodies is greater in front than behind, in adaptation to the lumbar curve. Their sides are slightly excavated, for economy of weight and bulk. Their "spinous processes" are broad, square, and lofty, to give good leverage to the extensor muscles of the spine; and stand out horizontally, so as not to interfere with the extension of the back. Their "transverse processes" are thin and long, and appear like stunted ribs. Their "articular processes" are vertical, and very strong: the upper, slightly concave, look towards each other; the lower, slightly convex, fit in between those of the succeeding vertebra. These articulations are so shaped as to admit not only of extension and flexion of the loins, but also of a certain amount of rotation, which is useful in progression. The "vertebral foramen" is triangular, with the angles rounded. The "*last lumbar vertebra*" is distinguished from the others by the slope on the lower surface of its body, in adaptation to the slope of the sacrum,—by the thickness of its transverse processes for the attachment of the ilio-lumbar ligament,—by the great width between the lower articular processes, in order to increase the base of support,—and by its spinous process being reduced in the antero-posterior direction, so as not to impede free extension in this part of the back.

Characters of the DORSAL VERTEBRÆ.

The following are the general characters of the dorsal vertebræ:—Their "bodies" are smaller than those of the lumbar, since they have less weight to bear. Their vertical depth is less in front than behind, in adaptation to the dorsal curve. They have two little cup-like articular surfaces on each side for the reception of the heads of the ribs, the lower cups being the larger. By referring to the spine (Plate II.), we observe that the socket for the head of the rib is formed by the articular cups of two vertebræ with the intervening fibro-cartilage. Their "spinous processes" are long and slanting, so that they overlap each other, and prevent extension of the spine in this region. Their "transverse processes" are thick and strong, and have each, near their ends, an articular surface for the ribs, which they support like so many buttresses. Observe that those of the eleventh and twelfth are very small, and have not this surface, because the corresponding ribs are too small and short to need their support. Of the "articular processes," the upper look backwards, the lower forwards, and the planes of both are so nearly vertical that it is manifest there can be but little movement between any two dorsal vertebræ. The vertebral foramen is nearly round.

Characters of the CERVICAL VERTEBRÆ.

With regard to the cervical vertebræ, their "bodies" present lateral ridges which fit into corresponding depressions on the side of the vertebra above, so as to prevent lateral displacement. They are smaller than in the dorsal region, and their greatest diameter is transverse. Their "spinous processes" are short and horizontal, in order to permit the free extension of the neck: observe more particularly the shortness of the third, fourth, and fifth. They are bifurcated* at the summit for muscular insertion. That of the seventh cervical vertebra is not bifurcated,—it projects beyond the others: and hence this vertebra is called the "vertebra prominens." The reason of its greater projection is, to give additional leverage to the elastic ligament (ligamentum nuchæ), and the muscles which maintain the head erect. Their "transverse processes" are very remarkable. There is a large "foramen" through their base, for the passage of the vertebral artery: there is a groove on their upper surface for the lodgment of the spinal nerves; and this

* This bifurcation of the spines of the cervical vertebræ is peculiar to the human skeleton, the object being to afford more room for the insertion of the powerful muscles which maintain the neck, and therefore the head, erect.

groove bifurcates their summit, so that it presents two "tubercles," —an anterior and a posterior, both for the attachment of muscles.* Strictly speaking, we ought to say that the transverse process of a cervical vertebra arises by two roots, which subsequently join, so as to form a foramen for the vertebral artery: the anterior root springs from the side of the body; the posterior springs from the arch. Their "articular processes" are oblique and inclined, so that their planes make an angle of about 45° with the horizon. This degree of obliquity permits the requisite flexion and extension of the neck, as well as slight lateral inclination of it. A dislocation of one of these vertebræ may happen without fracture of the articular processes. Such a dislocation is exceedingly rare; but there are specimens† of it in the Museum of St. Bartholomew's Hospital. It may be produced by sudden and forcible rotation of the neck. Baron Boyer‡ speaks of an advocate who dislocated one of his cervical vertebræ by suddenly turning his head round to see who was coming in at a door behind him.

Characters of the First & Second Cervical Vertebræ.

The first and second cervical vertebræ undergo more remarkable modifications than any of the rest, in order to permit the nodding movement and the rotation of the head.

The first cervical vertebra is called the "atlas," because it supports the head. This vertebra is more like a ring. It has no body, like the others, but only a little "tubercle" in front. The reason generally assigned for this is, that the body has been removed to make way for the "odontoid process" of the second vertebra. This is all very well so far as it goes. But the correct explanation is, that this same "odontoid process" *is* the body of the atlas, and it is thus transferred and fixed to the second vertebra, in order to form a pivot for the atlas to rotate upon. It seems, at first sight, rather far-fetched to say that the atlas rotates round its own body (detached); but it is nevertheless true, and borne out by the facts of philosophical anatomy.§

* Observe especially the large size of the anterior tubercle of the 6th cervical vertebra. It is called the carotid tubercle, being a guide to the carotid artery.

† Ser. iv. No. 8, 12, 13. ‡ Traité des Malad. Chir. t. iv. c. iv.

§ See the Homologies of the Vertebrate Skeleton, by Professor Owen.

Now the entire form of the atlas is modified so as to be adapted to the rotatory movement of the head. In the first place, there is a little articular surface for the odontoid process on the anterior part of the ring of the atlas. The "spinous process" is reduced to a mere tubercle (the posterior tubercle); for a large spine would obviously interfere with the free backward movement of the head. The "transverse processes" are thick and strong, and project far beyond those of the other cervical vertebræ, in order to give greater leverage to the inferior oblique muscles which assist in rotating the head from side to side. Its "inferior articular" processes are flat, and nearly horizontal, so as to slide, in the movement of rotation, on the upper articular processes of the second vertebra. The "superior articular" processes are oval, concave from before backwards, and higher on their external brims, so as to form two little cups for the support of the "condyles" of the occipital bone. They not only sustain the whole weight of the head, but are shaped to permit its "nodding" movement. Within the articular processes, we observe two tubercles, one on either side, which give attachment to the strong "transverse" ligament, which confines the odontoid process in its position. The "arch" formed by the laminæ is wider than in other vertebræ, to make ample space for the spinal cord.* On the upper surface of each lamina is a groove (sometimes a complete bony canal) for the vertebral artery. Lastly, the "notches" for the nerves are placed behind the articular processes, while in all the other vertebræ they are in front of them: and the reason of this is obvious, when we reflect that the articular processes of the atlas must necessarily be advanced in order to meet the condyles of the occipital bone, and to support as well as transmit the weight of the head in the line of the bodies of the succeeding vertebræ.

Second Cervical Vertebra. The second cervical vertebra is called the "axis," because it forms the pivot upon which the head (with the atlas) turns. The pivot, termed the "odontoid process," from its resemblance to a tooth, rises vertically from the "body" of the axis, and fits into a kind of socket formed in part by the

* Hence the possibility of lateral displacement of the atlas without compression of the spinal cord. See a most remarkable case of this kind, with a drawing, in Med.-Chir. Trans. vol. xxxi., by Mr. Paget.

atlas, and completed in the recent state by the transverse ligament. It is a mechanism, as Paley observes, resembling a tenon and mortise. The odontoid process has a smooth surface in front, for the play of the atlas; another behind, for that of the ligament. Moreover, it is slightly constricted at its lower part (forming what is called "the neck"), that the ligament may clasp it more securely. Lastly, its summit or "head" is rough, and sloped laterally for the attachment of the "check" ligaments, which fasten it to the occipital bone.* Considering the importance of the odontoid process, we are not surprised that nature has made its interior structure much closer than that of the body of the axis. The upper "articular processes" are flat, and nearly horizontal, in adaptation to the rotatory movement of the atlas; and, like those of the first vertebra, have a very strong base, because they, and not the "body," support the weight of the head. The lower "articular processes" are oblique, and placed considerably behind the upper, so as to correspond with the line of the articular processes of the succeeding vertebræ. The "transverse processes" are, comparatively, small, and not grooved or bifurcated; but the hole at their base is inclined obliquely outwards, to suit the curve of the vertebral artery. The "laminæ" of the arch are remarkably strong, and the "spinous process" stands well out, and bifurcates widely in order to give greater leverage to the inferior oblique muscles which rotate the head. The great size and projection of this *spinous* process is one of the distinguishing characters of the axis; and with this we should associate the large size of the *transverse* process of the atlas, these being the respective attachments of the inferior oblique muscles.

Characters of the SEVENTH CERVICAL VERTEBRA.

The seventh cervical is called the "vertebra prominens," on account of its long spine. This is for the attachment of the elastic ligament (ligamentum nuchæ) which assists in keeping the head erect. Its "transverse process" is not always perforated, neither is

* Notwithstanding the strength of its ligaments, the odontoid process does sometimes slip out of its ring. The following is an instance:—A lady was carrying her child on her shoulders. Losing its balance, the child clung to its mother's head, and drew it suddenly and forcibly backwards. The lady fell dead. It is more liable to dislocation in children, because the ligaments are weaker than in the adult. Petit relates the case of a child who was instantaneously killed by being lifted by the head.

it grooved; but its breadth and length suggest the idea of its being a rudimentary rib.*

Characters of the FIRST, ELEVENTH, and TWELFTH DORSAL VERTEBRÆ.

The "body" of the first dorsal vertebra has an articular surface for the head of the first rib, and a smaller one for half of that of the second rib. The eleventh and twelfth dorsal have only single articular surfaces for the last two ribs. Their "transverse processes" are much reduced in size, and do not articulate with ribs. The twelfth dorsal may be told from the eleventh, by the fact, that its lower articular processes look outwards, like the corresponding processes in the lumbar vertebræ.

Tubercles on Lumbar Vertebræ.

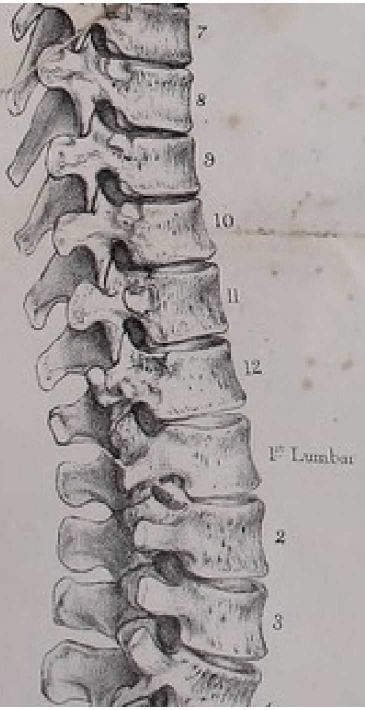
We must here notice the small risings termed the "anterior and posterior tubercles,"† which are seen, in most skeletons, on the last dorsal and on the lumbar vertebræ (Plate XLV. fig. 2). The anterior tubercle projects from the superior articular processes. The posterior tubercle projects between the superior articular and the transverse processes. In the human subject these "tubercles" serve only for the attachment of muscles; but in some animals, as Professor Owen has pointed out, they attain extraordinary size for particular purposes. For instance: in the armadillo, the anterior tubercle is as long as the spinous process itself, to help to support the armour. In the Quadrumana (monkey tribe), the posterior tubercles gain a development in the dorsal and lumbar regions more conspicuous than the articular processes themselves, and contribute to the security of the spine.

Vertebral column as a whole.

The spine is a most wonderful piece of mechanism, and has excited the admiration of anatomists, from the various and apparently incompatible offices which it serves. It forms a column, at once strong and firm, to support the erect position of the body; flexible, to admit the bending of the trunk in various degrees; and elastic, to prevent concussion of the head. It forms a continuous canal at the back of the column for the pro-

* The seventh cervical vertebra has sometimes two little ribs attached to it, one on either side, in form and situation resembling the cervical ribs of animals.

† The posterior tubercles are alluded to by Monro, Anatomy of the Human Bones, 1726; also by Soemmering, De Corp. human. Fabrica, 8vo. 1794.


7
8
9
10
11
12
1st Lumbar
2
3

tection of the spinal cord, a basis for the origin of the muscles which spread over the trunk, and a lever for the muscles which keep the body erect. All these offices are performed by it with so much safety, that even the feats of a mountebank rarely injure the spine.

The main strength of the spine depends upon this,—that it consists of a chain of bones so locked together, that the degree of motion between any two is limited, though that diffused through the whole is extensive. Another reason of the strength of the spine is its arrangement in alternate curves. Mathematicians have calculated that it is many times stronger, and more adapted to resist vertical pressure, than if it were straight, the force being decomposed by the curves.* Look at the enormous weight which a man can carry with ease and safety on his head. Moreover, the curves convert the spine into so many elastic springs, to prevent the jarring of the brain. Besides this, the curves are admirably disposed both for the lodgment of the internal organs, and the transmission of the weight of the head and trunk in the line of gravity. They are so regular and gentle withal, that the spinal cord runs no risk of compression; and lastly, they give the body that graceful form which has been the "line of beauty" in every age.

The curves of the spine are produced partly by the relative thickness of the bodies of the vertebræ in the different regions, but *chiefly* by the intervertebral fibro-cartilages and the tension and elasticity of the ligaments.

From common observation, as well as from experiments, it appears that flexion and extension, as well as lateral movement of the spine, are freest in the neck, less free in the loins, and least in the back. Now the vertebræ are adapted accordingly. Thus, in the neck the articular processes are oblique, the spinous processes of the third, fourth, fifth, and sixth vertebræ are short and horizontal, and the intervertebral substances thick. In the back these substances are thin, the articular processes nearly perpendicular, and the spinous processes overlap each other, so that there

* Rollin and Magendie make it sixteen times stronger; but this must surely be a mistake.

cannot be much movement between the bones. In the loins, again, the thickness of the intervertebral substances, the horizontal and wide-apart spines, and the configuration of the articular processes, combine to allow more motion than in the back, but less than in the neck.

The intervertebral substance between the bodies of the vertebræ provides for the elasticity as well as the flexibility of the spine. The solidity of this substance gradually diminishes from the circumference towards the centre, where it forms a soft and almost incompressible pulp, permitting, to a limited extent, the motions of a ball-and-socket joint; namely, a gentle bend in every direction, with a small amount of rotation. Its great elasticity breaks the force of jars by gradually yielding, and always tends to restore the column to its erect form. Long-continued pressure during the day will, indeed, make the intervertebral substances yield, so that a man loses in height perhaps $\frac{1}{3}$ or even $\frac{1}{2}$ an inch; but this is recovered after a night's rest. At the same time it should be remembered, that a habit of leaning too much on one side will make the yielding of the intervertebral substance *permanent*. Even the bones themselves, while they are growing, will yield under such circumstances. Thus we may have distortion without actual disease.

As to the form of the column, looking at it in front we observe that it is pyramidal, and that the bodies of the vertebræ gradually increase in size from above, in order to form a broad base of support. The atlas, in consequence of the great dimensions of its transverse processes, necessary for the rotation of the head, tops the pillar like a "capital." It is, however, necessary to remark, that there is a partial enlargement of the column about the lower part of the cervical region, to give a broader base to the neck; and again a slight decrease in its breadth, about the third and fourth dorsal vertebræ, to allow more room for the lungs. Moreover, we commonly observe a very gentle lateral curve in the dorsal region, particularly about the third, fourth, and fifth vertebræ, with the concavity towards the left side. The reason of this curve has been much discussed. Some anatomists attribute it to the more frequent use of the right arm; others to the presence of the aorta. The

PLATE IIa.


Odontoid process
1st Cervical or Atlas
2nd or Axis
An intervertebral foramen
1st Dorsal
1st Lumbar
Sacral vertebræ
Coccygeal vertebræ

solution of the question is of no practical value; all we need remember is, that the curve is natural.

Looking at the back of the column, we observe the long row of spinous processes forming the vertical crest which gives the name to "the spine." On either side of it is a deep furrow, termed the "vertebral groove," which is occupied by the strong muscles of the back. The crest being all that we can either see or feel of the spine during life, is the part we immediately examine in cases of injury or disease. In making this examination, we ought to be aware that the spines of the several vertebræ do not always succeed each other in a precisely straight line, but that one, here and there, may deviate to the right or the left, even in persons of the strongest frame.

Respecting the vertebral canal (shown throughout in Plate II. *a*), it is only necessary to remark how well it is protected from injury by the breadth of the arches of the vertebræ. The arches overlap each other so that it would be difficult for a cutting instrument to penetrate anywhere, except perhaps in the lumbar region and, again, between the arch of the atlas and the occiput, where animals are usually "pithed." The area of the canal is larger in the lower cervical and in the lumbar region than elsewhere, for two reasons:—first, because the spinal cord itself presents corresponding enlargements in these parts where the great nerves of the limbs proceed from it; secondly, because these regions being the most moveable, the cord runs less risk of compression. Observe well the relative size and mode of formation of the intervertebral foramina.

Ossification of the vertebræ.

As a rule, each vertebra is ossified from eight centres, of which three are "principal,"—namely, one for the body, and one on each side for the arch and its processes: the remaining five are "epiphyses," and appear, about the age of puberty, as follows:—one in the cartilaginous end of the spinous process, one in the cartilaginous end of each of the transverse processes, and one for each of the discs which form the articular surfaces of the body.

Ossification usually commences at the sides of the arch just before it does in the body of the vertebra,—viz. about the sixth or eighth week after conception. The sides of the arch unite first at the base of the spinous process, so as to complete the ossification of the arch in the first year after birth. During the third year the bases of the arch unite with the independently ossified "centre" or "body."

Where vertebræ undergo great modifications of form, we meet with exceptions to the above rule. Thus the atlas has only two "primary" centres,—one for each of its lateral halves; and two "epiphyses,"—one for the anterior tubercle, the other for the posterior. The axis has two additional centres, placed side by side, for its odontoid process.

BONES OF THE SKULL.

We divide the bones of the skull into those which form the "cranium" or brain case, and those which form the skeleton of the face. We shall first describe each of these separately, and afterwards examine the skull as a whole.

8 Bones of the Cranium.	Occipital, Frontal, 2 Parietal, 2 Temporal, Sphenoid, Ethmoid.	14 Bones of the Face.	2 Superior Maxillary, 2 Malar, 2 Nasal, 2 Palate, 2 Lachrymal, 2 Inferior turbinated, Vomer, Inferior Maxillary.

THE OCCIPITAL BONE.

(Plate III.)

Basilar process. The occipital bone contributes to form part of the base of the skull, as well as the back of the head. There is a large oval hole in it, called the "foramen magnum," for the passage of the spinal cord and its membranes, the two vertebral arteries, and the two spinal accessory nerves. The hole is very much larger than the parts which pass through it;

all the intervening space is occupied by a watery fluid (cerebro-spinal fluid) which acts as a protector. The narrow part of the bone, in front of the hole, projects, not exactly horizontally, but with a considerable inclination upwards: it is called the "basilar process," because it is wedged into the base of the skull. It corresponds with the top of the pharynx. This relation is of practical importance. It is well to know that the basilar process is within reach of the finger when introduced into the mouth, and that, consequently, we can explore it satisfactorily, so as to ascertain how far a polypus may be connected to it. The end of the basilar process is joined to the body of the sphenoid bone, in early life, by cartilage; but in the adult this cartilage becomes ossified. On its under surface (fig. 1) we notice a tubercle, exactly in the middle line, for the attachment of the "superior constrictor" muscle of the pharynx; and laterally, rough surfaces for the attachment of the "rectus capitis anticus major" and "minor." On the upper surface (fig. 2) of the basilar process there is a gently sloping groove (basilar groove), which supports the "medulla oblongata." Understand that the medulla is not in actual contact with the bony groove: a thin layer of fluid is interposed, which acts like a water bed, and protects this important part of the nervous system from concussion. On each side of this groove there is another, but much smaller (petrosal) groove, for the lodgment of the inferior petrosal sinus* of the brain.

Occipital part. The broad arched part behind the foramen magnum contributes to form the arch of the skull-cap. On the convex or cutaneous surface, about the middle, we notice a rough prominence, called the "occipital protuberance," and from this we trace down to the foramen magnum what is termed the "crest" of the occiput, which gives attachment to the elastic ligament (ligamentum nuchæ) at the back of the neck. From this middle protuberance and crest we trace outwards,

* The term "sinus" is used very vaguely in anatomy. It means, generally, the hollow of anything. Thus the air cavities in the bones of the head are termed "sinuses." When used in reference to the brain, a "sinus" means a channel formed by the fibrous membrane (dura mater) of the brain, for the return of its venous blood.

towards the borders of the bone, two lines on either side, termed the "superior and inferior curved lines." These lines, as well as the rough surfaces between them, are more or less evident in different instances, and are nothing more than faint traces indicating the attachments of muscles. The precise attachments of these muscles are mapped out on the right side of the drawing; and in examining them, understand, once and for all, that the blue outline denotes the *insertion* of a muscle; the red, the *origin.* The *origin* of a muscle is the term generally applied to its most *fixed* attachment; the *insertion* of a muscle is the attachment where the greatest motion is produced. However, it should be understood that the fixed point of even the same muscle may vary under different circumstances.

Thus, the bone near the superior curved line gives origin to the "trapezius" and the "occipito-frontalis," and insertion to the "sterno-cleido-mastoideus" and splenius capitis. The surface between the two lines gives insertion to the complexus. Below the inferior line are the insertions of the "rectus capitis posticus major," the "rectus capitis posticus minor," and "obliquus superior."

Condyles and condyloid foramina.

The articular processes of the occipital bone, called the "condyles," are placed one on either side of the foramen magnum. They are oblong and convex, with their anterior ends converging. Moreover, they slant so that their inner margins are lower than their outer; and thus they are admirably adapted to fit into the "cups" of the atlas. Owing to this beautiful arrangement, and the strength of the ligaments, dislocation of the head from the atlas is exceedingly rare. Further than this, by comparing the two bones, you will find that the condyles of the occiput are much longer than the cups which receive them, in order to permit the backward and forward motion of the head. On the inner side of each condyle there is a rough surface or tubercle, for the attachment of the "check ligaments," which prevent the head from turning beyond a certain distance. Outside each condyle is the "anterior condyloid foramen." The direction of this foramen is outwards and forwards, and it gives passage to the great motor nerve (hypoglossal) of the tongue.

Immediately above the "anterior condyloid foramen," or canal, as it should be called, there is a heaping-up of bone, which we term the "eminentia innominata." It looks like a strong bony bridge over the canal, and is obviously for the purpose of strengthening the base of the skull just over the condyle, after the manner of a flying arch. It is, in truth, the *pedicle* of the neural arch of the occipital vertebra, as one may easily demonstrate in the fœtal skull. Behind each condyle there is a deep depression or "fossa," at the bottom of which we find the "posterior condyloid foramen."* The fossa in question, by making room for the cups of the atlas, enables us to move our heads further backwards than we otherwise could have done; and the foramen at the bottom of it is the opening of a canal which runs horizontally forwards into the "groove for the lateral sinus" (fig. 2), and transmits a vein from the outside to the inside of the skull.

Immediately external to the condyles, the bone forms on each side a projection, termed the "jugular eminence."† On its under surface (fig. 1) there is a roughness for the insertion of the "rectus capitis lateralis." On its upper or cerebral surface there is a deep "groove for the lateral sinus," one of the large venous canals which return the blood from the brain. Trace this groove forwards, and you will observe that it turns suddenly downwards, so as to form a kind of gulf (sometimes termed the "jugular fossa"), which lodges the commencement of the internal jugular vein. By looking at the base of the skull (Plate XVII.) you will further

* In some skulls there are no "posterior condyloid foramina." In fifty skulls which I have examined I find them more frequently present than absent. Either the right or the left foramen may be absent.

† In very few skulls, there projects from the lower surface of the jugular eminence a more or less prominent tubercle, the "*paroccipital tubercle.*" It is a rudiment of a transverse process. It is quite a deviation from the human type, but is very constantly developed in the mammalian series. There is a good specimen of the tubercle in question in the Hunterian Museum (No. 5531), in a skull from an aboriginal of one of the Philippine Islands. The tubercle is even longer than the mastoid process, and presents an articular surface for joining its homotype, the diapophysis of the atlas. There is a similar tubercle in a skull in the Museum of St. Bartholomew's Hospital. There are also two specimens of it in the Museum of Anatomy in Richmond Street, Dublin.

observe, that it contributes, with the petrous part of the temporal bone, to form the "foramen lacerum posterius."

Cerebral surface. On the concave or cerebral surface (fig. 2) we observe two thick ridges of bone, crossing each other, — the one vertical, the other horizontal: both are more or less deeply grooved, for the sinuses of the brain. The groove of the vertical ridge contains the "superior longitudinal sinus" above, and the "occipital sinus" below the crossing. Near the foramen magnum, the groove for the occipital sinus generally subdivides into two smaller ones, which gradually lose themselves around its margin. The groove of the horizontal ridge contains the great "lateral sinus." By referring to Plate XVII. we may trace this great groove in its winding course along the occipital, part of the parietal and temporal bones, till it is lost at the "foramen lacerum posterius." It is seldom that the grooves for the lateral sinuses are equal in size on both sides of the skull: the difference depends upon the relative size of the branches of the superior longitudinal sinus. Generally, the larger branch of this sinus is to the right: hence the right lateral sinus is more frequently larger than the left; and hence, too, the larger size of the right internal jugular vein. Besides being grooved for the sinuses, it is necessary to know that the ridges give attachment to processes of the dura mater, for the support of the lobes of the brain. The horizontal ridge gives attachment to the "tentorium cerebelli," the longitudinal ridge to the "falx cerebri" above, and the "falx cerebelli" below the crossing.

At the point where the ridges cross each other, there is a heaping-up of bone, termed the "internal occipital protuberance." This is by far the strongest part of the bone, and is obviously so for the purpose of protecting the back of the cranium; besides which, it may be mentioned that at this protuberance no less than six sinuses* of the brain meet.

The interval between the ridges is excavated, so as to make four "fossæ" for the lobes of the brain,—the two upper for the poste-

* These sinuses are the superior longitudinal, the two lateral, the two occipital, and the straight.

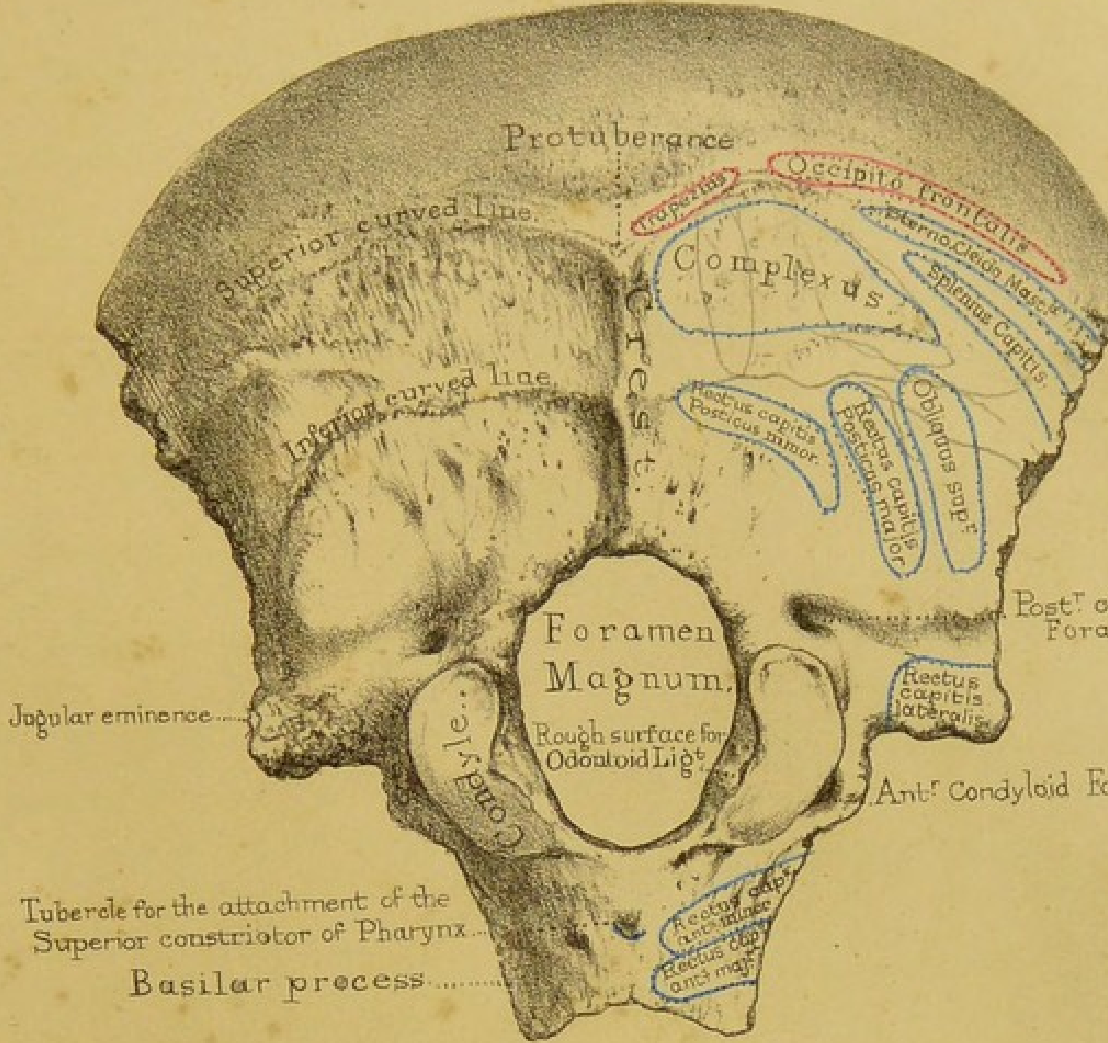


Fig. 1.

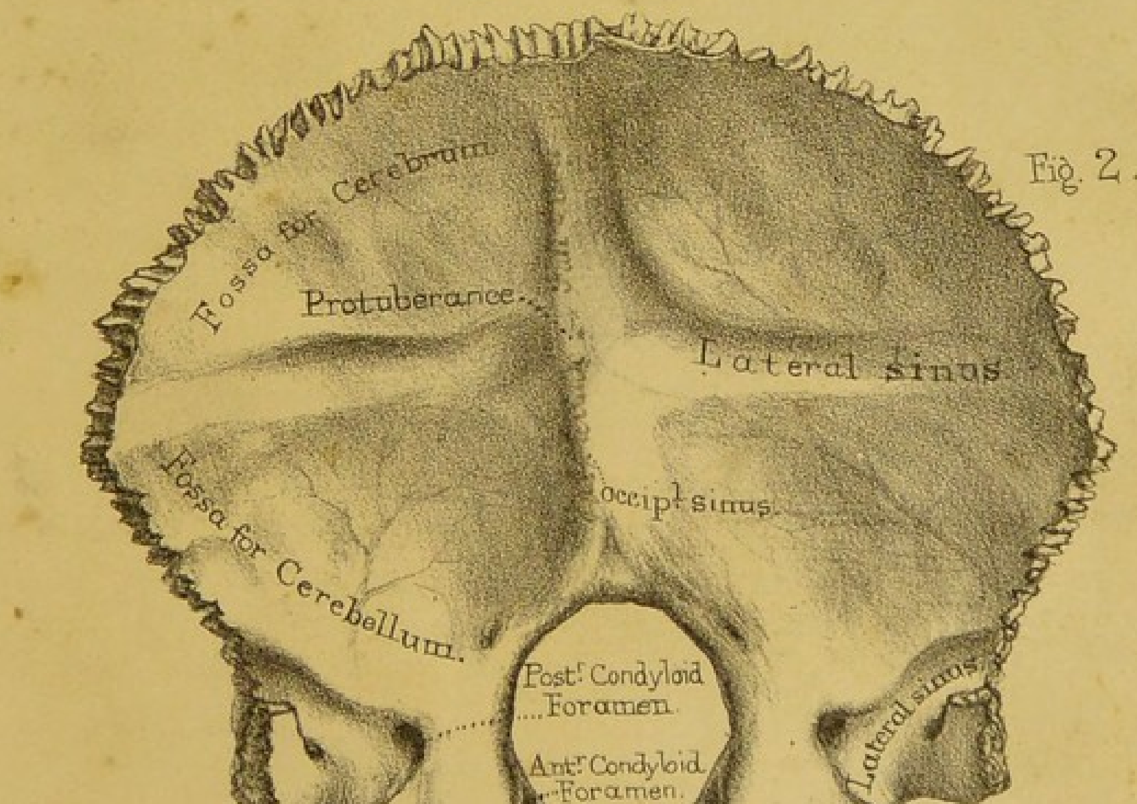


Fig. 2.

L. Holden ad natur del.t

T. Godart Lith

J. Serrill, Imp.

rior lobes of the cerebrum, the two lower for the lateral lobes of the cerebellum. That this is so is plainly seen from the impressions made by the convolutions of the brain. By holding the bone up to the light, you will see how thin are the walls of the fossa for the cerebellum, this being sufficiently protected by the mass of muscles at the back of the neck.

The occipital bone is connected to the two parietal bones by a remarkably serrated suture; also to the two temporal, and the sphenoid bones. The sutures are simply named after the bones which they connect: for instance, we speak of the "occipito-parietal" suture, the "petro-occipital," the "occipito-mastoid," and the "spheno-occipital." All these connections are well serrated, except that between the basilar process and the petrous bone. These are united by an intervening layer of cartilage, which rarely ossifies even in advanced age. The object of this cartilage is to break shocks transmitted from below, *i.e.* from the top of the spine. It is a kind of buffer at the base of the skull.

The occipital bone is developed from four distinct centres,—one for the basilar part, one for the occipital, and one for each condyloid part. They all meet to form the foramen magnum, and all are distinct at birth. These several elements are well seen in Plate LII. fig. 1.

PARIETAL BONE.

(Plate IV.)

This broad and roof-like bone is so named from its forming so much of the wall of the skull-cap. With its fellow of the opposite side it makes a beautiful arch for the protection of the brain. It is convex on one surface, concave on the other, and is somewhat square. On the outer or convex surface (fig. 1) we notice the "parietal eminence." This is the centre from which the bone was developed, and is the thickest part, being the most exposed to injury. Below the eminence is a curved line, termed the "temporal ridge," which gives attachment to part of the "temporal aponeurosis." The surface below this line forms part of the "temporal fossa," which gives origin to the "temporal muscle." The four angles of the bone are called, respectively, the "anterior superior," the "anterior inferior," the "posterior superior," and "posterior inferior."

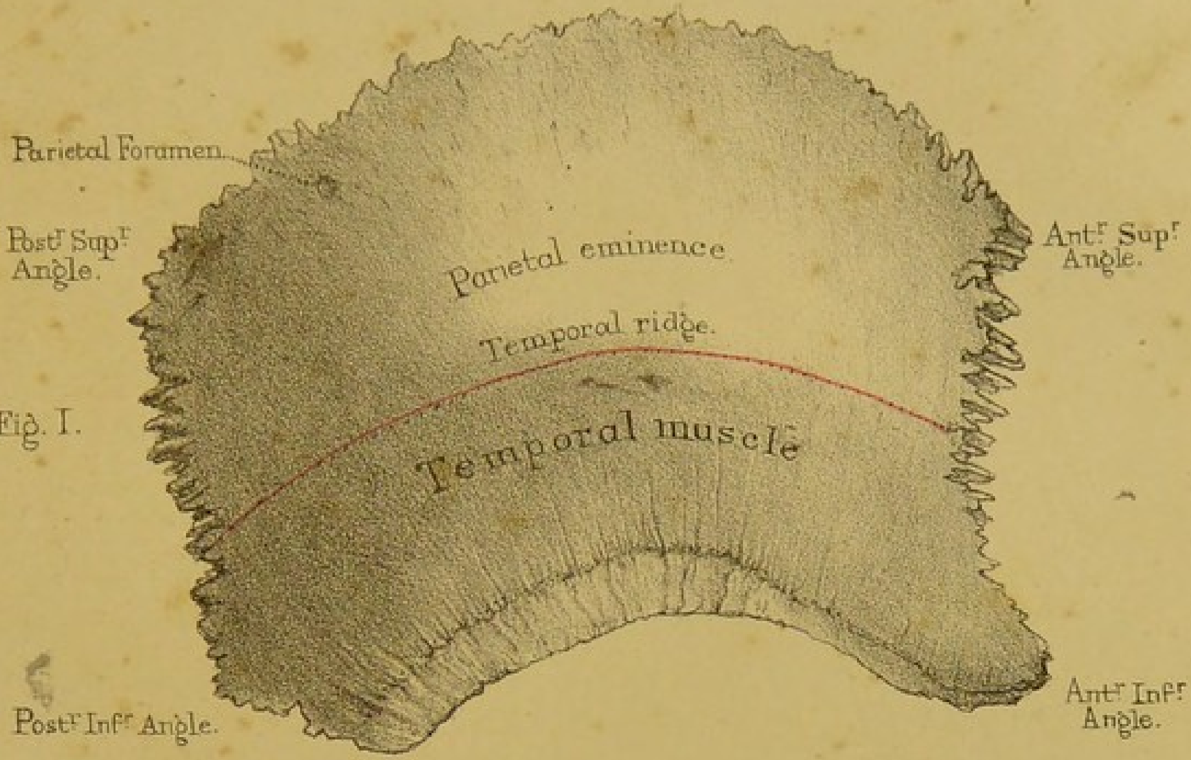
Its cerebral surface (fig. 2) is marked by the convolutions of the brain, but chiefly by grooves formed by the ramifications of the "middle meningeal artery." Observe that the trunk groove runs along the anterior inferior angle: hence the greater liability to effusion of blood in this situation; hence also the risk of trephining here. Along the border where the two bones of opposite sides unite—that is, in the middle line of the skull—there is the half groove for the longitudinal sinus, the other half being completed by the opposite bone. Near this border there is the "parietal foramen"* (fig. 1), which transmits a vein from the outside of the head into the longitudinal sinus. In the skulls of aged persons there are irregular depressions formed by the "Pacchionian glands" near the longitudinal sinus. Lastly, at the posterior inferior angle there is a trace of the "groove for the lateral sinus."

The parietal bone is connected by sutures with five bones (Plate XX. *a*), as follows:—With the opposite parietal bone, by the interparietal or sagittal suture; with the frontal bone, by the fronto-parietal or coronal suture; with the sphenoid bone, by the spheno-parietal suture; with the temporal bone, by the temporo-parietal or squamous suture; with the occipital bone, by the occipito-parietal or lambdoid suture. We must not fail to notice the beautiful arrangement of the sutures of the parietal bone: the sutural edges are beveled on alternate sides, so that the bone cannot be driven in without previous fracture.

It is developed from one centre, which makes its appearance at the parietal eminence.

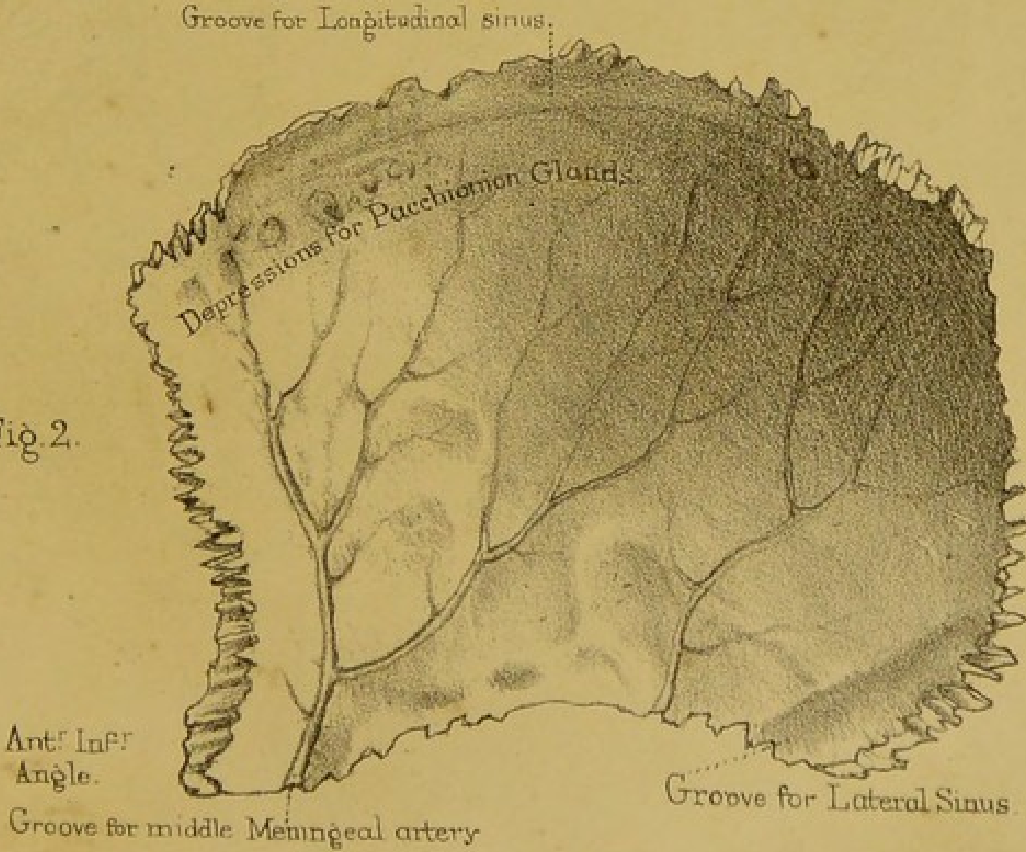
* This hole sometimes transmits a small branch of the temporal artery through the skull-cap to the dura mater. There may be two foramina on one side; or there may not be one.

Fig. I.



Parietal Bone

Fig. 2.



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FRONTAL BONE.

(Plate V.)

The situation of the frontal bone is implied by its name. As it forms not only the forehead, but also the roof of the orbits, we naturally divide it into a "frontal plate" and an "orbital."

Frontal plate.

The "frontal plate" is smooth and convex, and gives breadth and height to the forehead. We observe, first, the two "frontal eminences," one on each side, familiarly called the "bumps" of the forehead. They are the two centres from which the bone was originally formed, and their greater or less prominence indicates to a certain extent the amount of brain behind them. Not so the two projections lower down, termed the "superciliary ridges:" these have nothing to do with the brain, but are occasioned by air-cavities termed the "frontal cells" or "sinuses," situated between the two "tables" of the skull. And here it may be as well to mention, that the cap of the skull consists of two layers of compact bone, called, respectively, the outer and inner tables of the skull, and separated by an intermediate cancellous tissue termed the "diploe." We shall allude to the advantage of this structure hereafter; meantime we will merely observe that the frontal cells are formed by the separation of these tables. To see the extent of the cells, one ought to make vertical sections as shown in Plate XV.

Points of interest concerning the frontal sinuses.

Let us pause for a moment to consider one or two points of interest about the frontal sinuses. 1. They communicate freely with each nostril through a canal termed the "infundibulum" (fig. 2); therefore it is possible for insects to reach them.* Blumenbach mentions the case of a lady who had a kind of wood-louse (Scolopendra electrica) for a whole year in one of her frontal cells. It gave her

* Histoire de l'Académie des Sciences, 1708, 1733.

intense pain, and was expelled at last, alive, during a fit of sneezing. It is by no means uncommon to find the larvæ of insects in the frontal cells of animals. Sir C. Bell states that a man, having slept in barns, was afflicted with pains in the forehead, which were relieved after he had discharged from his nose a worm belonging to that class which spoils the corn. 2. As they are lined by a continuation of the same mucous membrane which lines all the other passages of the nose, we have a ready explanation of the aching pain in the forehead in cases of influenza, or a common head cold. 3. In cases of fracture of the base of the skull involving the walls of the cells, it is possible for fragments of the brain to escape from the nose. The author has seen a case of this kind where the patient recovered without any permanent ill effects except partial loss of smell. 4. If the outer wall of the cells be injured by violence or disease, the air, in sneezing or coughing, is liable to escape under the skin of the forehead, and give rise to "emphysema."* 5. We ought never to apply a trephine over them. 6. Their use is, not only to lighten the skull, but to help the resonance of the voice. They are not developed till the age of puberty, and progressively increase in size afterwards. In some tribes—for instance, in Australians—according to Professor Owen, they are never fully developed; and hence arises a certain want of resonance for which their voice is remarkable.† Lastly, even in Europeans, as common observation proves, their size and extent vary exceedingly. A good idea may be formed of their size in some persons, by the fact that they may lodge a musket ball. Mr. Guthrie states that a soldier was wounded at the battle of Talavera, by a ball which struck him on the forehead and lodged in the frontal sinus. It was readily removed by enlarging the opening, and the man recovered. The author has seen a case precisely similar, in a soldier who was wounded in the Crimea. The sinuses are commonly separated by a bony partition, often incomplete.

* Hyrtl (Topog. Anatomie) mentions the case of a boy who was kicked by a horse on the forehead, so that the frontal cells were exposed. There resulted a fistulous opening, through which, when the nose was held, he could blow out a candle.

† On this subject see an excellent work by Amman, De Loquelâ, written in 1700.

Their range may extend even more than half way up the forehead*, and backwards for an inch or more along the orbital plate of the bone. Sometimes one sinus is larger than the other, and consequently the bump on one side of the forehead may naturally be more prominent than that on the other, which is worth knowing. The obvious conclusion from all this is, that the "bumps" on the forehead mapped out in this situation by phrenologists, under the heads of "Locality," "Form," "Time," "Size," &c., do not necessarily coincide with any convolutions of the brain.

The margin of the orbit, termed the "supra-orbital arch," is composed of thick and strong bone,—as is, indeed, the entire circumference of the orbit. But the "internal and external angular processes"—in other and better words, the piers of the arch—are remarkably strong, because they form buttresses for its support. Near the inner third of the arch we remark the "supra-orbital foramen," or it may be a "notch" for the transmission of the frontal nerve and artery. It is this nerve which is affected in "brow ague." At the external angular process we notice the starting-point of the "temporal ridge," to which the temporal aponeurosis is attached (Plate XIV. fig. 2); and just below this is a little surface of bone which contributes to form the "temporal fossa" for the origin of the temporal muscle.

Cerebral surface. On its cerebral surface (Plate V. fig. 2) we observe that the "frontal plate" is concave, and mapped out by the convolutions of the brain and arterial† grooves. In the middle line is the groove for the commencement of the longitudinal sinus. Tracing the groove downwards, we observe that its margins gradually approximate, and lead to a small hole, the "foramen cæcum."‡ Though called "blind," it generally transmits

* It is the enormous size of these air-cavities which makes the high forehead of the elephant, the owl, &c. The head of the old elephant in the Hunterian Museum was riddled with balls before they could hit the brain. The proper place to aim at in this animal is in the hollow just above the root of the nose; here the case of the brain is not much thicker than a shilling.

† The anterior meningeal artery, which is a branch of the ophthalmic, and ramifications from the middle meningeal artery, on either side.

‡ The foramen cæcum sometimes leads into the frontal sinus, sometimes directly into the nose; or it may open on the posterior or anterior surface of the nasal bones. I have seen it transmit a small artery.

a small vein from the frontal cells into the longitudinal sinus; and this is one of the anatomical reasons assigned why bleeding from the nose relieves congestion of the brain, and why the old practitioners were in the habit of leeching the nose.

Very often the margins of the groove for the longitudinal sinus coalesce, so as to form a small ridge, before they reach the foramen cæcum. In any case, they give attachment to a perpendicular fold of the dura mater (termed from its shape the "falx cerebri"), which separates the hemispheres of the brain. In the feline race of animals, *e. g.* tigers and cats, this partition is bony instead of membranous. Therefore when we happen to see a frontal bone with a well-marked ridge along the beginning of the longitudinal groove, it is but the extra-ossification of part of a membrane which in some animals is entirely ossified.

Orbital plates. The "orbital plates" (Plate V. fig. 2) extend nearly horizontally backwards, and form at once a concave roof for the orbit, and a part of the floor of the cranium. Hold them up to the light, and you will observe how thin they are. In cases of extreme old age, when the diploe of the skull becomes absorbed, it often happens that the orbital plates have large holes in them. At any time of life their thinness renders them liable to be perforated by sharp instruments thrust into the orbit; and wounds of the brain from such accidents are sometimes met with. Sir C. Bell speaks of a young man having been killed by the thrust of a foil which had lost its guard, and which passed through the orbital plate into the brain. Their "cerebral surface" is slightly convex, and generally ridged and furrowed by the impressions of the brain.* Their lower surface is concave, more especially near the external angular process, where there is a deep depression ("lachrymal fossa") for the lodgment of the lachrymal gland. Again, near the

* The orbital plates of the frontal bone are more or less arched in different skulls. Of course the more they are arched the more they encroach on the cranial space, and therefore the less room there is for the anterior lobes of the brain. Compare the skull of a monkey with that of man, and you will observe a marked difference.

Phrenologists place the organ of language in that part of the brain which rests on the orbital plates, and say that the gift of language is denoted by prominent eyes, the prominence of the eye being occasioned, they say, by the depression of the orbital plate in consequence of the great development of the organ of language.

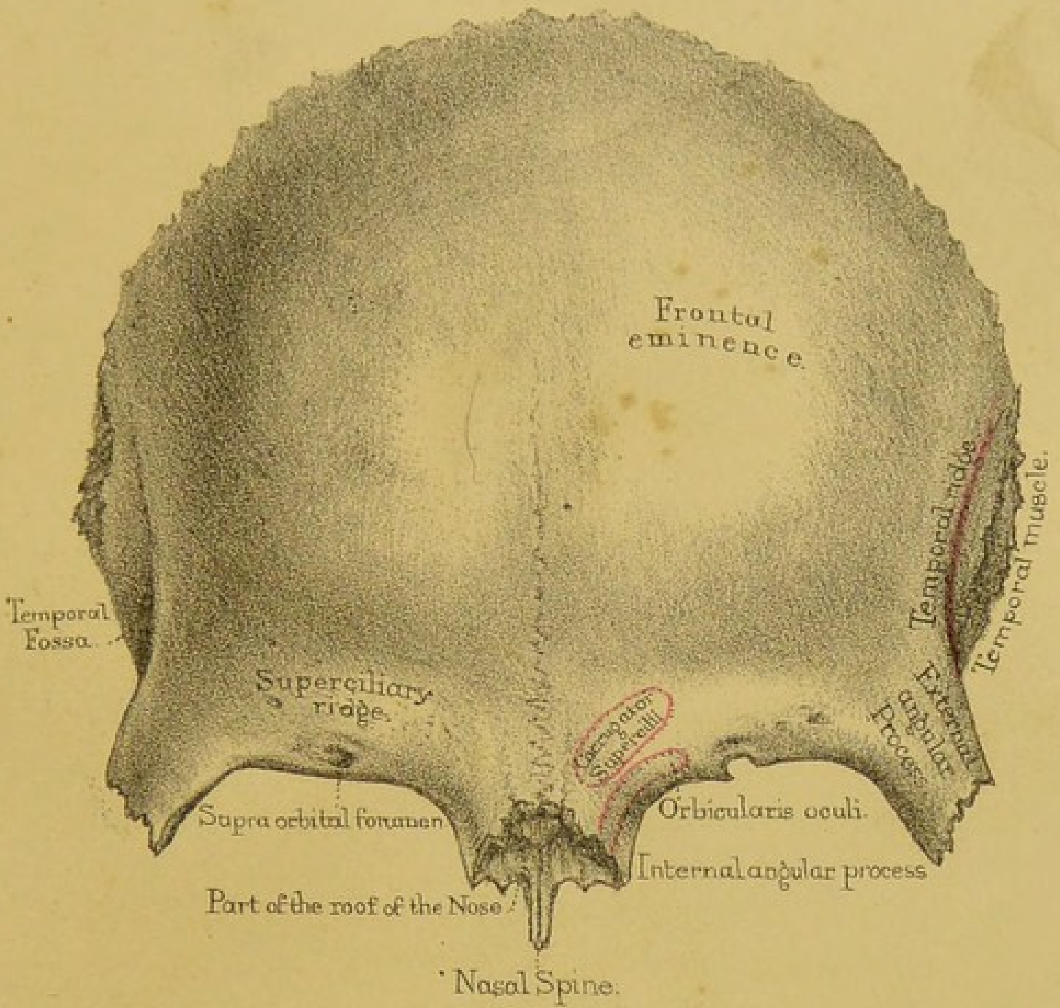


Fig. 1.

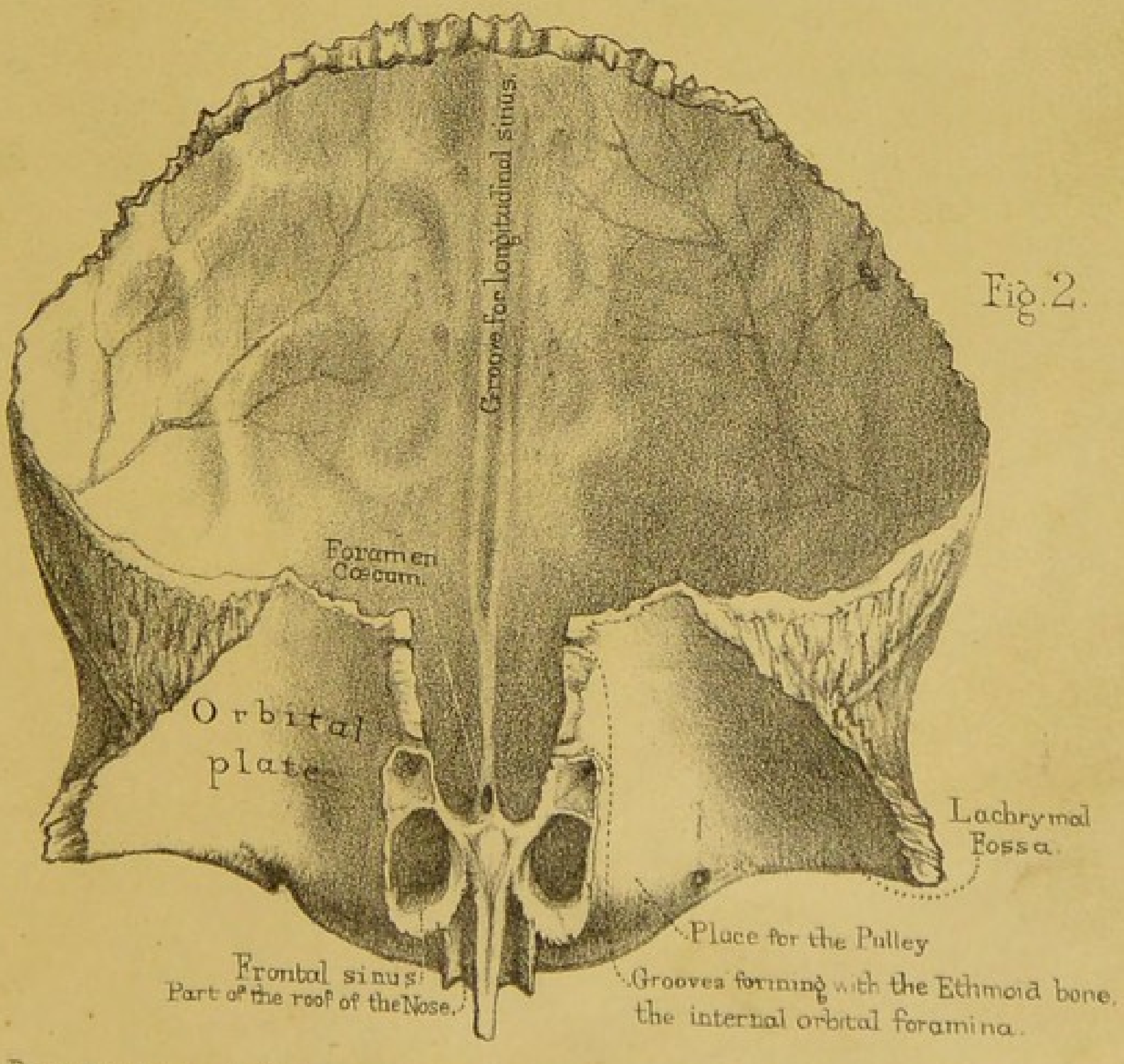


Fig. 2.

Drawn from nature by L. Holden

internal angular process there is the trace of a slight depression, indicating the attachment of the cartilaginous pulley of the "superior oblique" muscle of the eye.

The orbital plates are separated by a wide gap, called the "ethmoidal notch," because it receives the cribriform plate of the ethmoid bone, which here fits into the base of the skull (Plate XVII.). On each side of the broken margins of the notch, we observe incomplete cells with thin walls. These cells correspond with, and are closed by, the ethmoidal cells (Plate IX. fig. 2). However, the largest cell of all is in the front; and this, as seen in Plate V. fig. 2, leads into the frontal sinus. All of them are filled with air, and lined by the mucous membrane of the nose. At the front part of the notch, we observe the "nasal spine" of the frontal bone. This perpendicular projection—which, by the way, is generally broken off in taking the skull to pieces—serves to support the proper nasal bones (Plate XV. fig. 1), and also helps to form the septum of the nose, by uniting with the perpendicular plate of the ethmoid bone. On either side of it is a little groove which forms part of the roof of the nose (Plate V. fig. 1). Immediately in front of the nasal spine is the jagged surface which receives the nasal bones, and the nasal process of the superior maxillary bone (Plate XIII. fig. 2). Lastly, along the broken margin of the ethmoidal notch, we notice two canals which, with the ethmoid bone, form the "anterior and posterior orbital foramina"* for the passage of nerves and arteries from the orbit into the nose.

The frontal is connected to the two parietal bones by the fronto-parietal or coronal suture (Plate XX. *a*, fig. 2). Concerning this suture, we must not omit to observe how admirably it locks the bones together, and provides for the security of the arch of the skull. The margin of the frontal bone is beveled at the expense of its inner table above, but of its outer table below; and the parietal bone is adapted accordingly. Its external angular process is connected to the malar bone; its internal angular process, to the nasal bone and nasal process of the superior maxillary. Its orbital plate

* The anterior transmits the "nasal" branch of the ophthalmic nerve and artery; the posterior, the ethmoidal artery and vein.

is connected to the sphenoid, ethmoid, and lachrymal bones. In all, then, there are twelve; of which two—namely, the sphenoid and ethmoid—are single bones.

The frontal bone is developed from two centres, one on each side, in the situation of the frontal eminence. These lateral halves unite and form a vertical suture down the middle of the forehead, termed the "frontal" suture; so that in children the two halves of the bone are easily separated. In manhood the traces of this suture most frequently disappear.*

The frontal bone gives attachment to three muscles; namely, to part of the "temporal," part of the "orbicularis oculi," and the "corrugator supercilii."

TEMPORAL BONE.

(Plate VI.)

This bone occupies the temples. It is a complicated bone, even on the outside; much more so in its interior, because it contains the organ of hearing. At present we will confine ourselves to the description of all that can be seen on its outer surface; and to facilitate this, we divide it into three parts,—a *squamous* portion, situated in the temple; a *mastoid*, forming the little projection behind the ear; and a *petrous*, which contains the organ of hearing, and projects like a wedge into the base of the skull. This division is natural as well as convenient, since each of these parts is developed from a separate centre of ossification, and remains for some time distinct in childhood. Add to which, they represent permanently distinct bones in some of the lower animals.

SQUAMOUS portion.

The squamous portion, named from its scale-like appearance, forms part of the wall of the temple.

* Dr. Leach and others, who have examined the immense collection of crania in the Catacombs at Paris, have remarked that the number of adult skulls in which the frontal suture remained unobliterated was about one in eleven.

It is very thin: hence the danger of a blow here. Its outer surface is smooth, and entirely covered by the temporal muscle, to which it gives origin. Its inner surface is marked by the convolutions of the brain, and likewise by a narrow groove which sweeps, in a curved direction, from before backwards, and indicates the course of the middle meningeal artery (Plate VI. fig. 2).

At the lower part of the squamous portion there is an outgrowth of bone, termed the "zygoma" (ζύγωμα, a bolt or bar). It projects horizontally forwards, and is connected by a strongly serrated suture with a similar projection from the malar bone; so that the two together form an arch ("zygomatic arch"), beneath which the temporal muscle plays (Plate XIV. fig. 2). The base of the zygoma is very broad, and appears to spring from two roots,—an anterior and a posterior: in the space between them is the "glenoid cavity," which forms the socket for the lower jaw. The *posterior* root (or supra-mastoid ridge) runs backwards in the same line with the zygoma, and forms the upper boundary of the glenoid cavity: after that, we trace it over the meatus auditorius externus, and then it gradually fades away, marking the line of separation between the squamous and the mastoid divisions of the bone. In the negro race, this supra-mastoid ridge is strongly marked, and is characteristic of a degraded type of skull. The *anterior* root is the main root of the two: it is very broad and strong, and runs transversely inwards to form the front boundary of the glenoid cavity. It is called the "eminentia articularis." This is crusted with cartilage in the recent state, in order to form additional surface for the play of the jaw. Under ordinary circumstances, the "condyles," or hinges of the jaw, are in the socket of the glenoid cavity; but when the mouth is open wide, the condyles slide forwards out of the socket, and come to play on the articular eminences. In immoderate fits of laughter or of yawning, when the mouth is opened wide, the condyles may be suddenly dragged by the muscles even in front of the articular eminences; and then we have a dislocation of the jaw into the zygomatic fossa. Under such circumstances a person presents a very ridiculous appearance, since the mouth remains wide open until the dislocation is reduced. At the base of the zygoma we notice a little tubercle ("tubercle of the zygoma"), which serves for the attachment of the external lateral ligament of the lower jaw. Lastly, the upper edge of the zygoma gives attachment to the temporal aponeurosis; the lower edge gives origin to the masseter muscle.

The "glenoid cavity" (γλήνη, a socket), or socket for the lower jaw, is oval, concave from before backwards, with the long diameter transverse, or nearly so. At the bottom of it we notice a fissure, termed the "fissura Glaseri," or "glenoid fissure," which is the remains of the original separation between the squamous and petrous portions of the bone. The part in front of the fissure is the proper socket for the jaw: the part behind it has nothing to do with the jaw, but contains a lobe of the parotid or salivary gland. If you pass a bristle up the fissure, you will find that it leads to the tympanum of the ear.* Between the glenoid cavity and the meatus auditorius, there is a slight process which affords support to the lower jaw, and guards against dislocation backwards. This "post glenoid process" is generally well marked in African skulls, and always so in the Chimpanzee, the animal which makes the nearest approach to man.

MASTOID portion. The "mastoid portion" is so called because it forms the piece of bone behind the ear termed the mastoid "process" (μαστὸς, a nipple). One of the purposes of this process is to give insertion and greater leverage to some of the muscles† which move the head round. These, as seen in Plate VI. fig. 1, are likewise inserted into the rough surface above and behind the mastoid process. If a section be made through the process itself, we shall find that it is not a solid lump of bone, but hollowed in the interior by a number of large and freely communicating cells, termed "mastoid cells," which open into the back part of the tympanum. These cells, like the tympanum itself, contain warm air, which is admitted from the hinder part of the nostrils

* The glenoid fissure contains the "processus gracilis" of the "malleus," the "laxator tympani" muscle, and is usually said to transmit the "corda tympani" nerve: but this nerve, strictly speaking, runs through a little canal of its own, close by the fissure.

† The "sterno-cleido-mastoideus," under that the "splenius capitis," and still deeper the "trachelo-mastoideus." Beneath all these muscles the occipital artery runs to the back of the head, along a slight groove in the bone.

through "the Eustachian tube." They not only make the bone lighter, but are also useful to the sense of hearing, by allowing more space for the vibration of the air. Like the frontal cells, and indeed all the air-cells in the bones of the skull, they are not developed till towards the age of puberty. In cases of deafness arising from obliteration of the Eustachian tube, it was formerly the practice to make an opening into the mastoid cells, in order to admit free access of air into the tympanum. The success attending this proceeding induced Just Berger, physician to the King of Denmark, to have the operation done upon himself; but he died twelve days afterwards from extension of inflammation to the membranes of the brain; and the death of this illustrious man brought the operation into disrepute. Just internal to the mastoid process there is a deep fossa, termed the "digastric fossa," because the "digastric" muscle arises there. Behind the process there is a hole, called the "mastoid foramen," through which a vein runs from the outside of the head directly into the lateral sinus. This gives us a ready explanation why leeches, applied behind the ears, relieve congestion of the brain. Lastly, on the cerebral aspect of the mastoid portion, all we have to notice is the "groove for the lateral sinus."

Petrous portion. The "petrous portion" derives its name from the hardness of its constituent bone (πέτρος, a rock). It projects horizontally into the base of the skull (Plate XVII.), so as to carry far out of harm's way the delicate organ which it contains. Its shape is somewhat that of a triangular pyramid with the apex inwards; so that, for descriptive purposes, it may conveniently be divided into three surfaces,—an anterior, a posterior, and an inferior: then there is a base and an apex. Our best plan is to learn each of these parts separately, so that we may be able to answer the question, what is seen on the anterior, what on the posterior surface, and so forth. Take the base first.

At the *base* of the petrous portion is the orifice of the passage to the ear, termed the "meatus auditorius externus." It is situated immediately behind the glenoid cavity, and its boundaries are chiefly formed by a curved plate of bone, termed the "processus auditorius." Observe, first, that the edge of it is very jagged, for the attachment of the cartilage of the ear; and then look carefully down the passage, in order to see that the plate we are speaking of forms by far the greater part of its boundary wall; in short, all round, except at the uppermost part. This inspection will probably suggest that the whole plate is something superadded to the rest of the bone,—a sort of after-growth; which is precisely the case. In the fœtus there is no meatus, but simply a ring of bone*, forming three-fourths of a circle, the deficiency being at the upper part. This ring is ossified independently, quite distinct from the other parts, and is specially intended for the attachment of the drum of the ear (membrana tympani); so that at this early period it might be rudely compared to a hoop with a membrane stretched across it (Plate XX. *a*, fig. 5). In process of time, however, the hoop begins to grow out on its external side, and thus transforms itself into the canal or meatus, which, as it becomes longer, gradually coalesces with the other constituents of the bone. Respecting the shape of the passage, we should observe that it is oval, with the long diameter nearly vertical; therefore all specula for examining the ear ought to be of the same shape. The narrowest part of the passage, in the recent state, is about the middle; hence if a foreign body, such as a pea, happen to get into the ear, it is generally pushed through the narrow part by clumsy efforts to extract it, and then the moisture of the ear causes it to swell, and makes its extraction most difficult and painful. Mr. Wilde† mentions the case of a boy, eight years of age, into whose ear one of his schoolfellows thrust a grain of Indian corn. The schoolmaster, in his wisdom, endeavoured to remove it by attaching a piece of wax to the end of a stick, and thrusting it into the passage. Four days afterwards, the boy was brought, with his ear in a state of acute inflammation, to Mr. Wilde, who eventually succeeded in extracting the grain by means of a "curette," with the point bent to a right angle. The grain of corn had increased to one third more than its natural size.

The *anterior* surface (Plate VII. fig. 2) of the petrous portion forms part of the fossa for the lodgment of the middle lobe of the

* In many animals this remains permanently a distinct bone, under the name of the "tympanic bone."

† Aural Surgery, page 179.

brain, and is more or less marked by its convolutions. About the middle of it there is a little eminence, indicating the position of the "superior semicircular canal" (a part of the internal ear). More forwards, there is a small furrow leading to an opening termed the "hiatus Fallopii," which transmits the Vidian nerve. Immediately to the outer side of this is a smaller furrow and opening, for the passage of the "lesser petrosal nerve." Near the apex is a depression for the "Gasserian ganglion." Lastly, just at the angle where the squamous and petrous portions meet (Plate VII. fig. 1), you will observe two tubes running backwards parallel to each other, like a double-barrel gun (Plate VII. fig. 1): they both lead to the tympanum. The upper of the two is the canal for the "tensor tympani" muscle; the lower, which is by far the larger, is the Eustachian tube, or passage which conducts the air from the pharynx to the tympanum. The thin partition separating the two barrels is called the "processus cochleariformis."

The *posterior* surface of the petrous portion forms part of the posterior fossa of the base of the skull (Plate XVII.). The most prominent object upon it is the "meatus auditorius internus" (Plate VI. fig. 2), a large canal which runs nearly horizontally outwards, and transmits the "seventh pair" of nerves; that is, the proper auditory nerve (portio mollis), and the motor nerve of the face (portio dura). The meatus is much larger than the nerves which it transmits, and the space between them and the bony canal is filled by a watery fluid (cerebro-spinal fluid), which supports the most vital parts of the base of the brain. In fractures through the base of the skull involving the meatus, this fluid sometimes oozes out through the external ear: this, therefore, is regarded as a very dangerous symptom in cases of injuries to the head. Looking to the very bottom of the meatus, we find that it is divided by a small ridge of bone into two unequal parts. In the upper and smaller of the two, there is the commencement of a special canal (aquæductus Fallopii) for the motor nerve of the face; in the lower there are several minute apertures arranged in a spiral form, through which the fibres of the auditory nerve reach the internal ear. Behind the meatus is a slit-like opening termed the "*aquæductus vestibuli.*" This, though apparently of considerable size, soon contracts so much that it will barely admit a small bristle. It leads to the vestibule of the internal ear. Immediately below the meatus there is a conical pit, which is tolerably wide at first, but soon contracts to a minute canal, leading to the cochlea, termed the "*aquæductus cochleæ.*" The particular use of these minute "aqueducts" leading to the internal ear is not known: but it is certain they sometimes transmit small blood-vessels.

The *inferior* surface of the petrous portion presents a broken and irregular aspect, and has many holes in it (Plate VII. fig. 1). Beginning near the base, we observe, first, the "styloid process."* This is a long process which descends with a slight inclination forwards, gradually tapering to a sharp point. Its length varies in different skulls; generally it is about one inch long. In old skulls it is sometimes longer: there is a skull in the Museum of St. Bartholomew's Hospital which has a styloid process three inches long. Its use is to give origin to three muscles and two ligaments. The muscles are for the movement of the tongue and pharynx; they arise as follows:—the "stylo-pharyngeus," from the base; the "stylo-hyoideus," from the middle; and the "stylo-glossus," from near the tip of the process (Plate VI. fig. 1). To the tip itself is attached the "stylo-hyoid ligament," which runs downwards and forwards to the os-hyoides. In cases where the styloid process is unusually long, it is nothing more than ossification of this ligament. The other ligament attached to the process is the "stylo-maxillary," which separates the submaxillary from the parotid gland. Lastly, the fore part of the root of the styloid process is surrounded by a kind of bony sheath, termed the "vaginal process," about which there is nothing to be remarked except that it is a continuation of the plate of bone which forms the hinder part of the glenoid cavity.

Between the mastoid and styloid processes there is a hole termed the "stylo-mastoid foramen" (Plate VII. fig. 1). It gives exit to the facial nerve (portio dura), which entered the bone at the bottom of the meatus auditorius internus, and lets a small artery run in to

* So called from its resemblance to an ancient "style," or pen. It is, originally, distinct from the rest of the bone, but gradually coalesces with it about the age of three years. In animals it remains a permanently distinct bone.

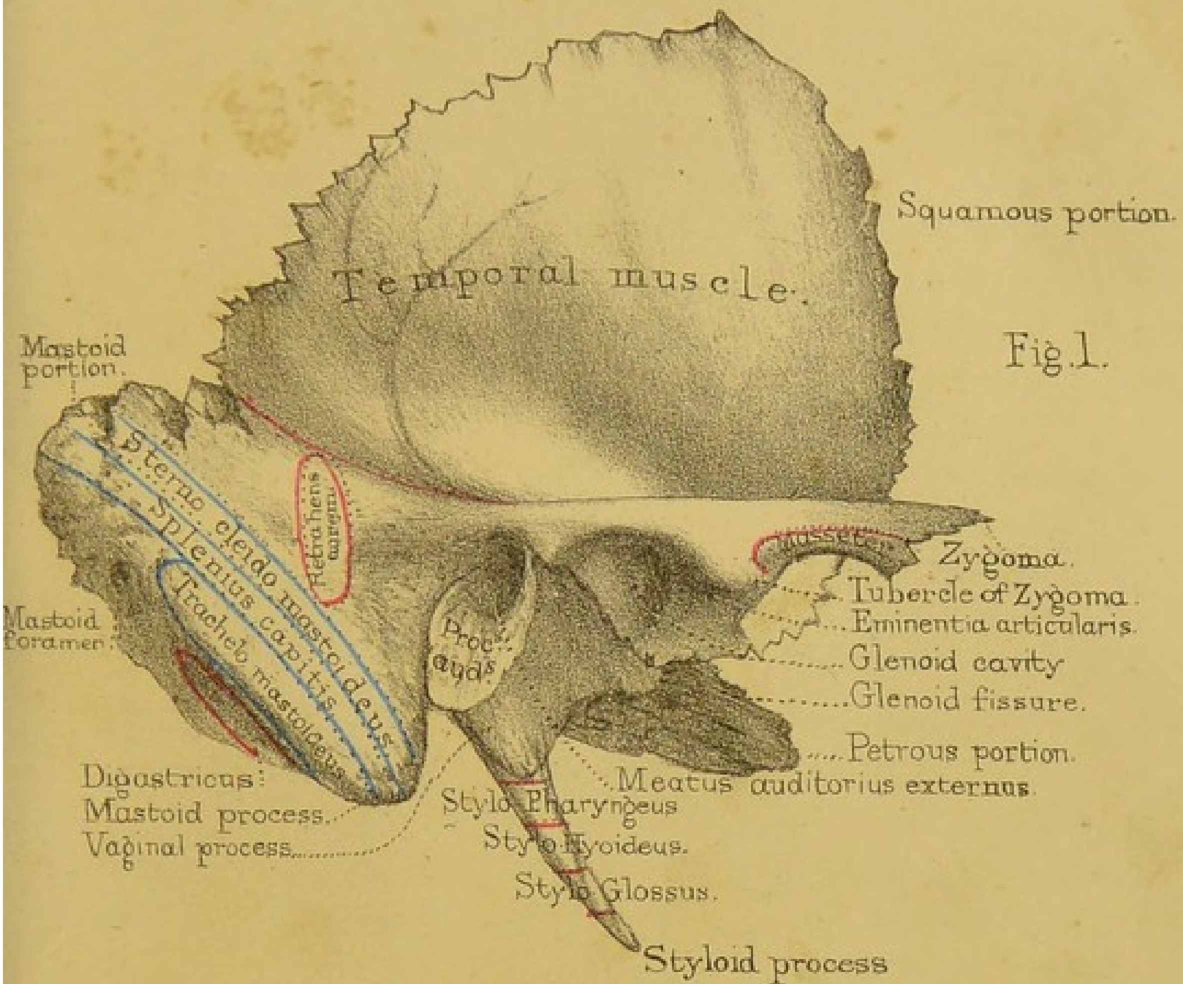


Fig. 1.

Temporal bone.

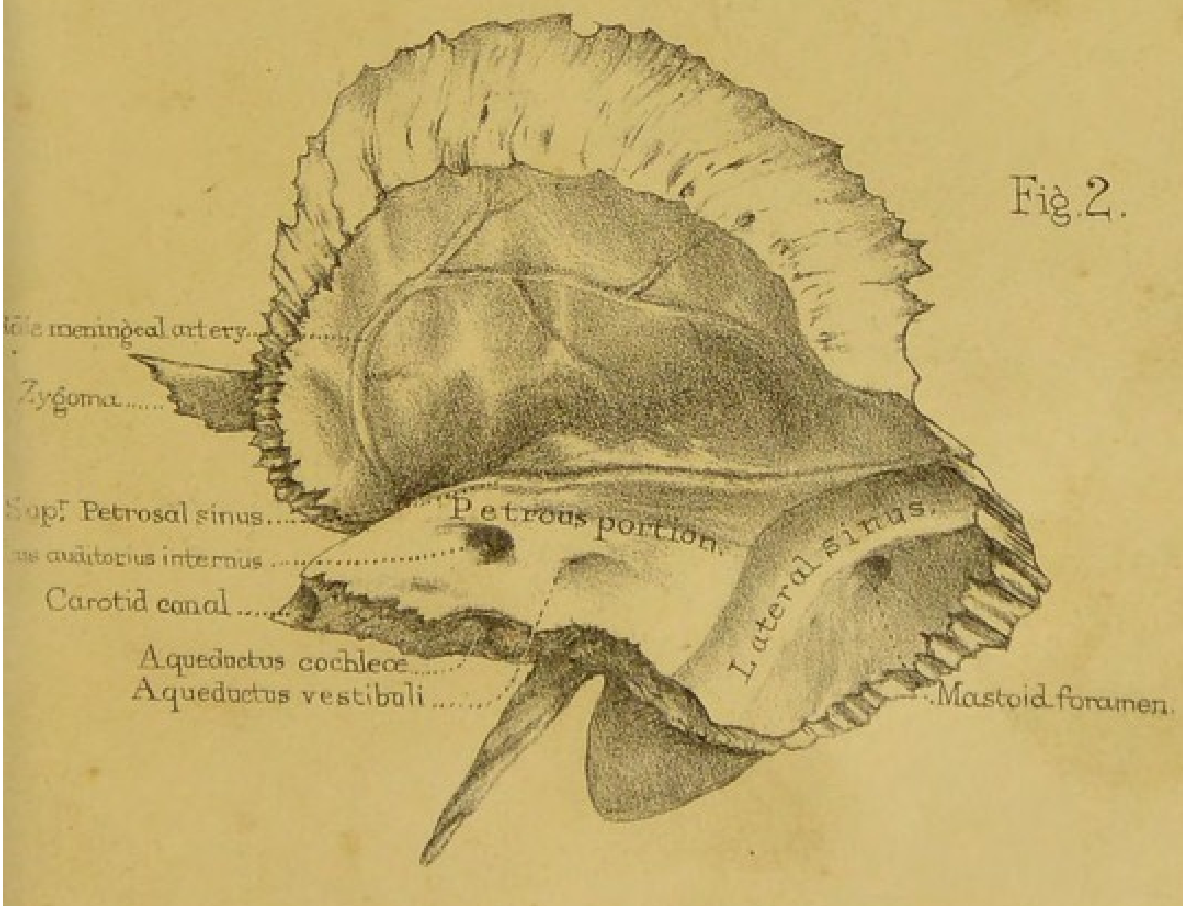


Fig. 2.

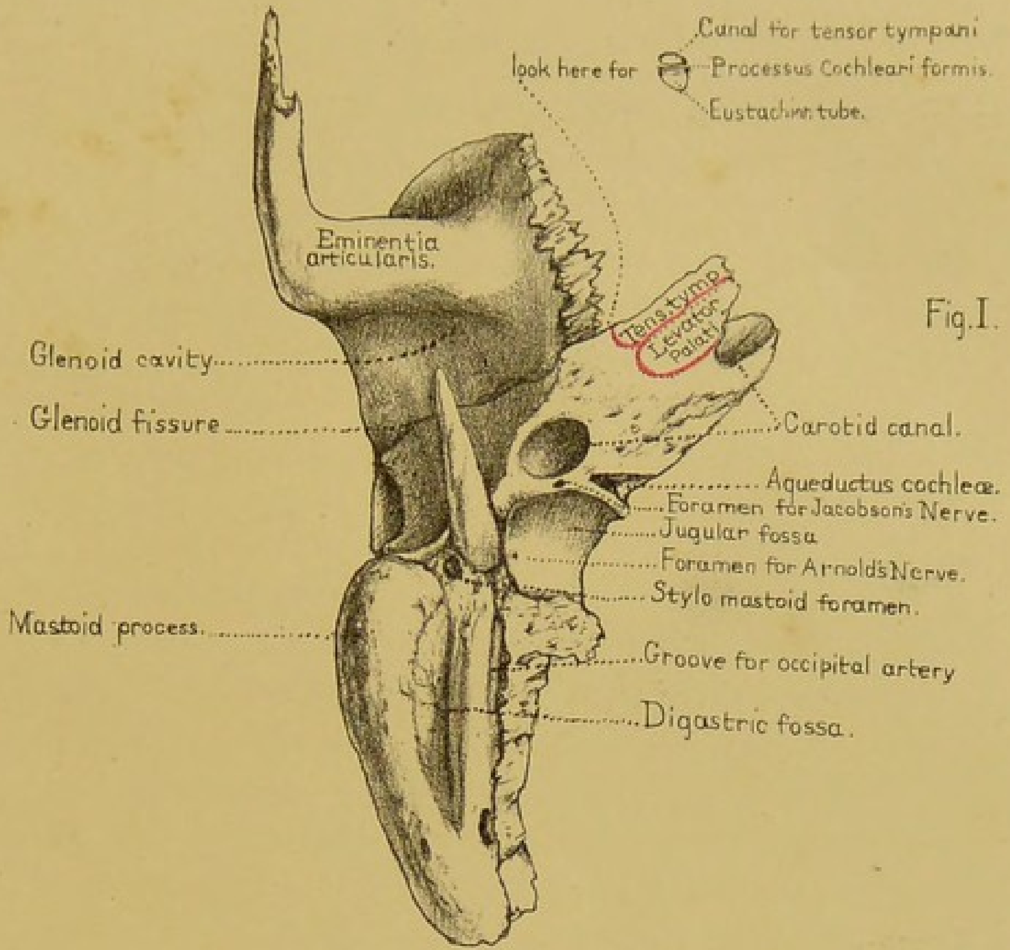


Fig. I.

TEMPORAL BONE

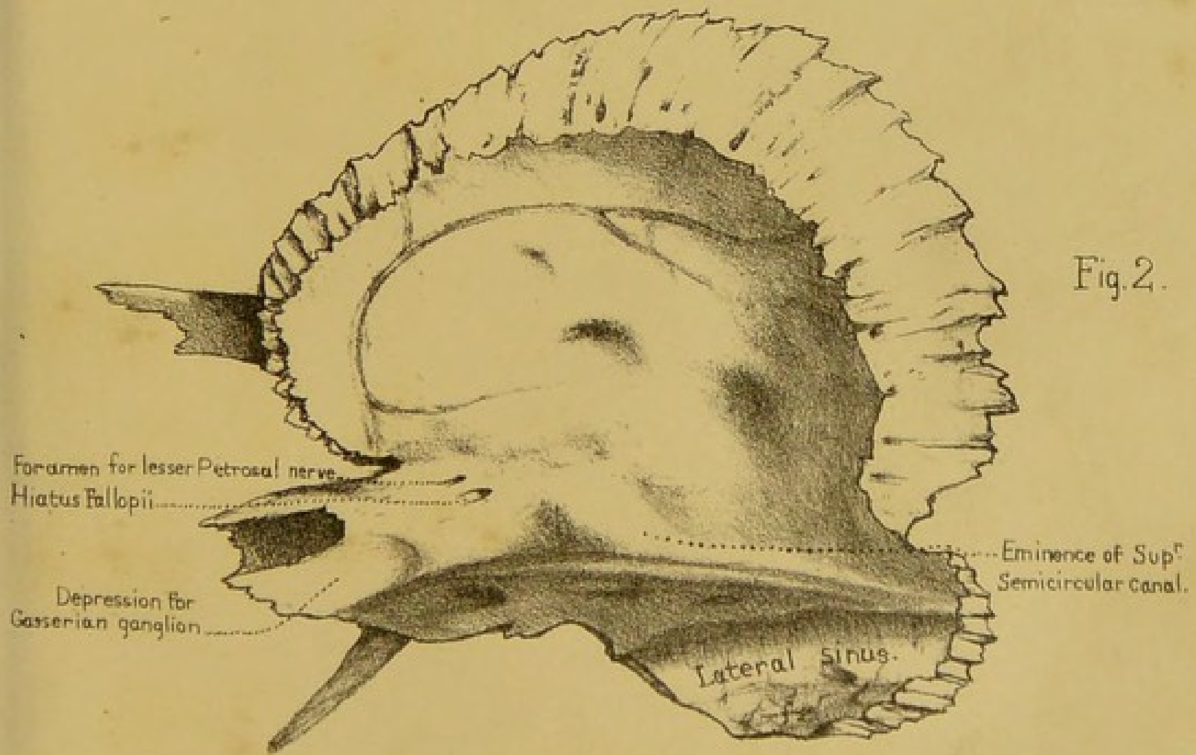


Fig. 2.

L. Holden ad natur del^t

T. Godart Lith.

J. Sarrill Imp.

supply the tympanum. Now if you introduce a stiff bristle into the hole, you will probably succeed in passing it through the bony canal traversed by the nerve from its entrance to its exit. The canal is a complete tube of bone, and is called the "aquæductus Fallopii* after the anatomist who first described it. The passage of this nerve through the temporal bone renders it liable to be injured in fractures of the base of the skull, or in disease of the ear; and this explains why we sometimes have paralysis of one side of the face under these circumstances.

On the inner side of the stylo-mastoid foramen we find a deep depression termed the "jugular fossa." This, with a corresponding part of the occipital bone, forms the "foramen lacerum posterius" (Plate XVIII.). Here the lateral sinus pours its blood into the commencement of the internal jugular vein, which forms a great bulge to fill the fossa. Here also the eighth pair of nerves leaves the skull. On the outer wall of the jugular fossa, near the root of the styloid process, we may find the minute foramen for "Arnold's nerve." In front of the jugular fossa there is the large circular commencement of the canal in the petrous bone, through which the carotid artery enters the skull ("carotid canal"). Observe that the canal mounts nearly perpendicularly for a short distance, and then, turning horizontally forwards and upwards, emerges at the apex of the bone. On the plate of bone which separates the jugular fossa from the carotid canal, there is a minute foramen for "Jacobson's nerve."† Near the apex there is a rough surface which gives origin to the "tensor tympani" and "levator palati" muscles. The apex itself presents nothing more than the termination of the carotid canal, and helps to form one of the boundaries of the ragged hole at the base of the skull, termed the "foramen lacerum medium" (Plate XVIII.).

Along the upper angle of the petrous portion we remark the groove for the "superior petrosal sinus," which discharges itself into the lateral sinus. The neighbourhood of these venous channels to the cavity of the tympanum explains why bleeding from

* Fallopius was a distinguished Italian anatomist, b. 1523, d. 1563.

† Arnold's nerve is a branch of the pneumo-gastric; Jacobson's nerve a branch of the glosso-pharyngeal.

the ear is sometimes met with in fractures running through the petrous portion of the temporal bone.

Connections of the temporal bone. The squamous portion of the temporal bone is connected to the parietal bone and the great wing of the sphenoid bone by the "temporo-parietal and temporo-sphenoid sutures," concerning which the following mechanism must be remembered; namely, that the squamous part overlaps the parietal above, but is itself overlapped by the sphenoid below,—an arrangement which greatly contributes to the security of the arch of the skull. The mastoid part is connected above to the inferior angle of the parietal by the "masto-parietal" suture, and behind to the occipital by the "masto-occipital" suture. The petrous part is wedged into the base of the skull between the sphenoid and occipital bones (Plate XVII. or XVIII.). The zygomatic process is connected to the malar bone by a strong suture.

Development of the temporal bone. The temporal bone is developed from five centres of ossification; namely, one for each of the following parts:—the squamous, the mastoid, the petrous, the tympanic, or processus auditorius, and the styloid process. These remain permanently distinct bones in the lower animals; and it is worthy of remark, that even in the human subject traces of the union of all are visible even in advanced age. The most curious development is that of the tympanic part, which, from being nearly a simple ring of bone in the fœtus, channelled inside for the attachment of the membrana tympani, eventually grows out so as to form the meatus auditorius. In the fœtus, the mastoid part is very small, and gradually enlarges towards puberty by the formation of the mastoid cells. The styloid part is for a long time cartilaginous after birth, and ossifies slowly with age.

SPHENOID BONE.

(Plates VIII. IX.)

The sphenoid bone is so called because it is wedged in at the base of the skull between all the other bones of the cranium (σφὴν, a wedge, εἶδος, form). As it not only enters into the formation of the base of the skull, the orbits, the temples, and the nasal passages, but is also connected with all the bones of the cranium, and many of those of the face, one cannot be surprised that it is a difficult bone to understand. Fortunately, it bears a remarkable resemblance to a bat with extended wings, so that we can shape our description of it accordingly. It presents, then— 1, a body, or central part; 2, the two greater wings; 3, the two lesser wings; 4, the pterygoid processes, which make the two legs of the bat.

BODY. Commencing with the body, we must describe four surfaces on it,—a "superior," an "inferior," an "anterior," and a "posterior."

The *superior* surface of the body (Plate VIII. fig. 1) comprises what is seen of the body on the inside of the base of the skull. There is a deep depression in it, termed the "pituitary fossa," for the lodgment of a gland belonging to the brain (the "pituitary" gland*). Another very common name given to it is the "sella turcica," from its resemblance to a Turkish saddle. In front of it there is an eminence like the pommel of the saddle, termed the "olivary process," from its olive-like shape. There is nothing remarkable in this process except that it supports the commissure of the optic nerves, which make a slight transverse groove (the "optic groove") upon it, leading on each side to the "optic

* This name was given to it by Galen, who thought that it secreted the "pituita," or mucus, and that this passed down into the throat through the small foramina which are often found at the bottom of the fossa (De usu partium, lib. ix. cap. 1).

foramen," through which they enter the orbit. In front of the olivary process there is a smooth and slightly excavated surface, which supports the olfactory nerves, and terminates in the middle line in the "ethmoidal spine," which articulates with the ethmoid bone.

Each side of the "body" is more or less distinctly marked by a broad groove which winds upwards in a gentle curve, and lodges the internal carotid artery after it has entered the skull.* The pituitary fossa is bounded behind by a square plate of bone, which, as it represents the back of the saddle, is termed the "dorsum ephippii." The corners of this plate project so as to form what are called the "posterior clinoid processes,"—thus named from their resemblance to bed-posts. These are directly opposite to the "anterior clinoid processes," of which we shall speak presently. The posterior surface of the plate slopes very obliquely backwards, is continuous with the basilar groove of the occipital bone, and forms an inclined plane for the support of the "pons Varolii." Lastly, the sides of the plate are generally notched for the passage of the sixth pair of nerves.

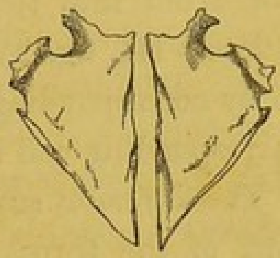
The *posterior* surface of the body is immovably connected with the basilar process of the occipital bone, in young subjects by cartilage, but in adults by bone, so that it is impossible to separate them without the saw. The section shows well the structure of this part of the base of the skull; namely, two plates of compact bone separated by about $\frac{3}{10}$ of an inch of cancellous tissue or "diploe." Thus the bone is rendered lighter, and shocks transmitted to the base of the skull are broken (Plate II. *a*).

The *anterior* surface of the body is adapted to fit the posterior part of the ethmoid bone. It presents in the middle line a perpendicular plate of bone termed the "rostrum." This forms part of the bony septum of the nose, and is, accordingly, connected in front with the perpendicular plate of the ethmoid bone,

* Generally, a little tubercle, called the "middle clinoid process," rises from the side of the groove to keep the artery in its place. In some skulls this tubercle is long enough to unite with the apex of the anterior clinoid process, so that the artery, in emerging from the groove, passes through a ring of bone. The two "clinoid processes" on each side give attachment to the "tentorium cerebelli."

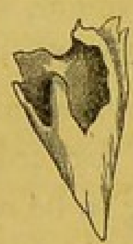
and below with the vomer; as may be seen by reference to Plate XV. fig. 1. The surface of bone on each side of the rostrum is completed by two plates of bone, one on each side, termed the "*cornua sphenoidalia*." Although apparently integral parts of the sphenoid, yet these little bones are formed each from a special centre of ossification, are distinct in early life, and remain separable till adult age. The annexed woodcut (fig. 8) shows the "cornua sphenoidalia" removed in a perfect state. The rostrum of the sphenoid would fit into the gap between them. We observe that each cornu is triangular with the apex downwards. Each completely walls in the sphenoidal cell of its own side, except at the upper part, where there is a round opening in the base of the cornu for the admission of air from the upper meatus of the nose. Fig. 9 represents one of the cornua seen from the surface towards the sphenoidal cell. It shows the thin scales of bone which project into the cell and assist in lining its walls. However, it is right to state that these cornua sphenoidalia are rarely met with perfect. In consequence of their coalescence with the sphenoid, ethmoid, and palate bones, they are generally broken in separating the bones of the skull, so that there appears in most sphenoid bones a large irregular hole leading into the sinus; as shown on one side of Plate VIII. fig. 2.

FIG. 8.



Cornua sphenoidalia.

FIG. 9.



We come next to examine the "sphenoidal sinuses" themselves. These are large air-cavities in the body of the sphenoid, generally two in number, and separated by a more or less complete perpendicular partition (Plate XV. figs. 1 and 2). Like the other air-cells in the bones of the skull, they are not developed in young subjects; but in the adult they gradually become large enough to excavate the whole body of the bone.* As just now observed, the

* In old skulls the sinus often extends into part of the basilar process of the occipital bone. In the chimpanzee the sphenoidal sinus extends far into the ali-sphenoid and pterygoid bones.

air is admitted freely into them from the upper and back part of each nostril, through an opening in the front wall of the sinus; and they are lined with a prolongation from the mucous membrane of the nose. This communication of the sphenoidal cells with the nasal cavities explains why we may have bleeding from the nose as a symptom of fracture through the base of the skull,—that is, through the body of the sphenoid.

Lastly, the sides of the anterior surface of the body are hollowed out into two or three small air-cells, one below the other (Plate VIII. fig. 2). Of these, the upper, one or more, are roofed in by corresponding cells of the ethmoid bone, and the lower by a corresponding cell in the orbital process of the palate bone.

The *inferior* surface (Plate IX. fig. 1) looks towards the upper part of the throat, and may, therefore, be called the "guttural" surface. A portion of the vertical plate or "rostrum" is seen here also; and you will observe that it expands a little towards its base. Now it is this lower part of the rostrum which is connected with the vomer, and the mode of connection is rather singular. The rostrum fits into a deep cleft between the two plates or "wings" of the vomer, and thus serves as a fulcrum from which this bone may pass forwards to form the septum of the nose. But the chief thing to be noticed on this surface is a thin plate or offshoot of bone which projects horizontally inwards, on each side, from the base of the pterygoid process. These two plates are termed the "vaginal processes," and their free edges rise just enough to allow the edges of the vomer to slide beneath them (Plate IX. fig. 1). This is another contrivance for fixing the vomer. Lastly, these plates are each traversed by a small groove, or perhaps a complete canal, termed the "pterygo-palatine canal," for the transmission of a small artery.*

So much for the anterior, posterior, superior, and inferior surfaces of the body of the sphenoid. All that we have to remark concerning the "*sides*" of the body is, that they are grooved for

* The pterygo-palatine canal transmits the pterygo-palatine artery. This is a branch of the superior maxillary, and runs from before backwards to supply the top of the pharynx and the Eustachian tube.

the carotid artery, and that the smooth plate of the body in front of the sphenoidal fissure contributes to form a part of the inner wall of the orbit (Plate XX.).

LESSER WINGS. The lesser wings project transversely from the upper part of each side of the body (Plate VIII. fig. 1). Their upper surface is smooth and flat, to support the anterior lobes of the brain; their lower surface overhangs the sphenoidal fissure, and forms the back part of the roof of the orbit: hence they are sometimes called the "orbital wings." Their base is traversed by the "foramen opticum," for the passage of the optic nerve and ophthalmic artery into the orbit. This foramen should be described rather as a short canal directed outwards and forwards. Towards the sella turcica each wing projects considerably in the form of a blunt angle, termed the "anterior clinoid process:" and between this and the body of the sphenoid there is either a deep notch or a complete ring for the internal carotid artery.

GREATER WINGS. The "greater wings," sometimes called the "temporal," project from the lower part of each side of the body. They present three surfaces, which respectively enter into the formation of the base of the cranium, the orbit, and the temple. Their "cerebral surface" is concave, and marked by the convolutions of the middle lobe of the brain. Their "orbital surface" is a smooth quadrilateral plate which forms more than half of the outer wall of the orbit (Plate XIII. fig. 2). Of the four borders of this plate you will notice that the superior is connected with the frontal bone, and the anterior with the malar bone; while the posterior and the inferior borders respectively enter into the formation of the "sphenoidal" and "spheno-maxillary" fissures. Their "temporal surface" is divided into two unequal parts by a transverse "crest" of bone: of these, the upper and larger one forms part of the temporal fossa, and gives origin to part of the temporal muscle: the lower one forms part of the zygomatic fossa, and gives origin to one head of the "pterygoideus externus" muscle. The posterior angle of the great wing terminates in a sharp process termed the "spinous process," which fits in the angle between the squamous and petrous portions of the temporal bone, and gives attachment to the internal lateral ligament of the lower jaw, as well as origin to the "laxator tympani" muscle.

The greater wings are separated from the lesser by a broad and long fissure, termed the "sphenoidal fissure," which leads from the base of the skull into the orbit, and transmits nerves to the eye and its appendages.* Immediately below the inner end of this fissure is the "foramen rotundum," which transmits the superior maxillary nerve. Farther back and more external is the "foramen ovale," which transmits the inferior maxillary nerve. Near the spinous process is the "foramen spinosum," through which the "arteria meningea media" enters the skull.†

Pterygoid processes.

The "pterygoid processes" descend nearly perpendicularly from the under part of the bone,—one on either side. These remarkable processes answer three purposes:—1. They bound the posterior opening of the nose; 2. They act as buttresses to support the upper jaw-bones; 3. They give origin to the powerful pterygoid muscles which produce the grinding movement of the lower jaw required for the mastication of the food. Each process consists of two plates, termed respectively the "external and internal pterygoid plates." These are united in front, but diverge from each other behind, so as to leave a deep interval, called the "pterygoid fossa," chiefly for the origin of the "pterygoideus internus" muscle. Immediately above this is a smaller fossa, termed, from its resemblance to a boat, the "scaphoid fossa," for the origin of the "tensor palati" muscle (Plate IX. fig. 1). At its lower part the pterygoid fossa presents a deep notch, which, in the perfect skull, is filled up by the tuberosity of the palate bone. Respecting the *internal* pterygoid plate, we have to observe, that it forms the lateral boundary of the posterior open-

* The sphenoidal fissure, sometimes called the "orbital," or, again, the "foramen lacerum in basis cranii anterius," gives passage to the third and fourth nerves, to the first branch of the fifth, the sixth, a few filaments of the sympathetic nerve, and also to the ophthalmic vein.

† Besides the foramina in the greater wing described in the text, there is often one (near the outer edge of the sphenoidal fissure) which leads into the orbit, and transmits a branch of the middle meningeal artery. There is often another (between the foramen spinosum and ovale), through which the lesser petrosal nerve runs, when it does not pass through the foramen lacerum medium.

Sphenoid Bone.

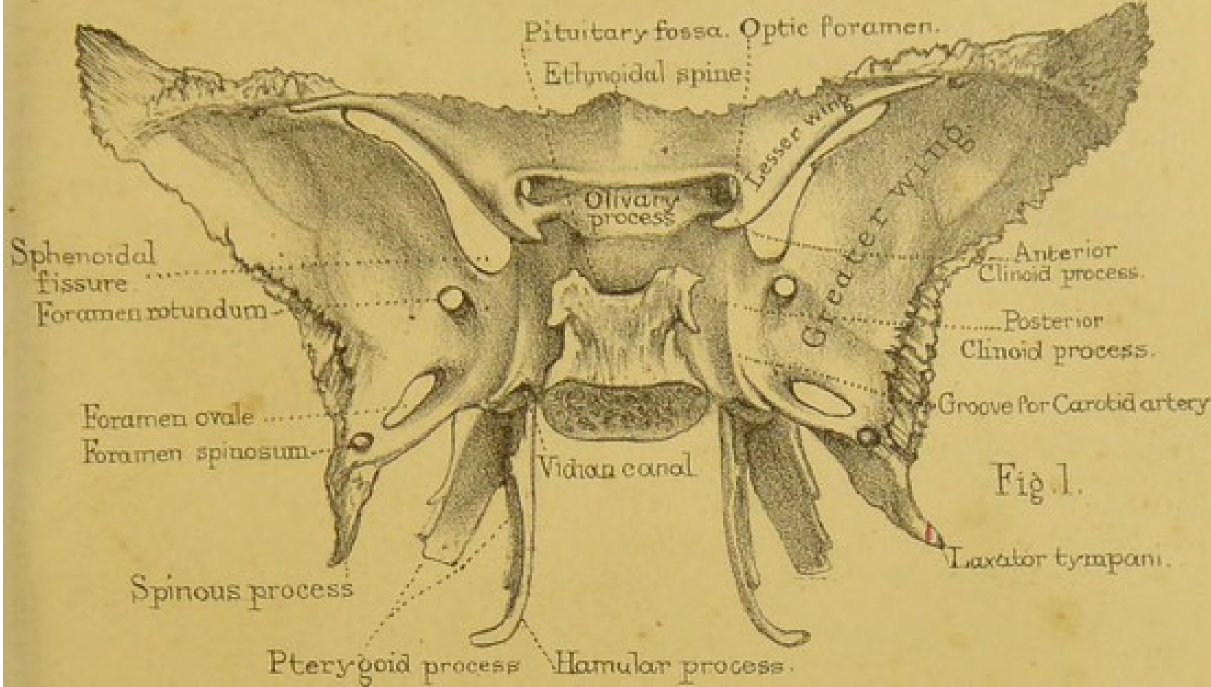


Fig. 1.

Posterior aspect.

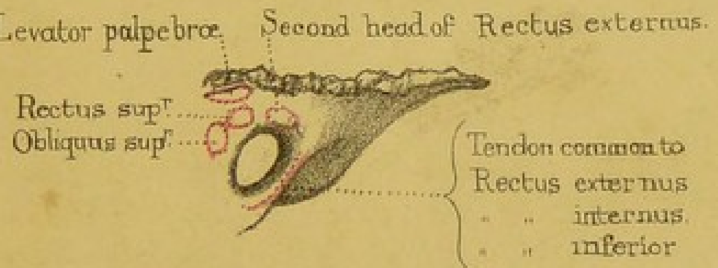


Fig. 3.

Muscles arising round the Foramen opticum.

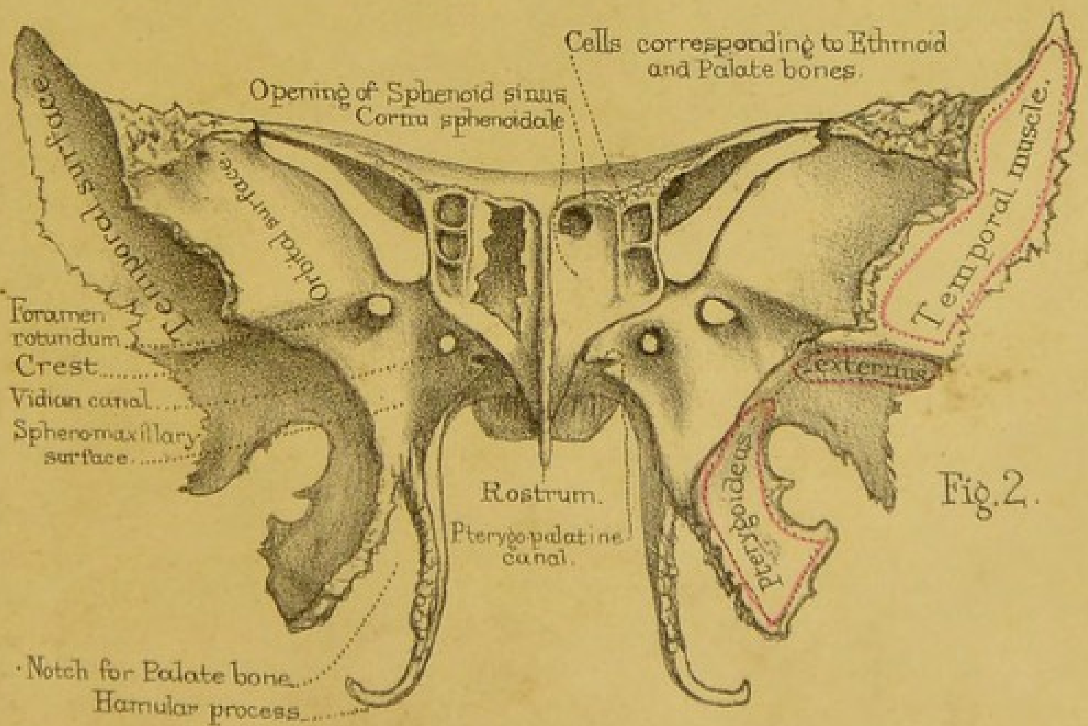


Fig. 2.

Anterior aspect.

L. Holden ad natur del.t

T. Godart Lith.

ing of the nose; that it has a crescent-shaped margin above, to make room for the cartilage of the Eustachian tube; and that below it terminates in a pointed hook, termed the "hamular process," which makes a beautiful pulley, round which the tendon of the tensor palati turns. There is nothing to remark about the *external* pterygoid plate, beyond the fact that its outer surface forms the floor of the zygomatic fossa, and gives origin to the "pterygoideus externus" muscle. Lastly, at the base of the pterygoid processes, a long canal, the "pterygoid" or "Vidian," runs from before backwards through the substance of the bone, and transmits the Vidian * nerve and artery.

Look now at the anterior aspect of the pterygoid processes, and you will observe, on each side, a plate of bone, standing off like a side buttress to connect them with the greater wing. The plane of this plate forms a smooth surface, termed the "spheno-maxillary," and nearly corresponds in direction with that of the "orbital surface" of the greater wing (Plate VIII. fig. 2). We draw special attention to this plate, and give it a special name, because it constitutes the superior wall of a deep and important fossa, termed the "spheno-maxillary," which, in the perfect skull, intervenes between the sphenoid and superior maxillary bones.

Connections of the sphenoid.

The connections of the sphenoid bone cannot well be understood without a general knowledge of the bones of the head. It is joined to all the bones of the cranium, and to five of those of the face. The "body" is connected behind with the occipital bone, and in front with the ethmoid bone, the two palate bones, and the vomer. The "lesser wing" is connected to the orbital plate of the frontal bone: the "greater wing" is connected to the orbital plate of the frontal by a rugged surface of considerable extent; to the anterior inferior angle of the parietal bone: to the squamous and petrous parts of the temporal bone; and to the malar bone. Lastly, the pterygoid processes are connected with the palate bones.

In the fœtus, the sphenoid bone is divided into two parts. The posterior, comprising the sella turcica and the greater wings, is

* Vidus Vidius was a professor at Paris, and physician to François I^er^.

called the "temporo-sphenoid;" the anterior, comprising the lesser wings, and that part of the body to which they are attached, is called the "orbito-sphenoid." Each of these parts has three centres of ossification,—one for the middle, and one for each of the wings; thus making six centres. The "cornua sphenoidalia" have each their own centre; so has each internal pterygoid plate. In all, then, there are ten centres.*

THE ETHMOID BONE.

(Plate IX. figs. 2 and 3.)

This remarkably light and spongy bone contains the organ of smell. It occupies the interval between the orbital plates of the frontal bone, and enters into the formation of the cranium, the orbit, and the nose. It appears, at first sight, complicated; but, in fact, it is simple enough when one understands the plan of it. It consists of a horizontal plate, which forms part of the base of the skull; of a central perpendicular plate which forms part of the septum of the nose, and of two "lateral masses" containing the air-cells. Each of these must be examined separately.

HORIZONTAL PLATE. The horizontal plate fits into the "ethmoidal notch" between the orbital plates of the frontal bone, and completes the base of the skull (Plate XVII.). It is called the "cribriform plate" (cribrum, ἠθμὸς, a sieve), because there are so many holes in it for the passage of the olfactory nerves. High above it rises a crest of bone, termed, from its resemblance to a cock's comb, the "crista galli." This, which is a continuation of the perpendicular plate, gradually rises sharp from behind, swells out as it proceeds, and stopping suddenly short, presents a broken

* For full information on the development of the sphenoid bone, see Meckel's Archiv, B. 1.

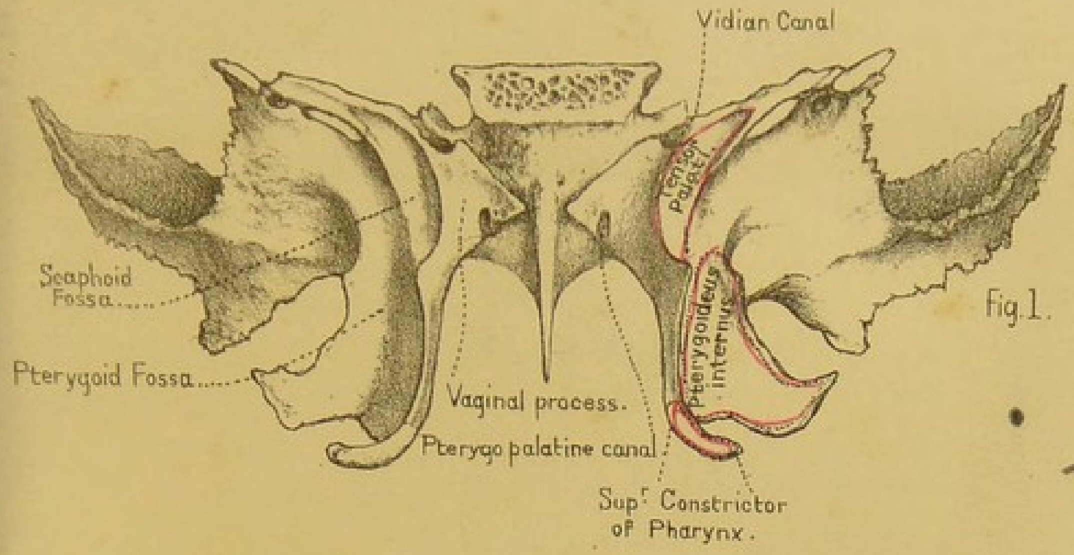


Fig. 1.

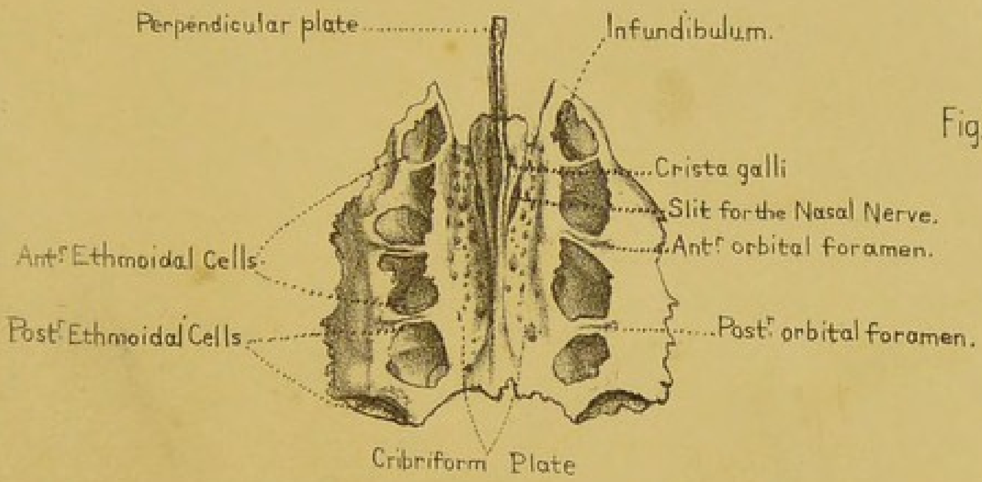


Fig. 2.

ETHMOID BONE.

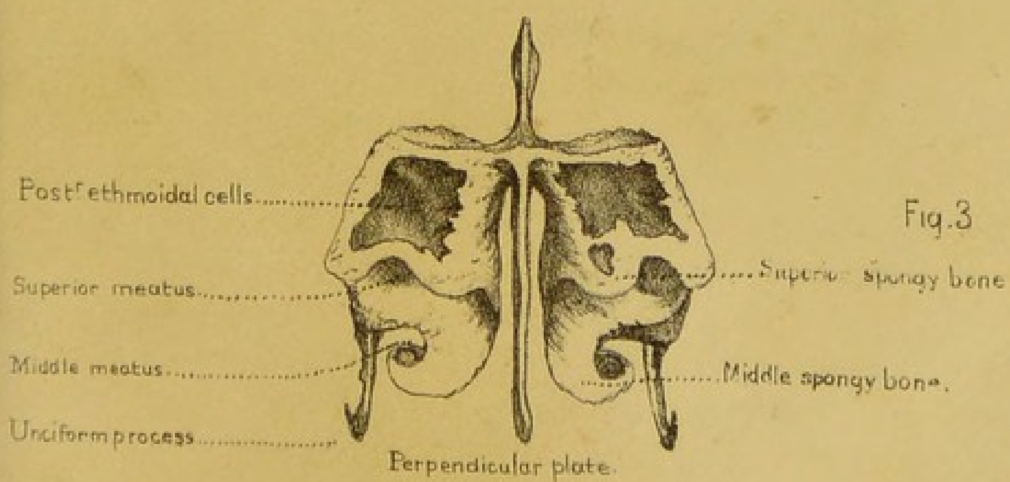


Fig. 3

Holden ad natur del^t

T. Godart Lith.

surface which is connected to the frontal bone.* The cribriform plate, you will observe, does not quite come up to the level of the lateral masses, but lies at the bottom of a deep groove (" olfactory groove "), which, with the crista galli in the middle, and the orbital plate of the frontal bone on each side, forms in the perfect skull two complete recesses adapted for the safe lodgment and support of the olfactory lobes of the brain. The foramina at the bottom are divided on each side into three sets or rows,—an outer, an inner, and a middle. By passing bristles down these holes, you will find that the outer and the inner rows lead respectively to the " olfactory canals " on the perpendicular plate and the upper spongy bones; while the middle holes run simply through the cribriform plate † (Plate XV. figs. 1 and 2). Close to the crista galli there is a long " slit," rather than a hole, which gives passage, not to one of the olfactory nerves, but to the " nasal nerve " (a branch of the first division of the fifth pair), which confers common sensation upon the mucous membrane of the nose.

PERPENDICULAR PLATE. The perpendicular plate descends from the cribriform plate to assist in forming the septum of the nose. We notice the numerous grooves and canals on its surface, already alluded to, for the passage of the olfactory nerves. Its connections are well shown in Plate XV. fig. 1. Behind, it is connected along a sloping line with the " rostrum " of the sphenoid and the vomer: in front it is connected with the nasal spine of the frontal, and the crest of the two nasal bones, of which it mainly serves to support the arch. The triangular gap in the septum in the dry skull is filled up, in the recent state, by the central cartilage of the nose.

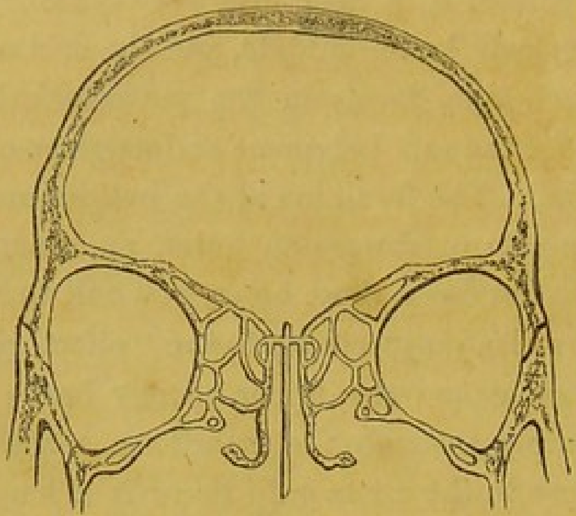
LATERAL MASSES. The " lateral masses " of the ethmoid (fig. 13) are made up of irregular air-cells, surrounded by paper-like walls of bone: hence they are somewhat happily called

* The " crista galli " serves for the attachment of the " falx cerebri." It varies in size, and has often a slight lateral inclination. Sometimes it contains an air-cell in its interior.

† These three rows of holes correspond to the three sets of olfactory nerves: namely, those that ramify on the septum, those that ramify on the spongy bones, and those that simply supply the roof of the nose.

the "labyrinths" of the nose. The cells are divided into two sets,—an anterior and a posterior; and the cells of one set do not communicate with those of the other. In the separated bone many of the cells are necessarily broken, because their walls, in the perfect skull, are completed by the adjoining bones. Thus, the cells on the upper surface are roofed in by corresponding cells in the orbital plate of the frontal; those behind are closed by the body of the sphenoid and the orbital process of the palate bone; those in front are walled in by the lachrymal; those below, by the superior maxillary bone. On the outer side of each lateral mass the cells are closed by a smooth and square plate of bone, termed the "os planum," belonging entirely to the ethmoid. This forms a large share of the inner wall of the orbit (Plate XX.), where it is easy enough to learn its connections with the surrounding bones, by tracing the sutures between them. In doing this, we cannot fail to notice the two notches on its upper border, which contribute, with the frontal, to form the "anterior and posterior orbital foramina."

Fig. 13.



Section to show the lateral air-cells of the ethmoid bone.

Turbinated Bones. On that surface of the lateral mass which looks towards the septum, we observe two thin plates of bone standing out, one below the other, and slightly curled, like a turbinated shell. These are the "turbinated" or "spongy" bones of the ethmoid (Plate XV. fig. 2), and can only be properly seen in a divided skull. The "superior" is the smaller of the two, and does not reach so far forward as the other, which is called the "middle," because there is a third or "inferior spongy" bone, still lower down in the nose; but this does not belong to the ethmoid. Now the spaces left between these spongy bones and the lateral masses are called, respectively, the superior and middle "meatus," or passages of the nose. Each is quite distinct from the other, so far as it goes, and leads to its own particular cavities, and to no other. The superior meatus, being farther back than the middle one, naturally leads into the "sphenoidal sinus," and also into the "posterior ethmoidal cells;" whereas the middle meatus leads into the "anterior ethmoidal cells," and also to the frontal cells, along a funnel-shaped canal (termed the "infundibulum") which traverses the foremost of the ethmoidal cells.

However, the great use of the spongy bones is to afford an additional extent of surface for the subdivisions of the olfactory nerves: and to this end their surface is studded with grooves and canals, through which the nerves come down from the cribriform plate and spread out upon the mucous membrane. In man, the arrangement of these bones is very simple; they make only a single curve. But in animals remarkable for their sense of smell, one sees them making rolls within rolls; or, as is the case in the seal, subdividing into a multitude of plates, like the separated leaves of a book, in order to afford a vast surface for the application of the olfactory membrane,—a surface which has been calculated to be not less than 120 square inches in each nostril.

Lastly, from the anterior part of each lateral mass an irregular plate of bone descends almost perpendicularly, and terminates in a kind of hook; hence it is called the "unciform* process" (Plate IX. fig. 3). By referring to Plate XV. fig. 2, it will be seen that this process is connected more or less with the inferior spongy bone, and also with the thin walls of the "antrum" of the superior maxillary bone; its chief purpose being to assist in narrowing the orifice of this great air-cavity.

The ethmoid is connected with thirteen bones, namely,—behind, with the sphenoid and two palate bones; above, with the frontal; below, with the two superior maxillary; and in front, with the two lachrymal bones. Again, the perpendicular plate is connected behind with the vomer, and in front with the two nasal bones. Lastly, the unciform process on each side is connected with the inferior spongy bone and the superior maxillary.

* The "unciform process" is almost always broken in taking the skull to pieces; but it is evident enough in a good section of the nasal cavities.

Until the middle of fœtal life the ethmoid is all cartilage. Ossification begins by a centre for each of the lateral portions; soon afterwards another centre appears in each of the spongy bones. During the first year after birth the cribriform plate and the crista galli ossify, and unite to the lateral masses. The perpendicular plate ossifies last of all. An arrest in the progressive ossification of this plate occasions a "pug nose." In the fœtus at birth there are no ethmoid cells; these are not formed till the fifth or sixth year.

BONES OF THE FACE.

There are fourteen of these; namely, the two superior maxillary, the two malar, the two nasal, the two lachrymal, the two inferior spongy, the two palate, the vomer, and the inferior maxilla.

SUPERIOR MAXILLARY BONE.

(Plate X.)

This bone gives much of its character to the human face, and forms the greater part of its framework. It is exceedingly irregular in shape, and, besides forming sockets for the teeth, enters into the composition of the nose, the orbit, the cheek, and the palate. For convenience of description, we divide it into a "body," which is hollowed out into a large air-cavity, called the "antrum," and four outstanding "processes;" namely, the "alveolar," which holds the teeth; the "palatine," which forms part of the hard palate; the "nasal," which assists in forming the nose; and the "malar," which helps to form the prominence of the cheek.

Walls of the Antrum. Let us take the body first, and learn its various relations well, for it is a part of great surgical interest, being liable to many diseases requiring surgical operations. The first thing to observe is, that the walls which bound its cavity have *four* aspects: one, namely the front, looks towards the cheek; another, namely the upper, looks towards the orbit; a third, namely the inner, looks towards the nose; and a fourth, which is behind, looks towards the zygomatic fossa. Therefore, when a morbid growth forms in the antrum, and distends it, any one or more of these walls may be protruded. They are all very thin, the orbital especially; but it is worth remembering that they are thicker in the child than in the adult.

Anterior wall. The anterior wall of the "antrum" is that which we generally remove in order to take out a morbid growth from the interior, and through which we tap the antrum to let out pus, or any fluid that may have accumulated there; cysts in the antrum being by no means uncommon. There is a depression in it, called the "canine fossa;" and just above this is the "infra-orbital foramen," or termination of the "infra-orbital canal," which transmits the "infra-orbital" nerve and artery. The canine fossa gives origin to the "levator anguli oris." Above the infra-orbital foramen arises the "levator labii superioris," and more internally the "compressor narium."

Posterior wall. The posterior wall of the antrum is convex, and bulges into the zygomatic fossa.* There are several small holes in it, leading to canals ("dental canals") for the transmission of the posterior dental nerves and arteries. Lower down it has a very rough surface, called the "tuberosity," by which it is firmly connected to the palate bone; and along the inner edge of this surface (fig. 2) is a groove, which, with the perpendicular plate of the palate bone, forms the "posterior palatine canal," for the passage of the posterior palatine nerve and artery.

Superior wall. The superior wall or roof of the antrum forms the sloping floor of the orbit. Like the other walls of the antrum, it is thin enough to be transparent. The chief thing to notice here is the "infra-orbital canal," for the passage of the superior maxillary nerve. It commences behind as a groove, but soon becomes a canal, which terminates on the front wall of the antrum, below the edge of the orbit. A little before its termination,

* Blandin (Anat. Topog. p. 44) relates a case in which a tumor, originating in the antrum, made its way into the zygomatic fossa, and caused a swelling in the temple.

the main canal gives off one or sometimes two smaller ones, termed the "anterior dental canals." These run down in the very substance of the front wall of the antrum, in order to transmit blood-vessels and nerves to the two incisor, the canine, and the first bicuspid teeth. To see these canals it is necessary to introduce a bristle as a guide, and then to rasp away the front wall of the bone. Near the lachrymal groove may be seen a small depression, indicating the spot where the "inferior oblique" muscle of the eye arises. This is the only muscle of the orbit which takes origin from the front; all the others arise from the back part, around the optic foramen. In the perfect skull (Plate XIII.) you will find that the upper wall or "orbital plate" of the antrum is connected on its inner side with the lachrymal, ethmoid, and palate bones; but that on its outer side it forms one of the margins of the "spheno-maxillary fissure," at the back of the orbit.

Internal wall.

On the inner or "nasal wall" of the antrum, the first thing we notice is the orifice of the antrum itself (Plate X. fig. 2). In the separate bone, this orifice is very irregular, and large enough to admit the end of a finger;* but in the perfect skull (Plate XX.) it is very much closed in by the ethmoid, palate, and inferior spongy bones. In the recent state, indeed, the orifice is generally so contracted by a fold of the mucous membrane of the nose, that it will only just admit the passage of a crow-quill. Observe, moreover, that the orifice is not near the bottom of the antrum, but very high up: the consequence of this is, that when fluid collects in the antrum it cannot run out until the antrum is nearly full, or until the head is inclined horizontally with the opposite cheek downwards.

ANTRUM.

So much for the four walls of the antrum. Now, observe the size and form of the cavity itself. The "maxillary sinus," or "antrum of Highmore,"† is by far the largest of the air-cells in the bones of the head. It is large enough to hold

* Sometimes there are two openings, separated by the thin plate (unciform process) which descends from the ethmoid bone.

† Nathaniel Highmore was an English anatomist, born 1613, died 1684, who wrote much about the diseases of the antrum. He did not discover the antrum. It was known to Galen as the "Sinus maxillaris."

a musket-ball with ease. Mr. Guthrie* says he has known a ball lodge in the antrum for months, and even for years, before it was removed. M. Jarjavay† speaks of a ball having lodged for eleven years in the antrum, and having finally made its way out through the roof of the mouth. However, it varies in size, and somewhat in shape, in different persons: but, as a rule, it has the form of a triangular pyramid, with the base towards the nose, and the apex towards the malar bone. Thin plates of bone are often found extending across the antrum; and, what is of more importance, the fangs of one or more of the molar teeth generally project into it, either quite bare, or covered by a thin scale of bone. Hence the practice, adopted by some surgeons, of drawing one of these teeth, say the first or second molar, in order to let out matter from the antrum. Again, the fangs of decayed or otherwise injured molar teeth are liable to set up disease in the antrum; and this is the explanation commonly given why morbid growths arise in the antrum more frequently than in any of the other air-cavities of the nose.

The following case gives one a good idea of the extent of the antrum:—"A lady suffering from tooth-ache submitted to the extraction of the canine tooth of the upper jaw, with which a portion of the alveolar process was removed, making an aperture in the antrum, from which a watery fluid constantly issued. The patient, desirous of ascertaining the source of the discharge, took a pen, and, having stripped off the barbs from the feathered part, found that the whole of it, full six inches long, could be introduced into the cavity. At this she was greatly terrified, believing it must have gone into the brain. She consulted Highmore, who explained to her that the pen had turned spirally within the sinus, and he, besides, counselled her to submit with patience to the inconvenience of the discharge from the cavity."‡

Alveolar process. The alveolar process is the thickest and strongest part of the bone, and contains, in the adult, sockets (alveoli) for eight teeth; namely, two "incisors," one "canine,"

* Commentaries, p. 528. † Anatomie Chirurgicale.
‡ Drake's System of Anatomy, 8vo. 1707.

two "bicuspid or præmolars," and three "molars." Thus the dental formula in man is—

$$i.\frac{2+2}{2+2},\ c.\frac{1+1}{1+1},\ p.\frac{2+2}{2+2},\ m.\frac{3+3}{3+3}=32.$$

The sockets correspond in number and size to the fangs of the teeth they receive. They vary in depth in different instances. The deepest of all is the socket of the canine tooth: this is often $\frac{7}{10}$th of an inch in depth in the dry bone. The first two of the molars have generally each three fangs, and as many sockets. Of these fangs, two are external, one internal. Irregularities in the shape and the direction of the fangs, whether diverging too much or converging, lead to unavoidable evils when it is necessary to extract them. Either a fang breaks, or part of the alveolus must be extracted with the fang. One cannot foresee this. Hence it follows that, now and then, even the most skilful operators will break teeth, or extract portions of bone. At the bottom of each socket there is a minute hole, through which the vessel and nerve come up to the fang; and there are also numerous holes in the bony partitions between the sockets, through which vessels come to supply the gums. These are the sources of the bleeding after the extraction of a tooth. The teeth are fixed, not only by the closely fitting socket, but also by the very vascular membrane, the periosteum, which lines the socket and adheres closely to the fang. This periosteum not only retains the teeth in their place, but maintains their vitality, and, being elastic, breaks shocks which would otherwise be communicated to the jaws. When the dental periosteum inflames, the tooth is partly lifted out of its socket, and the jaws cannot be closed without pain. If the inflammation goes on to the formation of matter, the periosteum quits its hold of more or less of the fang, and abscess in the socket is the result. The matter then makes its way out by the side of the tooth, or through a small hole formed by ulceration in the alveolar wall; and a gum-boil is the result. In the dry bones, most of the teeth fall out, because the periosteum shrinks, and thus the sockets become too large.

The alveolar process gives origin to two muscles (Plate X. fig. 1), namely, to the "buccinator" above the three molar teeth, and to the "depressor ~~labii superioris~~" above the incisor teeth, where there is a little depression, termed the "myrtiform fossa."

Nasal process. The nasal process ascends nearly perpendicularly, to abut, by means of a very rough suture, upon the internal angular process of the frontal bone. It supports the true nasal bones, and contributes to form the inner margin of the orbit. The principal point concerning the nasal process is the deep groove which runs almost vertically behind its orbital margin. It is called the "lachrymal groove." In the perfect skull you will find that it is converted into a complete canal by a corresponding groove in the lachrymal bone and a small portion of the inferior spongy bone. The canal thus completed is for the lodgment of the "lachrymal sac" and "nasal duct," which convey the tears into the inferior "meatus" of the nose. It is about the size of a common goose-quill. When, from inflammation or other cause—such as a tumor—the canal becomes obstructed, the tears necessarily flow over the edge of the eye-lid, and run down the cheek. To obviate this, it is often requisite to puncture the lachrymal sac, and introduce a style into the canal. Therefore one must know well the direction of the canal. It runs from above downwards, and with a slight inclination backwards. On the outer surface of the nasal process we observe the prominent ridge which forms the inner margin of the orbit. This gives origin to the "tendo oculi" and the "orbicularis oculi." A little in front of this the "levator labii superioris et alæ nasi" arises. On the inner surface we have to observe the two ridges to which the inferior and middle spongy bones are attached, and also the smooth surfaces between the ridges which respectively form part of the inferior and middle "meatus" of the nose. Near the top the nasal process often closes in one of the anterior ethmoidal cells. In front the nasal process presents a sharp crescent-shaped margin, which, with the similar one on the opposite bone, bounds the anterior opening of the nose, and gives attachment to the lateral cartilage.

Palatine process. The palatine process extends horizontally inwards, to form the anterior two-thirds of the hard palate, and also the floor of the nose; the posterior third being completed by the proper palate bone. On the palatine surface (Plate XVIII.)

we observe—1, the palatine groove for the palatine vessels and nerve; 2, the numerous foramina which transmit vessels into the bone; and 3, the pits made by the palatine glands. On the upper or nasal surface there is nothing to notice, more than that it is smooth and slightly concave. By adjusting the two superior maxillary bones together, you will find that the palatine processes are connected in the middle line by a very rough suture (palatine suture); and that they rise towards the nose into a kind of crest, which articulates with the vomer, and forms as it were a base for the bony septum of the nose (Plate XV. fig. 1). This crest projects in front in the shape of a sharp spine (the "anterior nasal spine"), which serves for the attachment of the cartilaginous part of the septum. In this palatine suture, immediately behind the middle incisor teeth, we observe the "anterior palatine canal" (Plate XVIII.). Towards the palate, this canal has, at first sight, only one large orifice; but if we look to the bottom of it, we shall probably find four openings. Two of these lie in the middle line, one behind the other, and transmit the anterior palatine nerves; the other two, much larger, are situated one on each side the middle line; they lead into the floor of each nostril, and transmit the anterior palatine arteries.*

Malar process.

The malar process stands off from the outer side of the antrum. It is remarkably thick and strong, and is connected, by a very rugged surface, with the malar bone. Observe that the malar process is situated just over the first and second molar teeth, and is therefore well calculated to resist pressure in mastication. When we crack a nut, we instinctively place it under these teeth.

The superior maxilla is connected with nine bones, as follows:—with the malar, the frontal, the nasal, the lachrymal, the vomer, the inferior spongy, the palate bone, its fellow, and lastly, the ethmoid. We mention this bone last of all, because we wish to

* The description in the text concerning the anterior palatine canals, applies to twenty out of forty skulls examined. Their disposition, in other cases, is very apt to vary, both as to number and size. It was Scarpa (Annot. Anatom. lib. ii. p. 75) who first pointed out the varieties in these canals. In many instances one of the canals is absent; or, if present, not pervious throughout.

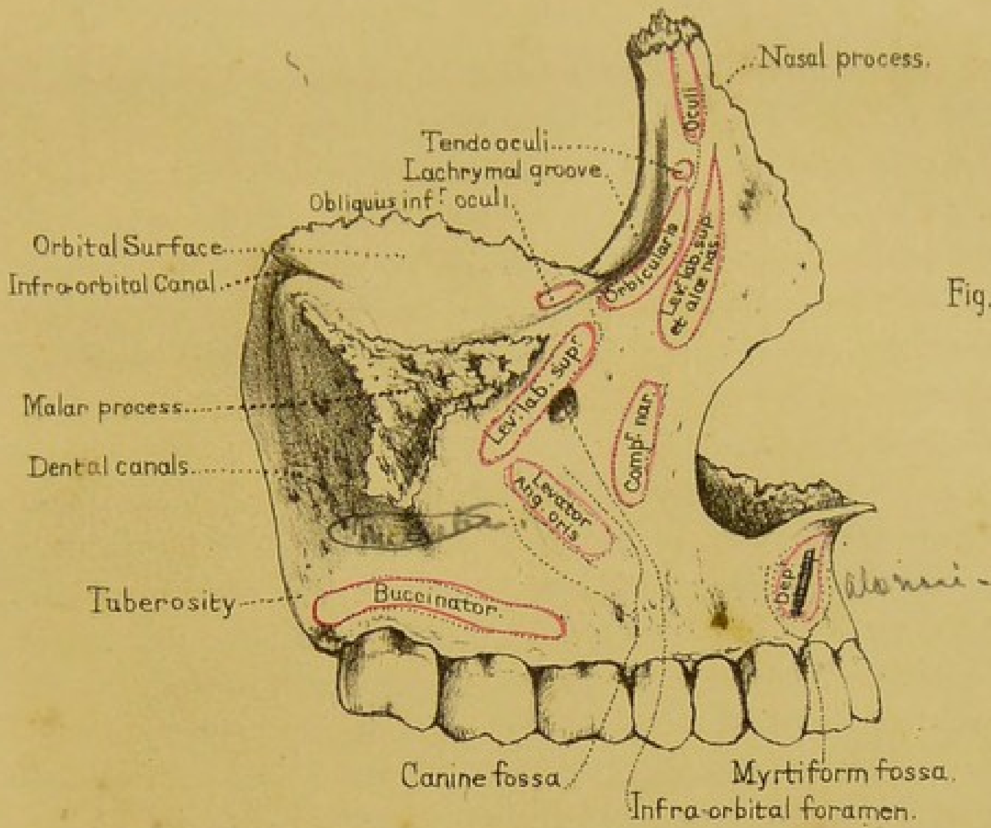


Fig. I.

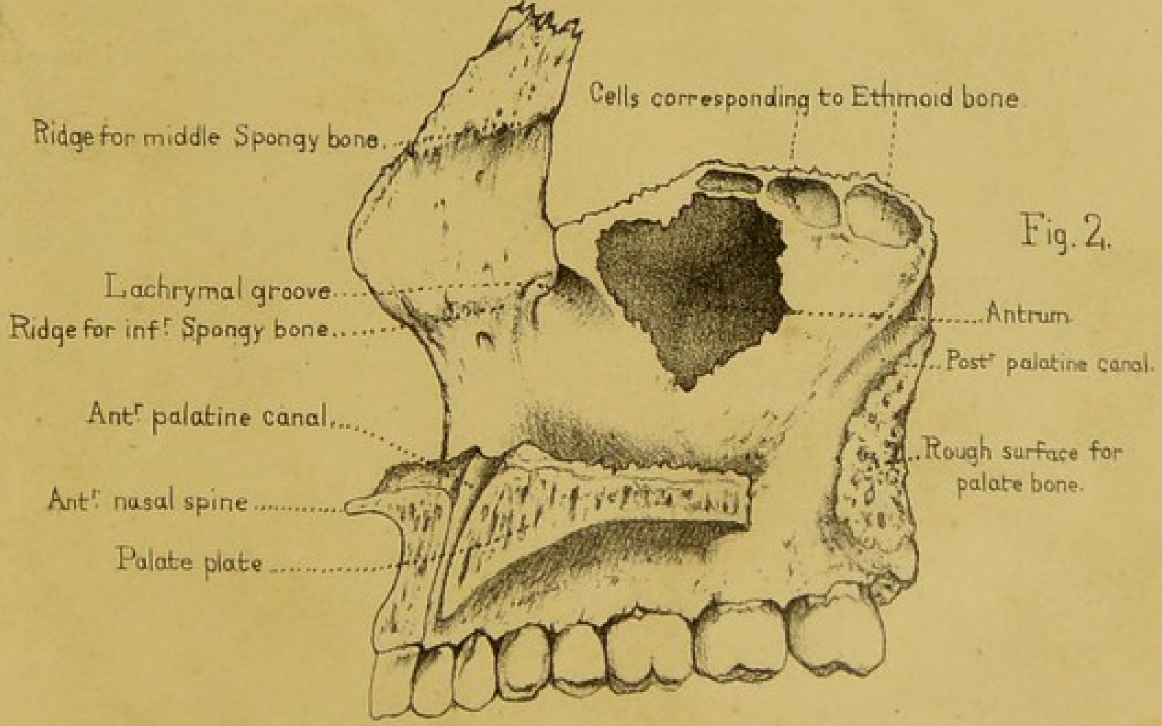


Fig. 2.

L. Holden. ad natur delt.

T. Godart Lith.

J. Sorrill, Imp.

direct attention to a fact which we have hitherto omitted to notice, that some of its cells are closed in by half cells usually seen along the orbital plate of the superior maxillary bone (Plate X. fig. 2).

The ossification of the upper jaw begins so soon (as early as the fifth week), and proceeds so quickly, that the number of its independent centres has not yet been accurately determined. There is one part,* however, which is certainly ossified from a distinct centre, that, namely, which contains the sockets of the two incisor teeth. In animals this remains a permanently distinct bone, called the "pre-maxillary." Indeed in most human skulls, if not very old, one can trace the remains of the pre-maxillary suture (Plate XVIII.). It runs outwards from the anterior palatine canal, and then through the alveolar border of the jaw, invariably between the second incisor and the canine tooth; and here we lose all trace of it. This is interesting surgically. In cases of double hare-lip, where the fissure is not confined to skin, the pre-maxillary bones on each side fail to unite with the rest of the upper jaw, and often project in a hideous manner through the fissure of the lip. When removed by operation, this portion of the jaw is always found to contain the capsules of the four incisor teeth.

MALAR BONE.

(Plate XII. fig. 3.)

The malar bone forms the prominence of the cheek, a part of the margin and wall of the orbit, and the greater portion of the zygomatic arch. It is remarkably thick and strong, in order to resist injury, to which the face, in this situation, is so obnoxious. We divide it into an anterior or *subcutaneous* surface, a superior or *orbital*, and a posterior or *zygomatic*.

* This part, in man, was first pointed out by the poet Goëthe.

On the subcutaneous surface there is nothing to observe except the orifice of one of the "malar canals," and that it gives origin to the "zygomaticus major" and "minor" muscles.

The superior surface forms part of the outer wall of the orbit, a small part of its floor, and, generally speaking, the corner only of the spheno-maxillary fissure.* There are usually two "malar canals" to be seen on it. By introducing bristles, it will be found that one of these leads to the subcutaneous surface; the other, to the zygomatic surface.†

The posterior surface is very concave, in order to form the anterior wall of the zygomatic fossa.

The malar bone has three free borders. One forms at least a third of the margin of the orbit, and reaches as far inwards as the infra-orbital canal: a second forms the upper edge of the zygomatic arch, and gives attachment to the "temporal fascia:" a third forms the lower edge of the arch, and gives origin to the "masseter" muscle (Plate XIV. fig. 2).

The malar bone is connected with four bones; namely, by a broad and very rough surface, with the superior maxillary; by suture, with the external angle of the frontal, the orbital plate of the sphenoid, and the zygomatic process of the temporal. These several connections are so strong, that the bone cannot be driven inwards towards the orbit, and fractures of it are very rare. It is developed from a single centre of ossification.

* From an examination of many skulls, I find that the malar bone is nearly as often as not excluded from the spheno-maxillary fissure. This exclusion is effected in one of two ways; either by the immediate junction of the superior maxillary and sphenoid bones, or, what is rather singular, by the interposition of a little "Wormian" bone just at the angle of the fissure.

† These malar canals transmit nerves which proceed from the orbital branch of the superior maxillary nerve to the cheek, and the zygomatic fossa respectively.

NASAL BONES.

(Plate XIII. fig. 3.)

The nasal bones, situated one on either side, occupy the space between the nasal processes of the superior maxillary bones, and, together, complete the bridge of the nose. Their length, breadth, and degree of inclination, determine the shape of the nose in different individuals. We have to examine their anterior and posterior surfaces, and their four borders.

Their anterior surfaces are subcutaneous, convex, and present the orifices of one or more canals, for the transmission of blood-vessels. Their posterior surfaces are concave, so as to form part of the roof of the nose, and are each marked by a groove for the passage of the nasal nerve.

Their upper borders are broad, serrated, and firmly articulated with the frontal bone. Their lower borders are thin and free in the dry bone, but connected in the recent subject with the lateral cartilages of the nose. Each has, generally, a little notch in it, through which the nasal nerve comes to supply the skin at the tip of the nose. Their outer borders are serrated, and slightly sloped, so as to articulate with, and be supported by, the nasal processes of the superior maxillary. Their inner borders articulate with each other, in the middle line, along the "nasal suture." Here the under surface of each bone rises into a high "crest." By putting the bones together, it will be seen how their crests form the beginning of the bony septum of the nose, and that they articulate with the nasal spine of the frontal bone, and the perpendicular plate of the ethmoid (see Plate XV. fig. 1). Hence, you cannot have a fracture with depression of the nasal bones, without a fracture of the perpendicular plate of the ethmoid. In some rare instances, the injury extends through the perpendicular plate of the ethmoid to the base of the brain. Observing the great strength of the nasal bones, and the arch they form; how the sides of this arch are supported by the nasal processes of the superior maxilla, while the centre is propped up by the nasal spine of the frontal bone, and the perpendicular plate of the ethmoid (Plate XV. *a*, fig. 2), one can readily understand what makes the arch so strong, and why the bones are so seldom broken. One has a pretty good proof of the strength of the arch, when one sees mountebanks support upon it, with impunity, a heavy ladder, with the additional weight of a man upon the steps.

Each nasal bone is developed from a single centre of ossification.

LACHRYMAL BONES.

(Plate XII. fig. 4.)

The lachrymal bones are situated, one on each side, on the inner wall of the orbit. They are exceedingly thin and delicate, and being shaped like the nail, are often called the "ossa unguis." In old skulls, they are often as thin as silver paper, and sometimes perforated. One surface looks towards the orbit; the other towards the nose. One of these bones is seen *in sitû* in Plate XIII. fig. 2.

The external or orbital surface has a vertical ridge upon it; and in front of this is a groove ("lachrymal groove"), which, together with the groove on the nasal process of the superior maxilla, forms the canal for the lachrymal sac. The ridge itself gives origin to the "tensor tarsi" muscle. The bone behind the ridge is smooth, slightly concave, and forms part of the wall of the orbit.

The internal or nasal surface presents a slight furrow corresponding to the external ridge. The surface in front of this forms part of the middle meatus of the nose; that behind it always covers the anterior cells of the ethmoid bone, and sometimes a small cell or two in the frontal bone.

By examining the orbit (Plate XIII. fig. 2), you will observe that the lachrymal bone is somewhat square, and that it articulates by suture with the frontal above, the ethmoid behind, the superior maxillary in front and below. But this is not all. The lower edge of the bone has a little triangular "tongue," which articulates with what is called the "lachrymal process" of the inferior spongy bone (see Plate XV. fig. 2). So, then, it articulates with four bones. It has one centre of ossification.

PALATE BONES.

(Plate XI. figs. 1, 2, 3.)

There are two "palate bones," one on each side, wedged in between the pterygoid processes of the sphenoid and the superior maxillary bone. They form part of the nasal fossæ and the orbits, as well as of the palate. As the palate bone somewhat resembles the letter L in shape, we can divide it, for convenience of description, into a horizontal and a vertical plate.

Horizontal plate. The horizontal plate completes the bony palate by fitting on to the palate plate of the superior maxillary bone. Its under surface (Plate XI. fig. 3) presents a transverse ridge, more or less marked in different bones, for the insertion of the aponeurosis of the "tensor palati." In front of this ridge and towards its outer end we observe the orifice of the "posterior palatine canal," for the transmission of the posterior palatine vessels and nerve. The anterior edge of this plate is serrated and cut obliquely, so as to articulate with, and be supported by, the palate plate of the superior maxilla. The posterior edge is smooth and concave, and gives attachment to the soft palate. The inner edge firmly articulates with its fellow, by means of a "median crest" raised up towards the nose, precisely like the corresponding parts in the superior maxillary bones (see Plate XV. fig. 1); and this crest serves to support the vomer, and form a basis for the septum of the nose. Behind, it terminates in a pointed process, termed the "posterior nasal spine" (Plate XVIII.), which gives origin to the "azygos uvulæ" muscle. Concerning the upper surface of the plate we have only to notice that it is smooth and slightly concave, in order to form part of the floor of the nose.

Vertical plate. The vertical plate of the palate bone contributes to form the outer boundary of the nasal fossa. On its inner surface (Plate XII. fig. 1) we notice a "ridge" for the attachment of the inferior spongy bone. The surfaces above and below this ridge, respectively, form part of the middle and inferior "meatus" of the nose. Still higher, there is a ridge for the middle spongy bone. On its outer surface we have to observe a vertical groove, which of itself almost forms the "posterior palatine canal" (Plate XI. fig. 1). The front part of the vertical plate fits along the inner wall of the antrum of the superior maxilla, and helps to contract the lower and back part of the orifice of the antrum. This part, however, is very fragile, and is generally broken in separating the bones.

Tuberosity. From the angle formed by the horizontal and vertical plates projects backwards what is called the "tuberosity" (Plate XI. fig. 1). This is the thickest and strongest part of the whole bone, and its use is to fit into and fill up the "notch" which, we remember, is left between the pterygoid plates of the sphenoid bone. For this purpose its posterior aspect presents a groove which completes the pterygoid fossa. This groove is bounded by two rough surfaces, which diverge from each other like the letter V reversed, in order to fit into the borders of the notch itself (Plate VIII. fig. 2). The anterior aspect of the tuberosity presents a very rugged surface, which articulates with the tuberosity of the superior maxillary bone. The inferior aspect has nothing remarkable on it, except the orifices of one or two canals large enough to admit a pin. They are the "accessory palatine canals," and transmit nerves to the soft palate.

Turning now our attention to the upper part of the palate bone, we observe, that at the top of the vertical plate there are two processes. One is appropriately called the "orbital," because it fills up a little corner at the back part of the orbit; the other is called the "sphenoidal," because it fits under the body of the sphenoid

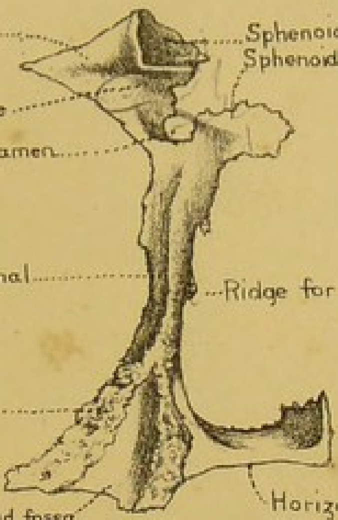


Fig.1.

Posterior view.

PALATE BONE.

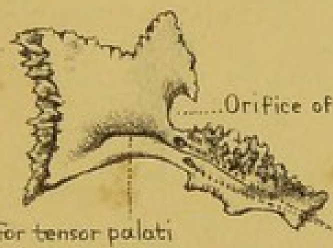


Fig.3.

Under surface.

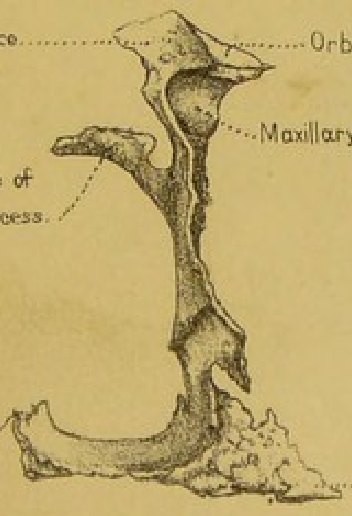


Fig.2

Anterior view.

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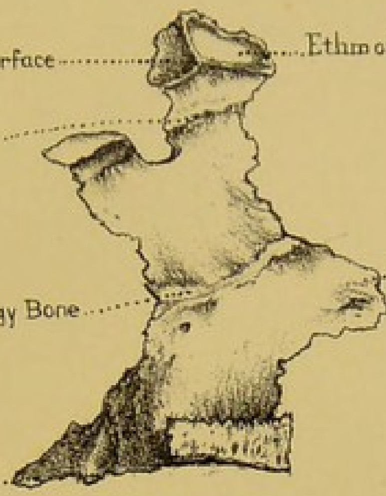


Fig. 1.

INTERNAL VIEW OF PALATE BONE.

Anterior or Maxillary surface.

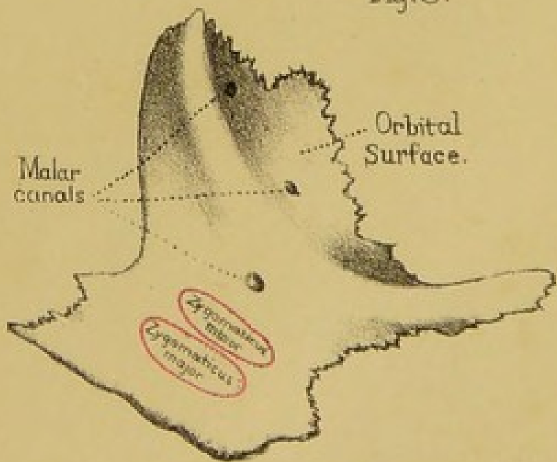
External or Zygomatic surface. | Superior or Orbital Surface. | Internal or ethmoidal surface.

Posterior or Sphenoid surface.

Fig. 2.

Diagram of the orbital process of the Palate bone.

Fig. 3.



MALAR BONE.

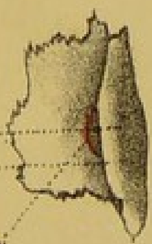


Fig. 4.

LACHRYMAL BONE.

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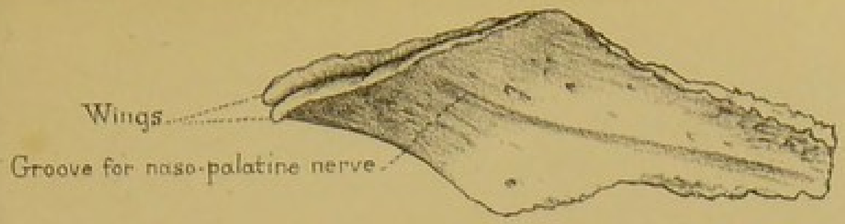


Fig. I

VOMER.

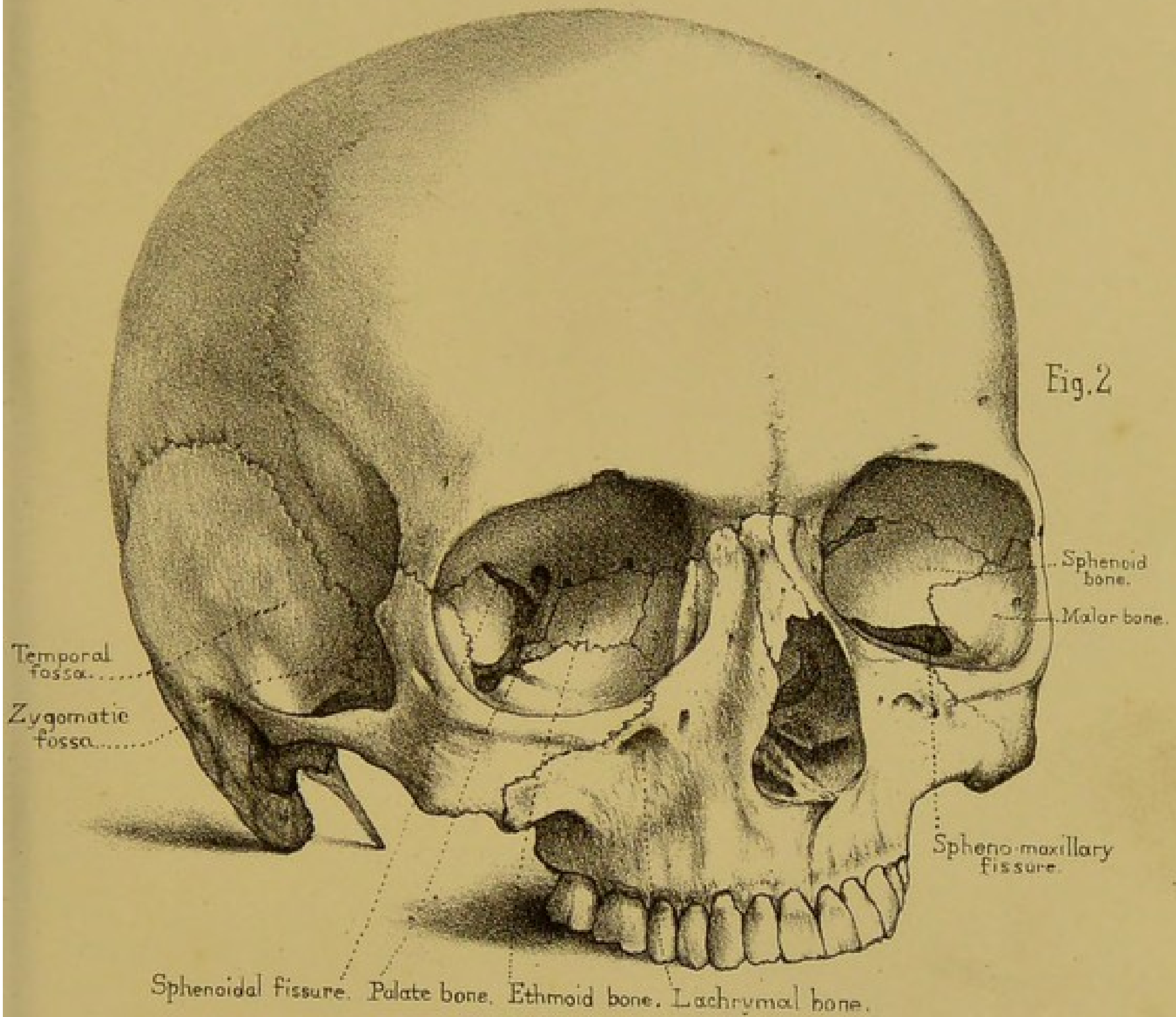
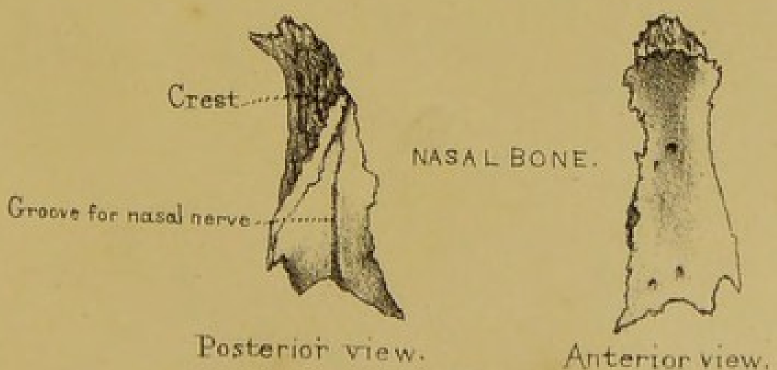


Fig. 2



NASAL BONE.

Fig. 3.

L. Holden ad natur del^t.

T. Godart. Lith.

bone. These processes are separated by a deep notch, which forms the greater part of the "spheno-palatine foramen."

Orbital process. The "orbital process" springs from the top of the bone by a narrow neck, and is hollow in its interior, so that it may be compared to a little box with paper-like walls of bone.* The interior contains air, which is admitted through one of the posterior ethmoidal air-cells. Our little box has *five* surfaces, each varying in extent, and looking in different directions. If you hold the bone before you, precisely as it is in your own person, and remember that it is interposed between the maxillary in front and the sphenoid behind, you will have no difficulty in recognising the direction of these surfaces to be as follows (see Plate XII. fig. 2):—the *superior* looks into the orbit; the *external* looks into the zygomatic fossa (or, more strictly speaking, into the spheno-maxillary fossa); the *posterior* is connected with the body of the sphenoid; the *internal* with the ethmoid; and the *anterior* with the superior maxillary bone. Thus, then, we have a superior or orbital surface, an external or zygomatic, a posterior or sphenoidal, an internal or ethmoidal, and an anterior or maxillary: of these five, two only are free, namely, the orbital and the zygomatic,—the other three are attached to the respective bones with which they are contiguous. Plate XX. shows the little corner at the inner and back part of the orbit, which is filled up by the palate bone, and also the relative position of the bones with which the orbital process is connected. It likewise shows that the "zygomatic surface" forms that part of the floor of the spheno-maxillary fossa which lies above the spheno-palatine foramen.

Sphenoidal process. The "sphenoidal process" is a thin plate of bone, which arches inwards beneath the body of the sphenoid bone, and forms part of the roof of the nasal fossa. As it is generally broken in the separate bone, one can see it best in the perfect skull (Plate XVIII.). The arch which it forms has three

* Why should the palate bone creep up into the orbit? One may be sure that such connection is the best possible for the function of the bone, without knowing the reason why. But the "secret" reason is disclosed by comparative anatomy; namely, that it mounts up into the orbit in order to be connected to the vomer or body of the frontal vertebra, to which it constantly belongs throughout all vertebrate animals. A striking instance, this, of unity of design.

surfaces,—an upper or convex surface, which closes in the pterygo-palatine canal; an under or concave surface, which we see in looking into the nasal fossa; and, lastly, an outer, which we see in looking at the bottom of the spheno-maxillary fossa.

Respecting the "spheno-palatine foramen," we need, for the present, merely observe, that it is an opening which leads from the spheno-maxillary fossa into the cavity of the nose, in order to convey nerves and blood-vessels there (Plate XX.).

The palate bone articulates with seven bones,—namely, its fellow, the sphenoid, ethmoid, inferior and middle spongy bones, the vomer, and the superior maxilla.

It is developed from a single centre of ossification, which appears at the angle of the horizontal and vertical portions, about the middle of the second month.

INFERIOR SPONGY BONE.

(Plate XIV. figs. 1 and 3.)

In each nasal cavity there are three spongy bones,—an upper, a middle, and a lower. The upper and middle, form part of the ethmoid bone, and have been already described. We have now to examine the lower one.

This thin plate of bone is well called "spongy," from its appearance, and "turbinated," from its curved form. By referring to Plate XV. fig. 2, you will see it *in situ*, and observe how much longer it is than either of the others. Its internal surface, forming the convex part of the roll, looks towards the septum of the nose; its external surface forms the concave part, and bounds the inferior meatus of the nose. Both surfaces are covered with little ridges and furrows, and more or less horizontal canals, specially for the lodgment of numerous plexuses of arteries, but chiefly of veins. This quite accords with the purpose served by the bone, namely, to afford an additional extent of surface for warming the air on its passage into the lungs. It has nothing to do with the sense of smell: we cannot trace the olfactory nerves lower than the middle spongy bone.

By its upper edge it is attached along the outer wall of the nose to several bones, as follows:—Beginning from the front, we find it attached, 1, to a ridge along the nasal process of the superior maxilla: 2, by means of a little "tongue" ("lachrymal process") to just such another "tongue" of the lachrymal; it is this part of the bone which completes the nasal duct; 3, to the orifice of the antrum by means of a triangular plate termed the "maxillary process" (Plate XIV. fig. 3), which turns down like a dog's ear, and helps to narrow the lower part of the orifice of the antrum; 4, to the unciform plate of the ethmoid by means of a little tongue called the "ethmoidal process"; 5, and lastly, to a ridge along the vertical plate of the palate bone. Notwithstanding these numerous connections, the bone is by no means strongly fixed in its position: in the dry skull it often falls out: and in the operation of extracting a polypus from the nose, it is quite possible to pull out the entire bone with the disease.

Its lower edge is free, and, generally, about half an inch from the floor of the nose, so that there is just room enough to introduce the tube of a stomach pump through the nose.

The bone has one independent centre of ossification, which appears about the fifth month of fœtal life.

THE VOMER.

(Plate XIII. fig. 1.)

The "vomer" is so named from its resemblance to a plough-share. It is a thin and delicate plate, situated perpendicularly in the middle line, and, together with the perpendicular plate of the ethmoid bone, forms the bony septum of the nose (Plate XV. fig. 1).

Thin as it is, the vomer consists of two plates, united below, but more or less separated above, where they diverge from each other, and form a deep groove which receives the "rostrum" of the sphenoid. The diverging edges of the groove, called the "wings," fit into the little furrows beneath the "vaginal processes" of the sphenoid (Plate IX.). Concerning the other connections of the vomer, we have to observe that, the two plates of which the bone is composed part from each other at every edge of it; and as the vomer receives the other bones into its grooves, so it is locked in on all sides. Below, it articulates with the crest of the maxillary and palate bones; in front, with the perpendicular plate of the ethmoid, and the median cartilage of the nose; behind, its edge is sharp and free, and, in the perfect skull, is seen as the septum between the posterior openings of the nasal fossæ.

Both surfaces of the vomer are marked by grooves for blood-vessels and nerves: but the only groove deserving notice is that which descends obliquely and transmits the "naso-palatine nerve."

It is necessary to know that the direction of the vomer is not, in all persons, perpendicular. In 100 skulls, I find the vomer perpendicular only in 24. There are instances in which it projects more or less into one side of the nose; and such an unusual projection, when covered by its vascular and swollen mucous membrane, might easily be mistaken for a polypus. Such mistakes are alluded to in surgical works.*

The vomer is developed from one centre of ossification, which begins at the lower part, and proceeds upwards along each lateral plate.

* Jarjavay, Anatomie Chir. t. ii. p. 61.

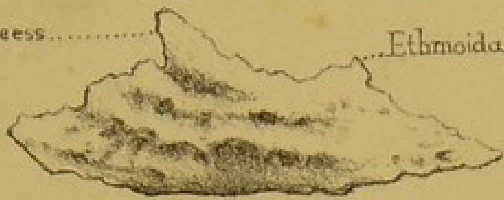


Fig. I.

Inferior Spongy bone. inner surface.

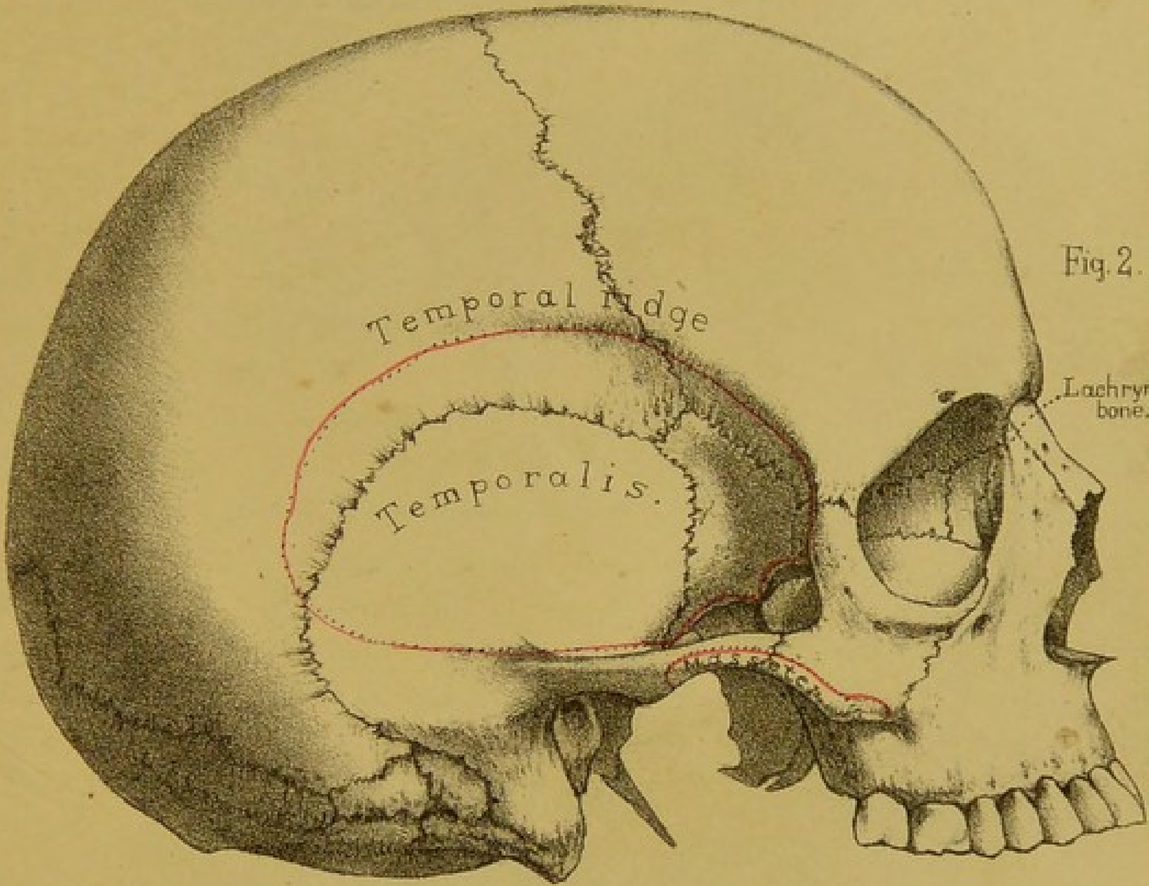


Fig. 2.

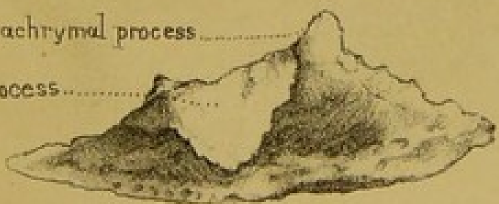


Fig. 3.

Inferior Spongy bone. outer surface.

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T. Godart Lith.

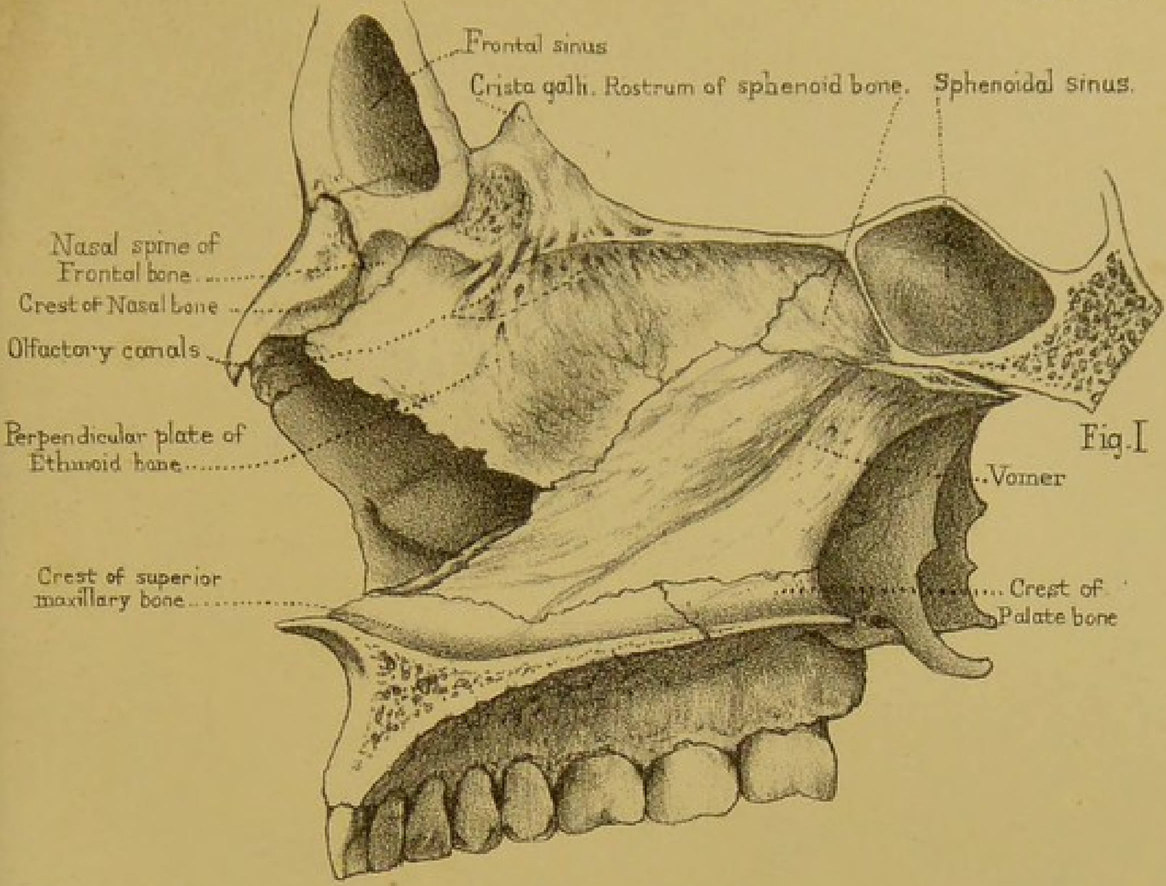

Fig. I

View of the septum of the Nose

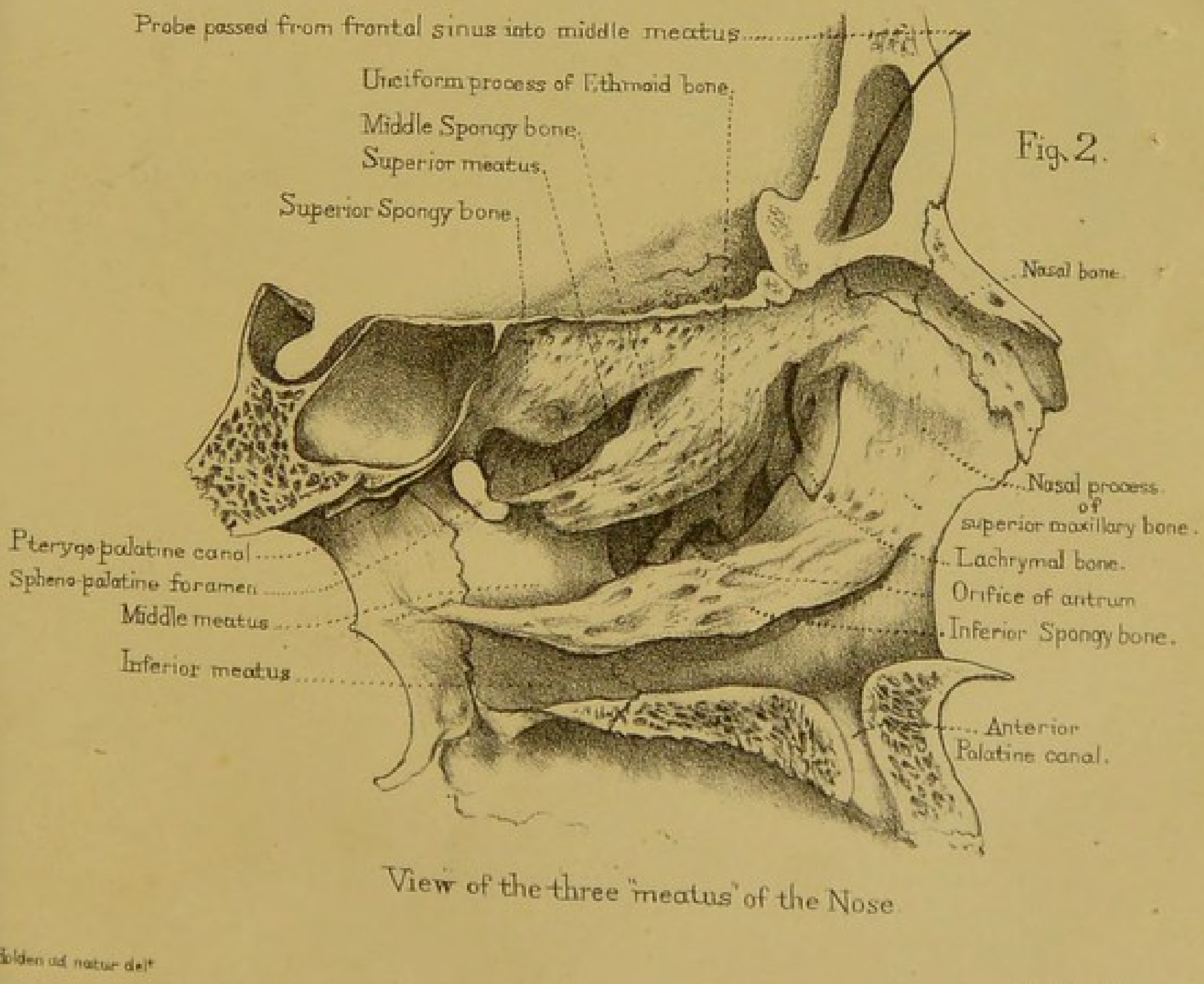

Fig. 2.

View of the three "meatus" of the Nose.

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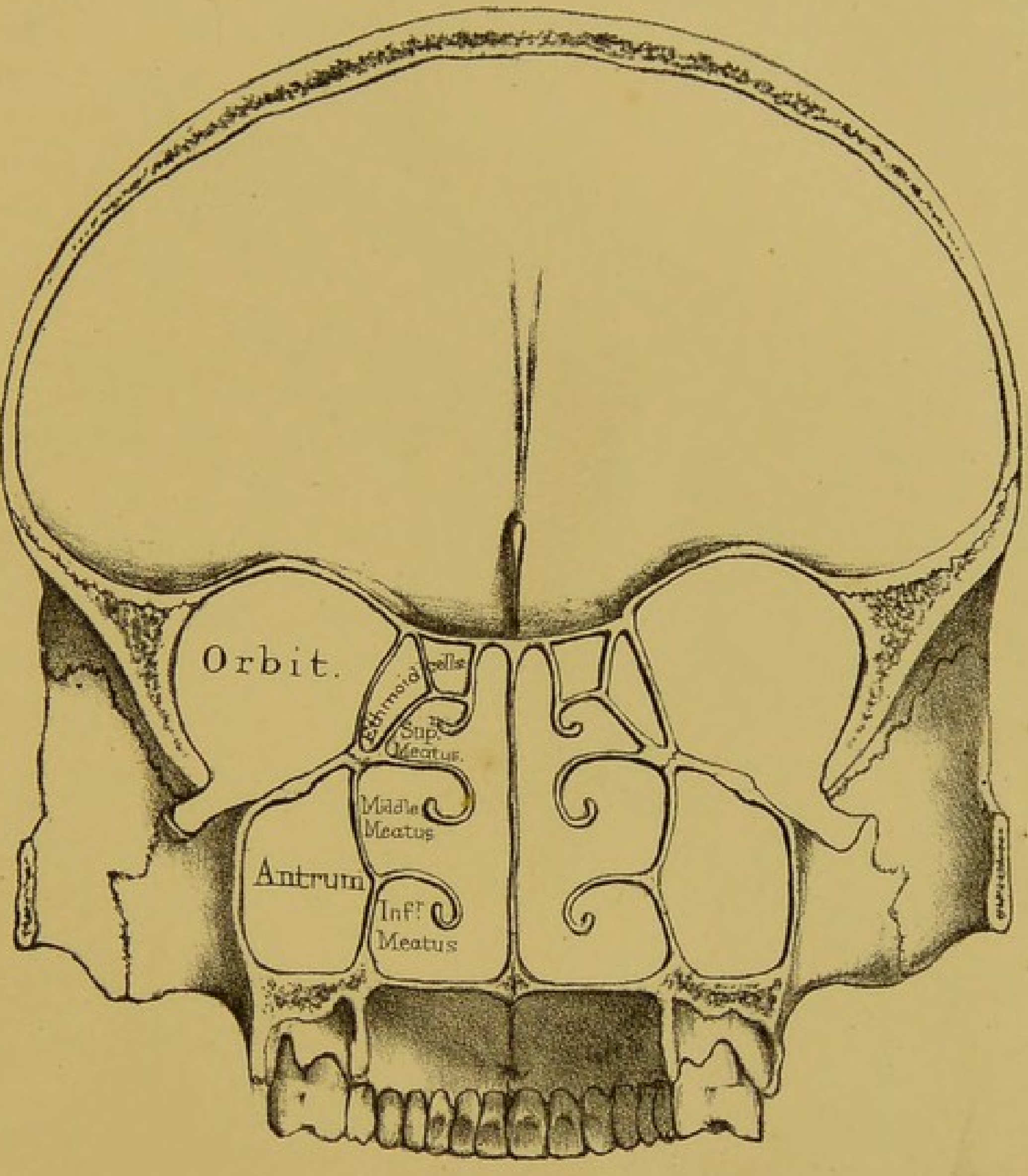
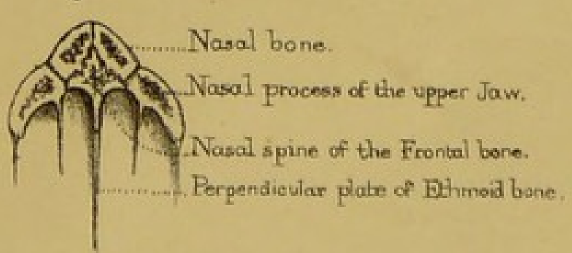
T. Godart Lith

Fig. 1.



Section showing the Meatus" of the Nose.

Fig. 2.



Section showing the Nasal arch.

L. Holden Del. T. Godart Lith

THE INFERIOR MAXILLARY BONE.

(Plate XVI.)

For convenience of description we divide the lower jaw into the arched part in front, which we call the "body" of the jaw, and the part behind, called the "ramus," which ascends at nearly a right angle. At the top of each ramus we observe the "condyle" or articular surface, the "coronoid" process for the insertion of the powerful temporal muscle, and the "sigmoid notch." Let us examine what is to be seen, first, on the convex surface of the "body;" secondly, on the concave surface; and, lastly, on each surface of the ramus.

Body. The convex part of the body presents, exactly in the centre, a slight ridge, termed the "symphysis." This is the strongest part of the bone, and indicates where the two halves of the bone grew together.* Observe that its direction is vertical: this is one of the characteristics of man; he alone has a chin. The "symphysis" terminates, below, in a triangular "mental process," which is more or less marked in different individuals. On each side of the symphysis is a slight depression, termed the "mental fossa," which gives origin to the "levator menti" muscle. More externally, and generally in a line with the first præ-molar tooth, is the "foramen mentale,"† which transmits the "mental branch" of the dental nerve and artery. From the lower part of the symphysis we trace the beginning of the "external oblique

* In serpents the lateral halves of the jaws, upper and lower, are not united by bone, but held together by an elastic ligament, which permits the two halves of the jaws to be separated from each other sideways, to a considerable extent. This is one of the many provisions by which a boa is enabled to swallow its prey, though larger than its own body.

† The position of the "foramen mentale" is by no means constant.

line" or ridge, which curves backwards towards the root of the coronoid process. This line gives origin to the "depressor labii inferioris" and "depressor anguli oris" muscles. A little below both these, is the insertion of the "Platysma-myoides" of the neck. Along the alveolar border near the molar teeth is one origin of the "buccinator."

On the concave or hinder surface of the body (fig. 2), we observe, at the symphysis, four small tubercles, *i. e.* two on each side, one above the other; the upper one gives origin to the "genio-hyo-glossus," the lower, to the "genio-hyoideus" muscle.* Beneath these, there is a well-marked depression on each side, for the insertion of the "digastricus." On this surface, also, we see another oblique line, beginning faintly near the symphysis, and becoming gradually more prominent as it ascends, backwards below the last molar tooth. It is called the "mylo-hyoid ridge," because it gives origin to the "mylo-hyoideus" muscle. Beyond this, it gives origin to part of the "superior constrictor" of the pharynx. Below this ridge is a slight depression, indicating the place where the sub-maxillary salivary gland lies. Above the ridge is the place for the sublingual gland; but this is not well marked.

The oblique lines or ridges alluded to on the two surfaces of the body, denote something more than mere muscular impressions. They indicate the limit between the "alveolar" part which contains the teeth, and the lower or "basilar" part of the jaw. We make these distinctions because these parts come and go at different periods of our existence. In infancy we have only the alveolar part; towards puberty the basilar part slowly grows to perfection; in old age again when the teeth fall out, and their sockets are absorbed, the basilar part alone remains, and the chin gradually approximates the nose. The absorption of the sockets (alveoli) which is natural in old persons, becomes disease when it happens in middle life, and produces premature age in the jaws. This absorption is apt to arise from long salivation, scurvy, or purpura; frequently it is hereditary.

* These four tubercles in some instances are confluent, and appear as one.

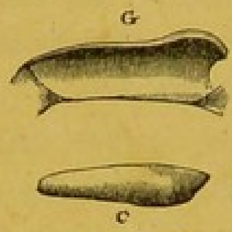
Teeth in the lower jaw. The teeth in the lower jaw correspond in number (16) with those in the upper, but differ from them in one or two particulars:—1. The lower molars have only two fangs, an anterior and posterior, while the upper molars have three; 2. When the mouth is closed the teeth of the lower jaw shut behind those of the upper jaw which forms a larger arch; 3. The external tubercles or cusps of the teeth of the lower jaw fit into the hollows between the external and internal cusps of the teeth of the upper jaw; by which arrangement we are enabled to use the entire surface of the opposing teeth in grinding the food. When the jaws are closed, each tooth in one jaw is opposed by two in the opposite jaw; one good result of this is, that when we lose a tooth, the corresponding tooth in the other jaw being still more or less opposed, is still of service in mastication.

Ramus. The ramus of the jaw mounts up from the body nearly at a right angle. Hence we speak of the "angle" of the jaw. Excluding its outstanding processes, the ramus is nearly square. Nearly the whole of its outer surface gives insertion to the powerful "masseter" muscle, which closes the jaw (fig. 1). On its inner surface (fig. 2) we observe the "dental foramen," or the orifice of the canal for the transmission of the inferior dental nerve and artery. The inner margin of the orifice is raised into a short "spine" for the attachment of the internal lateral ligament of the jaw. Leading down from the orifice is the "mylo-hyoid groove," which contains the small nerve of the same name. Below the groove is the rough surface for the insertion of the "pterygoideus internus" muscle. Observe that strong muscles are inserted into the *angle* of the jaw both on the outer and on the inner surface; and that for this reason fractures through this part of the bone sometimes escape detection.

Condyle. The "condyle" projects from the upper and back part of the ramus in order to form the joint of the jaw, and it fits into the glenoid cavity of the temporal bone. It is oblong in form, with the long axis directed horizontally inwards and slightly backwards, so that, if prolonged, the axis of the two condyles would meet near the front of the "foramen magnum." The condyle is supported on a contracted part termed the "neck" of the jaw. This neck is flattened in the same direction as the condyle, and is slightly excavated in front for the insertion of the "pterygoideus externus" muscle.

Why are the condyles of the jaw placed obliquely? The answer is, in order to facilitate the oblique rotatory movements necessary for the mastication of our food. In masticating, we can readily feel that one condyle advances towards the anterior margin of the glenoid cavity, while the other recedes towards the posterior margin.

FIG. 14.



The joint of the lower jaw in man, is a much more beautiful mechanism than it appears at first sight; but in order to appreciate it we must look a little at the form of the joint in animals. In all animals the joint of the lower jaw varies according to the structure of their teeth and the food they eat. There are three principal types of this joint:—the carnivorous, the ruminant, and the rodent. The *carnivorous* type is a simple transverse hinge: this form is well seen in the badger, in which animal the condyle of the jaw is mechanically locked in its socket. It is shown in fig. 14, where G represents the shape of the glenoid cavity, and C the shape of the condyle which fits into it. The *ruminant* type presents a socket and a condyle nearly flat so as to admit of the lateral movement necessary for grinding the food. This form is seen in fig. 15, which is taken from the sheep. In the *rodent* type there is a longitudinal groove in the temporal bone in which the condyle plays from before backwards like a plane. Fig. 16 shows the corresponding surfaces of the glenoid cavity (G), and the condyle (C) in the capybara.

FIG. 15.

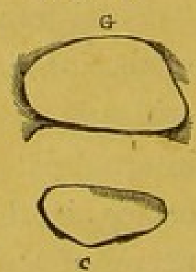
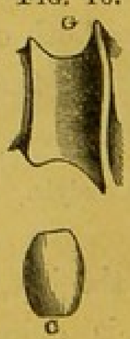


FIG. 16.



Now the joint of the lower jaw in man partakes, more or less, of the nature of these three types: that is to say,

INFERIOR MAXILLA.

Fig. 1.

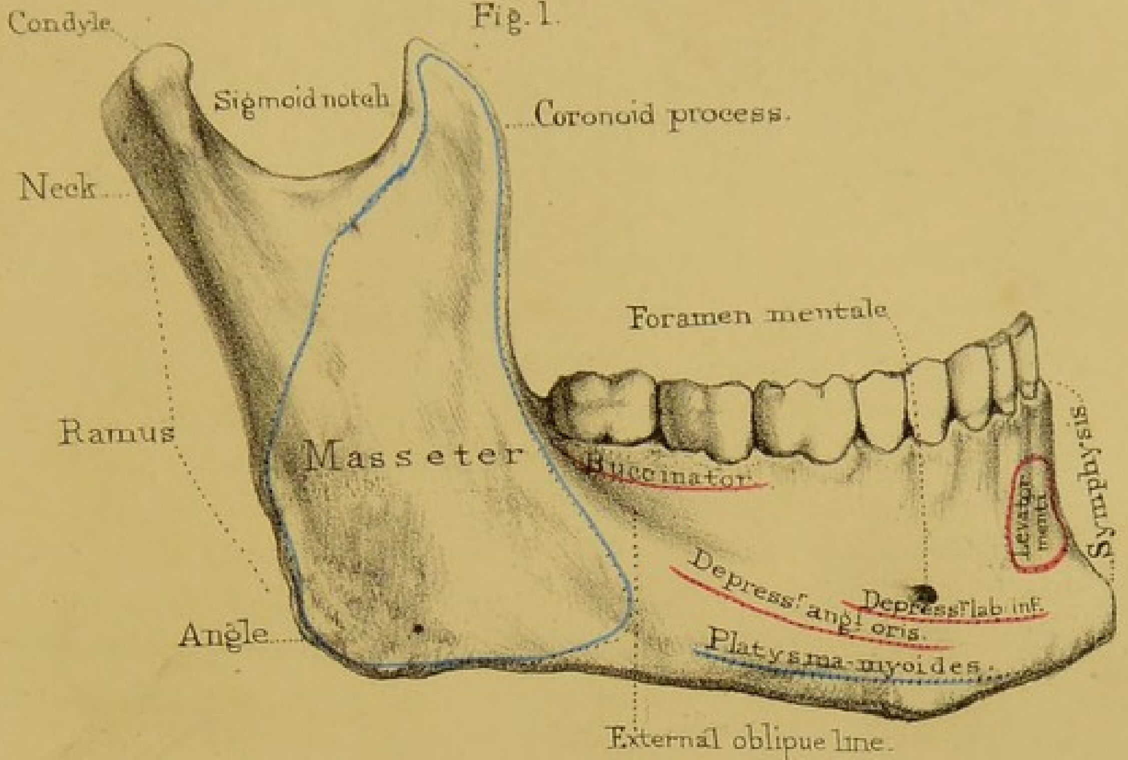
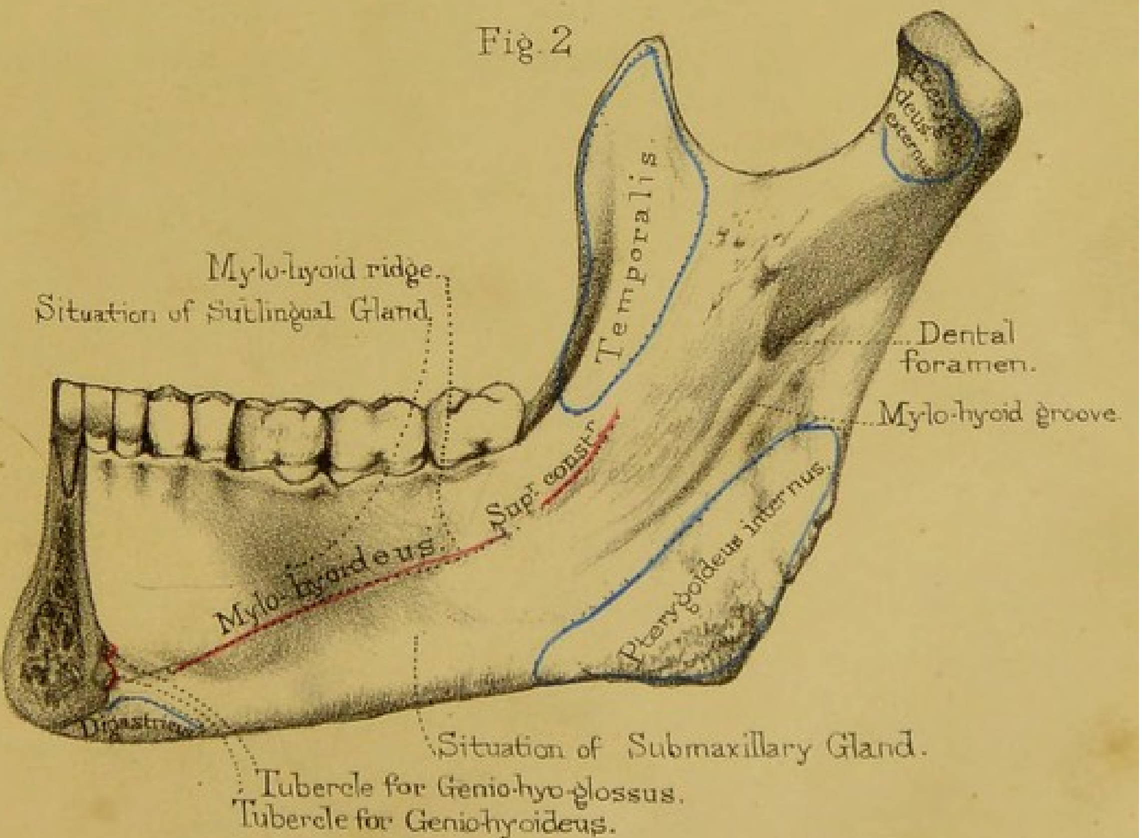


Fig. 2



L. Holden ad naturam del.

T. Godart Lith.

we can move our jaw in the vertical direction, from side to side, and from before backwards. The teeth of man are likewise intermediate in structure between those of carnivorous and those of ruminant animals. Man, therefore, is omnivorous.

The "coronoid" process is a triangular, lofty plate of bone, which ascends beneath the zygomatic arch in order to increase the leverage of the temporal muscle which closes the jaw. Observe that the insertion of this muscle occupies only the inner surface and front border of the process; the outer surface of the process is occupied by the masseter. Respecting the "sigmoid notch" there is nothing to be said, except that it transmits the "masseteric" nerve and artery.

The walls of the lower jaw, particularly at the basilar part, are exceedingly compact and tough. In operations for removal of parts of the bone, it is necessary to use the saw freely, before the bone forceps can be of any service. The interior assumes the form of "diploe," and is traversed by the "inferior dental canal," which carries the vessels and nerves to the teeth. We have seen that the canal begins on the inner side of the ramus; if it be traced out by cutting away the inner wall, we shall find that it curves forwards, beneath the sockets of the teeth, and, towards the front, divides into two, of which one ends at the "foramen mentale," the other, much diminished in size, runs on through the diploe nearly to the symphysis, in order to convey vessels and nerves to the canine and incisor teeth.

The lower jaw has two centres of ossification, one for each lateral half. Their junction at the symphysis takes place about the close of the first year after birth. In the lower animals the symphysial suture remains throughout life.

SKULL AS A WHOLE.

The examination of the skull as a whole is easy and intelligible, provided the individual bones have been carefully studied.

Course of the sutures.

First of all we must learn the course of the sutures. This is of practical moment,—1, because it enables us to say with precision in what direction the head of the child is presenting during labour; 2, because in injuries of the skull we must not commit the error of mistaking a suture for a fracture;* 3, because it is desirable not to trephine in the course of the sutures.

The "coronal suture" (Plate XX. *a*) (fronto-parietal) connects the frontal with the parietal bones. It extends transversely across the top of the skull, from the great wing of the sphenoid on one side to the other. Concerning the construction of this suture we have to remember, that in the middle the frontal overlaps the parietal bones, whereas at the sides the parietals overlap the frontal: a provision which manifestly tends to lock the bones together.

The "sagittal suture" (inter-parietal) connects the two parietal bones. It runs directly backwards, in the middle line, from the frontal to the occipital bone.

The "frontal suture" is formed by the union of the two halves of the frontal bone. It runs down the middle of the forehead, from the sagittal suture to the root of the nose. It always exists in infancy and childhood, but is generally obliterated in the adult.

The "lambdoid suture" (Greek letter Λ) (occipito-parietal) unites the two parietals to the occipital bone.

The "occipito-mastoid suture,"† apparently a continuation of the

* Skilful as he was, Hippocrates once mistook a natural suture of the skull for a fracture, and was afterwards so ingenuous as to leave his mistake on record. On this, Celsus observes: "A suturis se deceptum esse Hippocrates memoriæ prodidit, more scilicet magnorum virorum, et fiduciam magnarum rerum habentium. Nam levia ingenia, quia nihil habent, nihil sibi detrahunt: magno ingenio, multaque nihilominùs habituro, convenit etiam simplex veri erroris confessio; præcipuèque in eo ministerio quod utilitatis causâ posteris traditur, ne qui decipiantur eâdem ratione, quâ quis antè deceptus est." (liber viii. cap. iv.)

† The old anatomists call this the "additamentum suturæ lambdoidalis." This old name, as well as others mentioned in the text, *e. g.* "Coronal," "Sagittal," and "Lambdoid," are gradually falling into disuse, and giving place to more appropriate terms, derived from the bones connected, as, "inter-parietal," "fronto-parietal," &c.

lambdoid, connects the occipital with the mastoid portion of the temporal bone.

The mastoid part of the temporal is connected to the posterior inferior angle of the parietal bone by the "masto-parietal suture."

The squamous part of the temporal is connected to the parietal bone by the "squamous suture" (squamo-parietal); and to the great wing of the sphenoid by the "squamo-sphenoidal" suture. Concerning these connections, we must observe the great extent to which the squamous bone overlaps the parietal; an adaptation which mainly strengthens the arch of the skull at the sides, and prevents the lateral expansion of the buttresses.

Wormian bones. In the mastoid suture more frequently than in any other, we meet with what are termed "Wormian* bones," or "ossa triquetra." They are like little islands of bone developed from distinct centres, in the membrane which connects the cranial bones. They vary in number and size. In the museum of the College of Surgeons there is the hydrocephalic skull of an adult (from the collection of the late Mr. Liston), in which there are upwards of one hundred of these little bones.

Of the sutures which connect the bones of the cranium with the face, there is one which deserves notice, as being very comprehensive. It is called the "transverse frontal suture." It extends from the external angular process of the frontal bone, from one side to the other, across both orbits and the root of the nose (Plate XIII.). It connects the frontal with the malar, sphenoid, ethmoid, lachrymal, superior maxillary, and nasal bones. Other short sutures, such as the "spheno-malar," "spheno-parietal," "zygomatic," &c. speak for themselves.

We said that a knowledge of the sutures concerns midwifery. It enables us to say which way the head of the child is presenting. If we feel the meeting of the three sutures at the top of the occipital bone, we know the back of the head presents; if, on the other hand, we feel the "anterior fontanelle," or lozenge-shaped

* So called after Olaus Wormius, a physician of Copenhagen, to whom the first description of these "complementary" bones has been assigned,—but erroneously: they were known to Eustachius and Paracelsus.

space where four sutures meet, we know it is a forehead presentation.

THE SKULL-CAP.

Outer surface. The skull-cap is composed of the expanded arches of three of the cranial vertebræ, and forms a beautiful oval dome for the protection of the brain. We all know the outward form of the head and that the greatest breadth of it is about the parietal protuberances. In a well formed European head, if we look at the dome of the skull-cap from above, (the beginning of the sagittal suture being in the centre of the perspective plane) we see scarcely anything but the smooth expanded vault of the cranium. But in the Negro and the Australian, the narrowness of the temples allows the zygomata to come into view, and in the most "prognathous" examples, the incisor teeth appear in front of the frontal sinuses. On the outer surface of the skull-cap there are a multitude of minute foramina, which transmit blood-vessels from the pericranium into the substance of the bone. Hence, if this membrane be torn off during life, the bone bleeds through minute pores. We observe on each side of the sagittal suture the "foramen parietale," which transmits a vein from the outside into the great longitudinal sinus: sometimes a small artery runs with it, and communicates with a branch of the middle meningeal. Along the side of the skull-cap we observe the curved line called the temporal ridge (Plate XIV.). It indicates the attachment of the temporal aponeurosis, and runs along the side of the frontal and parietal bones. The ridge circumscribes the "temporal fossa" which is formed by the frontal, parietal, temporal, sphenoid, and malar bones. The fossa gives origin to the temporal muscle, of which the tendinous rays, converging beneath the zygoma, are inserted into the coronoid process of the lower jaw. The size of the temporal fossa in all animals depends upon the size of the temporal muscle. Hence it is largest in the carnivora. In these animals the fossa occupies the whole side and upper part of the skull, and is increased in extent by bony ridges growing from the frontal, parietal, and occipital bones; so that their enormous temporal muscle almost completely covers the cranium.

Inner surface. On the inner surface of the skull-cap we observe —1, the groove in the middle line, which gradually becomes broader as we trace it backwards, for the great longitudinal sinus; 2, on either side of this, especially in old skulls, there are a number of irregular excavations, occasioned by the "so-called" glands of Pacchioni;* 3, grooves for the ramifications of the "arteria meningea media." The main groove, at first perhaps a complete canal, is seen at the anterior-inferior angle of the parietal bone; from thence we trace its wide-spreading branches over the frontal and parietal bones: one of very considerable size often traverses the posterior-inferior angle of the parietal. The surgical interest attached to these groups is—1, that we ought not to apply a trephine in the course of them; 2, that, in fractures of the skull, the arteries running in them are liable to be injured, and thus occasion an effusion of blood between the bone and the dura mater, producing compression of the brain.

Thickness of the skull-cap. The skull-cap differs in thickness in different parts. This is easily ascertained by holding it to the light. As a general rule, it is thicker in parts which are most exposed to injury,—as at the frontal, parietal, and occipital eminences, also along the course of the longitudinal sinus. If one were asked, what is *about* the ordinary thickness of an adult skull, one would say, about one-fifth of an inch. But then it would be right to add, that it varies very much at different periods of life. In the anatomical museum at Pavia there is the skull-cap of a child, in which a hole was picked by the beak of an angry cock. Whoever is in the habit of making post-mortem examinations will soon observe how much skulls vary in thickness, even in persons of the same age, and this without any obvious reason to account for it. Generally speaking, any cause which produces a chronic congestion of the vessels of the head,—such as habits of intemperance, —will increase the thickness of the skull. For the same reason constant exposure to the action of the sun will thicken and

* These are not true glands, but fleshy excrescences from the surface of the dura mater.

indurate the skull-cap. The pathology of "Herodotus"* is very sound when he says that "the Egyptians have thick skulls because they expose their shorn heads to the heat of the sun; whereas the Persians have thin and soft skulls, because they cover them with turbans from infancy." A severe blow may thicken the skull." Mr. Quekett has in his possession part of a skull-cap nearly an inch in thickness. It belonged to a gentleman who received a blow on his head some years before his death. He recovered perfectly, to all appearance, from the effects of the injury. By and by, however, his head began to grow larger;—but this, strange to say, was first discovered by his hatter, who found it necessary from time to time to give him a larger hat.

In very old persons, the skull-cap, owing to the absorption of the diploe, becomes in some parts not thicker than a shilling. Not only the skull, but all the bones become much lighter in old age. Soemmerring says the skull of a centenarian is two-fifths lighter than in middle age. There may be some truth in the mediæval saying that "old witches do not sink in water."

The inner surface of the skull-cap is marked by the cerebral convolutions, so that it takes a pretty accurate impression of the brain. But it cannot be said with truth that a particular impression on the inner surface has a corresponding bump outside. A glance at any skull-cap is sufficient to prove this. The depressions occasioned by the convolutions take place at the expense of the diploe; and even the external bumps are often caused by a mere thickening of the outer table. On the other hand it holds good, as a general rule, that the external form and dimensions of the cranium may be taken as a *general* expression of the corresponding lobe of the brain, whether in the frontal, the parietal, or the occipital region. The general characters of the brain, then, may be ascertained by external examination, but not the individual detail.

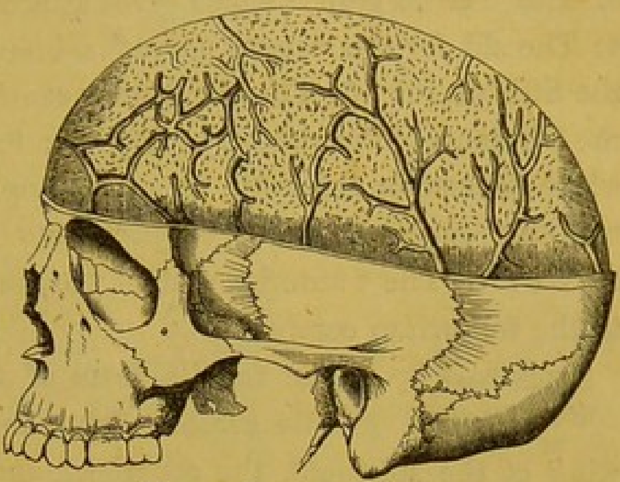
Veins of the diploe.

The diploe of the skull-cap is traversed by numerous venous canals. These, as shown in the adjoining cut (fig. 17), are of considerable size, and are best dis-

* Thalia, xii.

played by filing off the outer table. Their course is by no means so regular as they are commonly drawn; but, in a general way, we may speak of the frontal, temporal, and occipital "diploic" veins. The two former discharge their blood into the veins on the outside of the cranium; the latter generally opens into the lateral sinus. After injuries of the head, these veins are liable to inflammation, and thus give rise to pus in the diploe, accompanied with all the disastrous effects of phlebitis. This suppuration in the diploe, explains the hitherto inexplicable occurrence of visceral abscesses, especially hepatic after injuries of the head,—a circumstance which had not escaped the notice of the old surgeons.

Fig. 17.



Venous Canals in the Diploe.

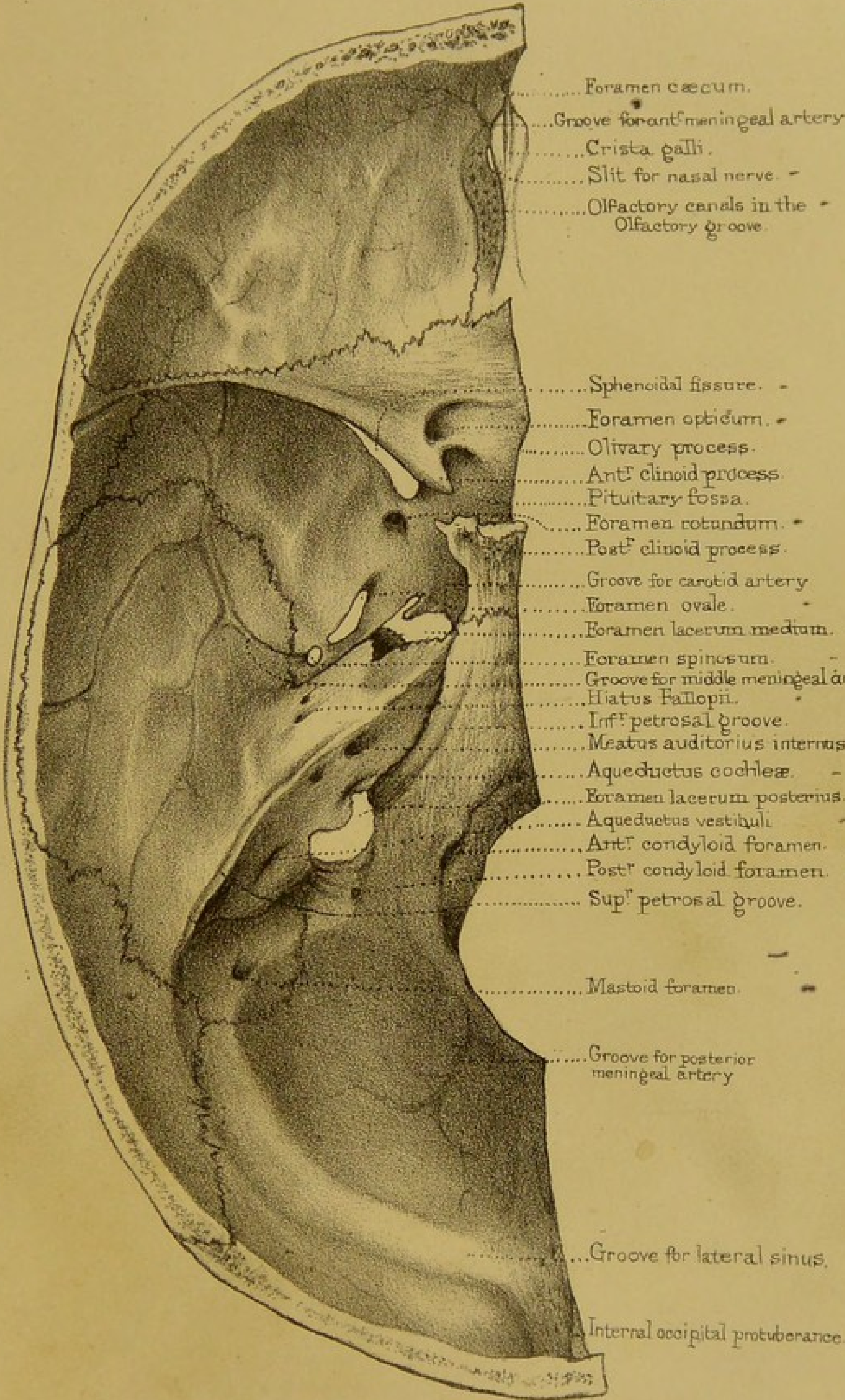
BASE OF THE SKULL AS SEEN FROM WITHIN.

By referring to Plate XVII. it will be observed that the base of the skull presents on each side three fossæ,—an anterior, middle, and posterior,—respectively corresponding to the anterior and middle lobes of the cerebrum, and to the cerebellum. These several fossæ are marked by the cerebral convolutions, just as much as the skull-cap; but phrenologists take no notice of *these* convolutions, and have omitted to assign any office to them. All their "organs" are placed at the top and sides of the brain;—why are there none at the base?

Anterior fossa of the cranium. The anterior fossa of the cranium is formed by the orbital plate of the frontal and the lesser wing of the sphenoid. Between the orbital plates we observe the cribriform plate of the ethmoid, which supports the olfactory lobes. The points to be noticed in this fossa are as follow:—1. The "foramen cœcum," which, if pervious, generally transmits a vein from the nose into the longitudinal sinus: 2. The groove for the "anterior meningeal artery," one of the secondary branches of the ophthalmic: 3. The "crista galli," which gives attachment to the falx cerebri: 4. The slit for the "nasal nerve," a branch of the first division of the fifth nerve: 5. The "olfactory canals," which give passage to the filaments of the olfactory ganglion: 6. The "foramen opticum," which transmits the optic nerve and ophthalmic artery: 7. The "olivary process," which supports the commissure of the optic nerves: 8. The "anterior clinoid process," which gives attachment to the tentorium cerebelli.

Middle fossa of the cranium. The middle fossa of the cranium supports the middle cerebral lobe, and is formed by the great wing of the sphenoid, the squamous and petrous portions of the temporal bone. The points to be noticed in this fossa are as follow:—"The sphenoidal fissure" between the wings of the sphenoid leads to the orbit, and transmits the 3rd, the 4th, the first division of the 5th, and the 6th nerves, also some filaments of the sympathetic and the ophthalmic vein. The "foramen rotundum" gives passage to the superior maxillary, or second division of the 5th nerve. The "foramen ovale" gives passage to the inferior maxillary or third divison of the 5th nerve, and also to the arteria meningea parva. The "foramen spinosum" gives passage to the arteria meningea media and its two veins;—the main trunk of this artery grooves the squamous part of the temporal and the anterior-inferior angle of the parietal bone. The "foramen lacerum medium" is blocked up, in the recent state, by fibro-cartilage: through this cartilage the Vidian nerve enters the skull. The internal carotid artery also passes through it. At the apex of the petrous portion of the temporal bone is the termination of the "carotid canal" through which the carotid artery enters the skull: the artery then winds along the groove on the side of the body of the sphenoid. In the centre of the sphenoid is the "pituitary fossa," for the reception of the pituitary gland. The "posterior clinoid process" gives attachment to the "tentorium* cerebelli," a

* This "tentorium" is ossified in the seal tribe and in the carnivorous mammalia.



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J. Sarrill, Printer.

On stone by T. Godart.

process of the dura mater which supports the posterior lobes of the brain.

Posterior fossa of the Cranium. The posterior fossa is the largest and deepest of the three cranial fossæ, and is formed by the occipital bone, the petrous and mastoid parts of the temporal bone. It supports the cerebellum. Proceeding from before backwards, we observe, in the middle line, the "basilar groove," which supports the medulla oblongata and the pons. On each side of this is the groove for the "inferior petrosal sinus." Along the top of the petrous bone is the groove for the "superior petrosal sinus." Both these sinuses terminate in the great lateral sinus, which is seen grooving, successively, the occipital, posterior-inferior angle of the parietal, mastoidpart of the temporal, and, last of all, the jugular process of the occipital bone. Behind the basilar process is the "foramen magnum," which transmits the spinal cord and its membranes, the vertebral arteries, and the spinal accessory nerves. On each side of the foramen magnum are the "condyloid foramina," of which the "anterior" transmits the hypoglossal or 9th nerve (motor nerve of the tongue); the "posterior," a vein from the outside of the skull into the lateral sinus. The "mastoid foramen" also transmits a vein from without into the lateral sinus. At the back part of the petrous bone there is the "meatus auditorius internus," which transmits the 7th pair of nerves and the auditory artery. The "aqueductus vestibuli" transmits, if any thing, a small vein from the vestibule of the ear. Lastly, the "foramen lacerum posterius" transmits the blood from the lateral sinus into the internal jugular vein, and also the three divisions of the 8th nerve.

BASE OF THE SKULL AS SEEN FROM BELOW.

(Plates XVIII. XIX.)

The base of the skull comprises such a wide area, that it is desirable to draw certain limitary lines. If, then, a line be drawn from the first incisor tooth on each side, backwards to the mastoid process, and another transversely, from one mastoid process to the other, we shall describe a triangle within which are contained all the parts usually spoken of as at the base of the skull.

Palate. Commencing at the front, we observe the arch of the "hard palate," formed by the superior maxillary and palate bones: its "middle" and "transverse" sutures cross each other at right angles. A pin introduced at the point of crossing would touch five bones, the 5th being the vomer. Generally speaking, when the palate presents a fine arch, free from contraction in any direction, the voice is clear and sonorous. The best singers have always well-formed palates. Observe how rugged its surface is for the lodgment of the palatine glands, and how it is riddled with minute holes for the passage of blood vessels. Behind the incisor teeth is the "anterior palatine canal." This is a single orifice below, but double above, so as to open separately into each nostril. It transmits the anterior palatine vessels and nerves. Near the last molar tooth is the "posterior palatine canal," formed conjointly by the palate and superior maxillary bones: and from this we trace forwards the "palatine groove" for the lodgment of the posterior palatine vessels and nerves. Lastly, there is the "ridge" on the palate-bone for the attachment of the "tensor palati," and the "posterior nasal spine," to which is attached the "azygos uvulæ" muscle.

Posterior openings of nose. Behind the palate we observe the "posterior openings of the nasal fossæ," separated by the sharp edge of the vomer. Each opening is somewhat oval, about one inch in the long diameter and half an inch in the transverse. We should remember this in plugging the nostril. It is bounded, above, by the body of the sphenoid and the sphenoidal process of the palate bone; below by the horizontal plate of the palate; outside by the internal pterygoid plate of the sphenoid; and inside, by the vomer. On the roof of each we notice the expanded "wings" of the vomer, which receive between them the "rostrum" of the sphenoid; and also the "pterygo-palatine canal." This, as its name implies, is formed conjointly by the "pterygoid plate of the sphenoid and the sphenoidal process of the palatine bone, and transmits nothing of importance beyond a branch of the internal maxillary artery to the top of the pharynx.

Pterygoid region. On each side of the nasal openings are the "pterygoid processes" of the sphenoid. These pterygoid processes answer three purposes:—1. They bound the posterior openings of the nose. 2. They act as buttresses to support the upper jaw-bones behind. 3. They serve for the origin of the powerful pterygoid muscles which grind the food. From the pterygoid fossa, or, more strictly, from the *inner* surface of the external pterygoid plate, arises the "pterygoideus internus;" while the *outer* surface of the same plate gives origin to the "pterygoideus externus." At the base of the internal plate is the scaphoid fossa, for the origin of the "tensor palati;" and at the apex is the beautiful pulley, termed the "hamular process," round which the tendon of this muscle turns. Besides this, the hamular process gives origin to part of the "superior constrictor" of the pharynx. Immediately above the "scaphoid fossa," we notice the posterior orifice of the Vidian canal.

Proceeding backwards from the base of the pterygoid processes, we come next upon the great foramina at the base of the skull, most of which we have already seen in the examination of the base from within. In the great wing of the sphenoid there is the "foramen ovale;" behind this is the "foramen spinosum;" and still farther back is the apex of the wing, termed the "spinous process," which is wedged between the squamous and petrous bones, and gives attachment to the internal lateral ligament of the lower jaw From the spinous process we trace outwards the "glenoid fissure," which runs across the glenoid cavity of the temporal bone. Between the sphenoid and petrous bones is the canal for the "Eustachian tube," which is completed in the recent state by fibro-cartilage.

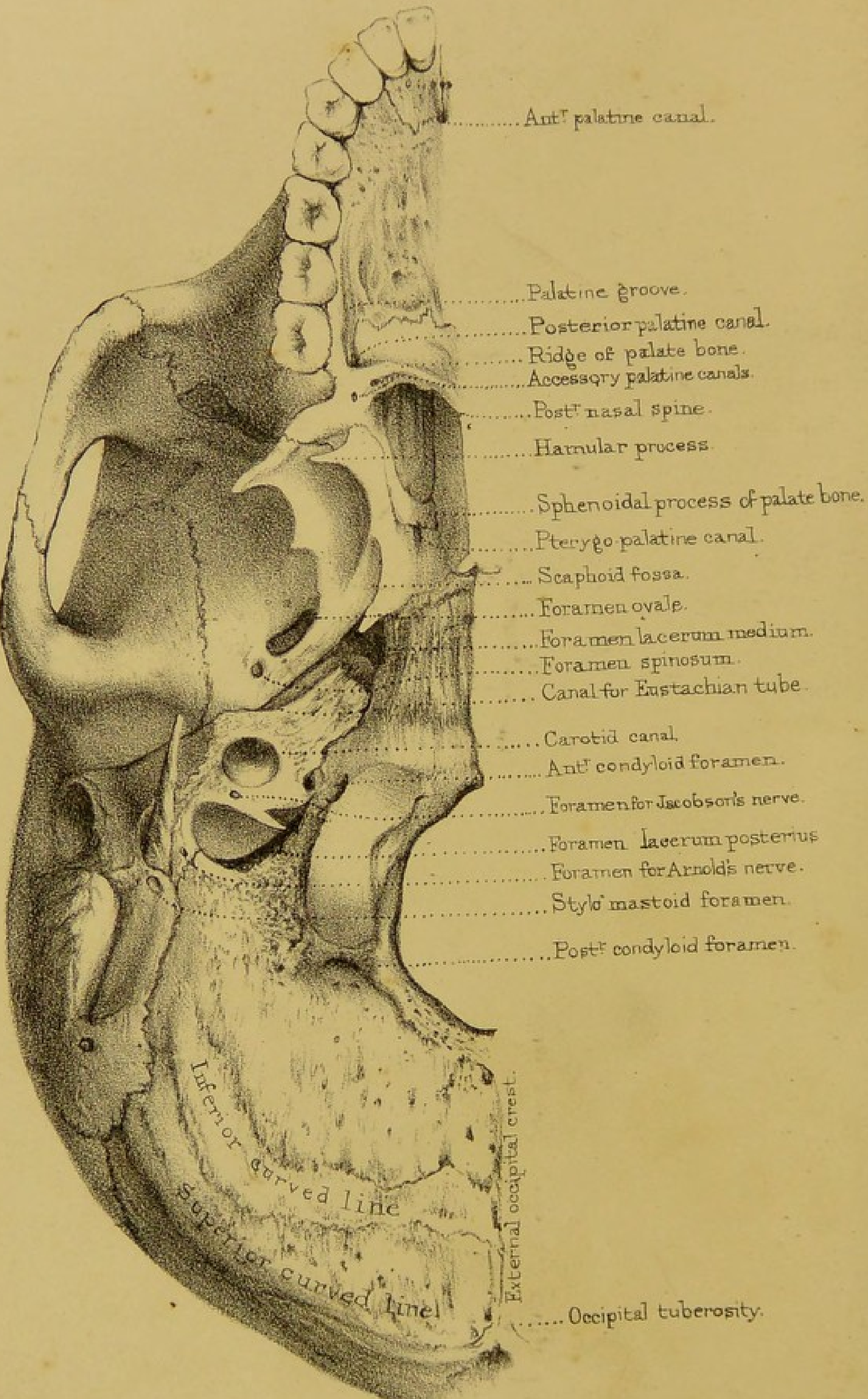
Petrous region. The petrous portion of the temporal bone is wedged in between the sphenoid and the basilar process of the occipital. Observe that the apex of the wedge is cut short, so that an irregular opening remains between the three bones, termed the "foramen lacerum medium." Remember that in the perfect skull this space is filled with cartilage, which serves the important purpose of breaking shocks transmitted to the base, and remember too that through this cartilage pass the internal carotid artery and the Vidian nerve. The apex of the petrous bone gives origin to the "tensor tympani" and "levator palati" muscles. In the middle of the petrous bone is the wide orifice of the carotid canal which transmits the carotid artery. Trace this canal, and you will find that it does not enter the skull direct, but ascends for a short distance, and then runs horizontally forwards and inwards through the petrous bone, till it opens at the apex into the foramen lacerum. Thus the carotid artery has to make two curves, like the letter S, before it enters the skull,—the first curve in the bony canal, and the second through the cartilage which fills up the foramen lacerum. This disposition of the great arteries at the base is intended to check the impetuosity of the blood on its passage to the brain.

Behind the carotid canal is the "foramen lacerum posterius," or "foramen jugulare," another irregular opening left between the petrous and occipital bones. The size and shape of it is subject to great variety*; but it is, generally, divided by a projecting tongue of bone into an anterior part, which transmits the 8th pair of nerves, and a posterior, which is by far the larger, for the passage of the blood from the lateral sinus into the commencement of the internal jugular vein.

Outside the foramen lacerum posterius is the "styloid process," projecting, more or less, beyond the "vaginal process" at its root. Behind this, is the "stylo-mastoid foramen," through which the facial nerve emerges; and still farther back is the mastoid process and the digastric groove for the origin of the digastric muscle.

Basilar process. Lastly, we have to notice how the basilar process of the occipital bone projects into the base of the

* From an examination of many skulls, I find that the right jugular foramen is larger than the left in point of frequency as 2 : 1.



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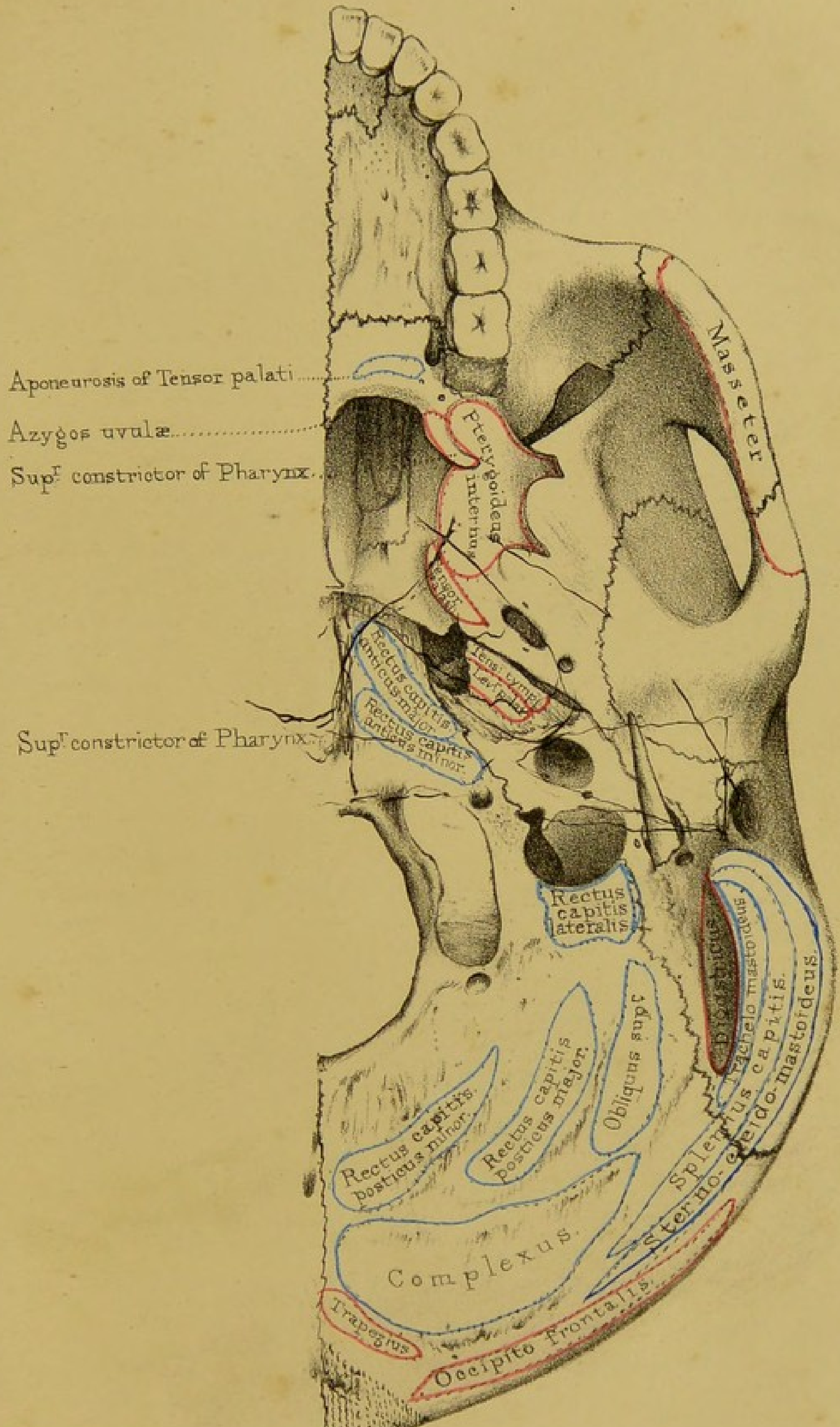


L. Holden, del. T. Godart Lith.

skull, so as to be joined to the body of the sphenoid. Here it forms the roof of the pharynx. This relation is of practical importance. It is well to know that the basilar process is within reach of the finger introduced into the mouth, and that we can explore it satisfactorily, so as to determine how far a polypus may be connected with it. It affords insertion to the "rectus capitus anticus major" and "minor," and (by means of a little tubercle) to the "superior constrictor" of the pharynx. Behind the basilar process is the "foramen magnum." On each side of this are the "condyles" of the occiput, with the "anterior" and "posterior condyloid" foramina; and on the outside of each condyle is the jugular eminence, which gives insertion to the "rectus capitis lateralis."

Position of the occipital foramen.

In a well-formed European skull, the plane of the occipital foramen is horizontal, and its anterior extremity is about half way between the tuberosity of the occipital bone and the incisors of the upper jaw. This central position of the occipital foramen and the condyles is one of the great peculiarities of man, who is destined to stand erect. His head, therefore, is almost equally balanced on the top of the spine. In monkeys, who hold a middle rank between man and quadrupeds, the foramen magnum is placed farther back: in the orang outan, it is about twice as far from the foramina incisiva as from the back of the head. Consequently, although monkeys can stand erect for a time, they cannot do so long. In quadrupeds, again, the foramen magnum is still nearer to the back of the head, and its plane forms a considerable angle with the horizon. The weight of the head in quadrupeds is sustained not by the spine, but by an elastic ligament of great strength (ligamentum nuchæ), which arises from the lofty spines of the dorsal vertebræ, and is fixed to the middle of the occiput. This ligament, as we may imagine, is immensely strong in the elephant. A beautiful example, this, of nature's economy. She accomplishes, by a lowly organised structure, an object which must otherwise have been gained by powerful muscles well supplied with blood and nerves. In other words, she does by mechanical force, what must otherwise have been done by vital force.

TEMPORAL AND ZYGOMATIC AND SPHENO-MAXILLARY FOSSÆ.

The temporal fossa, of which the description has already been given (page 108), leads into the zygomatic fossa, the boundary between them being a crest of the sphenoid bone.

The "zygomatic fossa" is bounded externally by the zygomatic arch, which not only serves as a strong buttress to support the bones of the face, but also to give origin to the powerful "masseter" muscle which closes the jaw.* In front of the fossa there is the back part of the superior maxilla; and, at the bottom of it, the outer pterygoid plate of the sphenoid, which gives origin to the external pterygoid muscle. At the deepest part of the fossa we observe two wide fissures: one, nearly horizontal, leads into the orbit, and is called the "spheno-maxillary fissure;" the other, nearly vertical, leads to the "spheno-maxillary fossa." Now this fossa deserves particular notice, not from any surgical importance, but because there are five openings into it (Plate XX.). Observe, first, its boundaries. In front it is bounded by the back of the superior maxilla, behind by a smooth surface at the base of the pterygoid process, and it is separated from the nasal fossæ by the perpendicular plate of the palate bone.

Spheno-maxillary fossa.

The five openings into the spheno-maxillary fossa are as follow:—

FIVE OPENINGS INTO SPHENO-MAXILLARY FOSSA.

1. Spheno-palatine foramen	transmits into the nasal fossa .	Nasal branch of spheno-palatine ganglion. Nasal branch of internal maxillary artery.
2. Posterior-palatine canal .	transmits to the palate . .	Posterior palatine artery and nerve.
3. Foramen rotundum .	transmits . .	Superior maxillary nerve, or second division of fifth pair.
4. Vidian canal . . .	transmits . .	Vidian artery and nerve.
5. Ptergo-palatine foramen .	transmits . .	Pterygo-palatine branch of internal maxillary artery.

* The zygomatic arch, in all animals, bears a direct proportion to the size of the muscles of the jaw and the character of the teeth. It is most strongly marked in the carnivora. In them it is arched both in the horizontal and the vertical direction, to give more room for the temporal muscle, and more power to the masseter. In the ant-eater, which has no teeth, there is no zygoma.

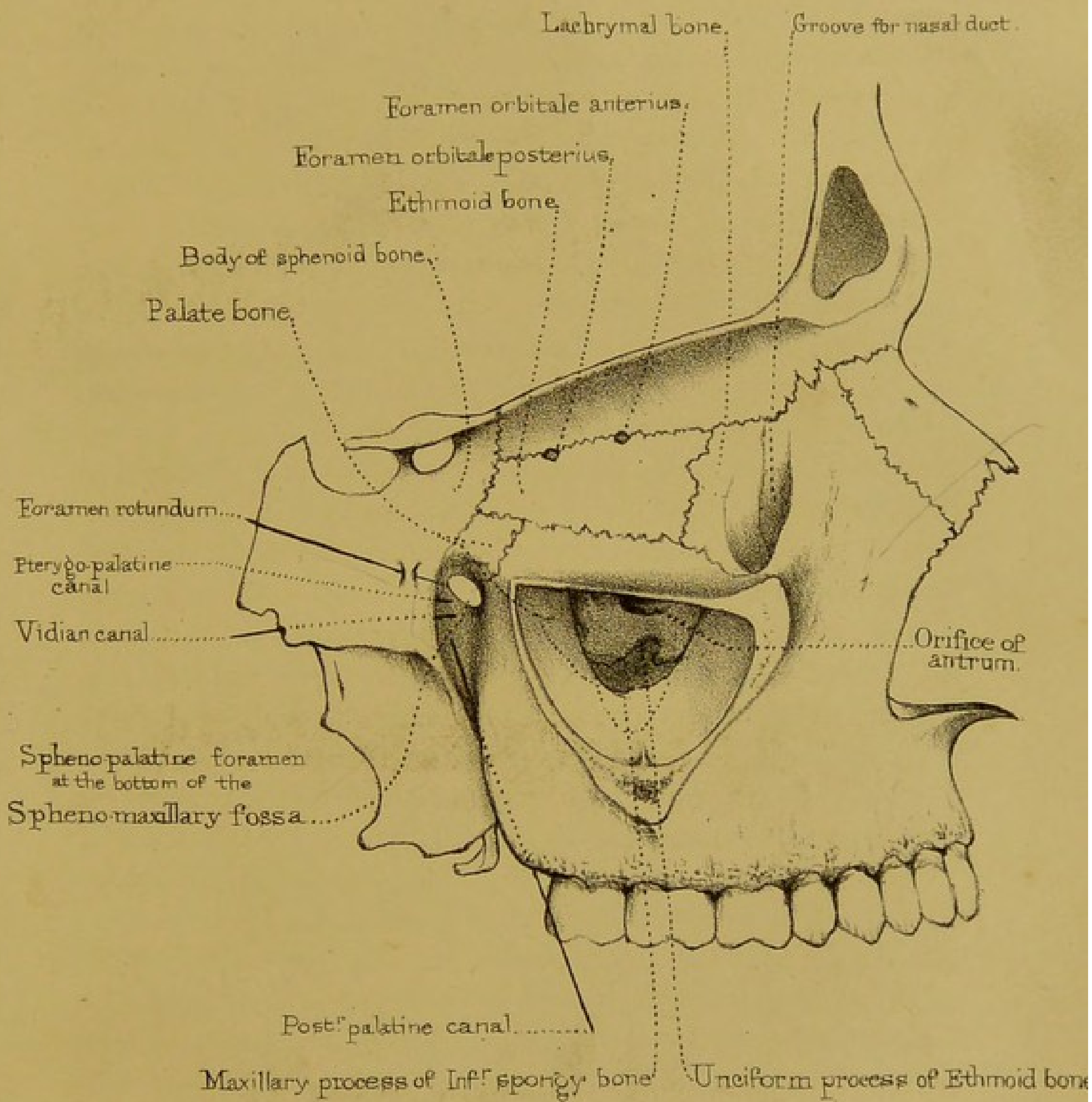


Diagram of the Bones and Foramina

on the inner wall of the Orbit, the five openings into the Spheno-maxillary fossa, the antrum and bones contracting its orifice.

L. Holden del. T. Godart. Lith.

THE ORBITS.

The orbits, or sockets for the eyes, may be compared to crypts excavated beneath the cranium (Plate XX. *a*). To use the words of Sir Charles Bell, "these under arches are groined;" that is to say, they are provided with strong ribs of bone, so that there is no need of thick bone in the interstices of the groinings. The plate between the eye and the brain is as thin as parchment: but look how strong is the arch forming the orbital margin, and what a strong ridge of bone runs up from the zygoma, like a buttress to support the side of the arch. When the eye is retracted in its socket, the margin of the orbit is more than strong enough to protect it from the effects of violence.

Each orbit is of a pyramidal form, with the apex behind. Their axes are not parallel, but, if prolonged, would pass through the optic foramina, and meet behind the pituitary fossa of the sphenoid. This divergence gives us a greater range of vision.

Upper wall of orbit. The upper wall of the orbit is slightly arched, and formed by the frontal bone and lesser wing of the sphenoid bone.* On this wall we have to observe—1, the optic foramen; 2, the fossa beneath the external angular process for the lachrymal gland; 3, the little depression for the pulley of the "superior oblique" muscle; 4, the supra-orbital foramen or notch, situated at the junction of the inner with the middle third of the orbital margin.

Lower wall of orbit. The lower wall of the orbit slopes downwards and outwards, and is formed by the orbital plate of the superior maxilla, by part of the malar bone, and behind by the orbital plate of the palate bone. On this wall there is nothing to observe, except the groove for the infra-orbital nerve.

Inner wall of orbit. The inner wall (Plate XX.) is formed by the nasal process of the superior maxilla, by the lachry-

* The orbital plates of the frontal bone are more or less arched in different skulls Of course the more they are arched, the more they encroach on the cranial space, and the less room there is for the anterior lobes of the brain. Compare the skull of a monkey with that of man in this respect, and you will observe a marked difference. Phrenologists place the organ of language in that part of the brain which rests on the orbital plates; and the gift of languages, they say, is denoted by prominent eyes.

mal, the os planum of the ethmoid, and part of the body of the sphenoid bone. Here we have to observe the groove for the nasal duct, or canal, formed conjointly by the nasal process of the superior maxilla, the lachrymal, and the inferior spongy bone. Its direction is downwards, backwards, and a little outwards, and it leads into the inferior meatus of the nose. Besides this, there is the "foramen orbitale anterius" and "posterius."

Outer wall of orbit.

The outer wall of the orbit is formed by the malar bone and the orbital plate of the great wing of the sphenoid. Here we notice one or two small foramina (malar canals), which transmit small nerves from the orbit to the cheek and temple. Observe that the outer wall of the orbit recedes more than the other parts of its circumference, in order to give a greater range of vision externally. This range is of such an extent that by simply rotating the head on each side of the spine, we can see all around.

Thus, seven bones enter into the composition of each orbit: namely—the frontal, ethmoid, and sphenoid, the superior maxilla, the malar, the lachrymal, and the palate: but there are only eleven bones in the two orbits, since three bones are common to both orbits.

Sphenoidal and spheno-maxillary fissures.

At the back of the orbit we find two wide fissures for the purpose of admitting blood-vessels and nerves. The upper one is the "sphenoidal fissure," formed between the greater and lesser wings of the sphenoid bone. It leads into the cranium, and transmits the third, fourth, ophthalmic branch of the fifth, and the sixth nerve, some filaments of the sympathetic nerve, and the ophthalmic vein. The lower one, termed the "spheno-maxillary fissure," leads into the zygomatic fossa. The borders of this fissure are formed, on one side by the superior maxillary and palate bones, and on the other, by the sphenoid. Often, it is completed in front by the malar. Through this fissure the infra-orbital artery, and the superior maxillary nerve, enter the groove along the floor of the orbit. There are some points of practical interest concerning these two fissures.

1. Concerning the *spheno-maxillary fissure* we should remember that in blows on the temple, blood is apt to make its way

through the fissure into the orbit, and produce ecchymosis under the conjunctiva. 2. In the operation for the removal of the superior maxillary bone, we saw through the orbital wall into the fissure, so that it is requisite to know its precise position. Concerning the *sphenoidal fissure*, we should know;—1, that in fracture through the base of the skull involving this fissure, the effused blood is likely to make its way into the orbit and produce ecchymosis of the conjunctiva, which is therefore always an unfavourable symptom. 2. That a sharp instrument might penetrate through this fissure into the brain. Surgery has such cases on record. Here is one. Henry II. of France, one of the last princes of the House of Valois, was mortally wounded (in a tournament held in 1559, on the occasion of the marriage of Philip II. with Elizabeth of France) by Montgomery, Captain of the body guard. A splinter from a lance entered through the sphenoidal fissure, stuck fast, and could not be extracted. The king died on the eleventh day.

NASAL FOSSÆ.

(Plate XV.)

These cavities open widely to the air in front through the nostrils, and behind into the top of the pharynx. To see them properly, it is indispensable to have a skull divided longitudinally on one side of the septum, so that we can examine the roof, the floor, the outer and inner surfaces of the cavities.

Boundaries of nasal fossæ.

The "roof" of the nasal fossæ is formed by the nasal bones, by the nasal spine of the frontal, the cribriform plate of the ethmoid, and the body of the sphenoid. Observe that it does not form a horizontal line from before backwards. It is only the cribriform plate which is horizontal; from this, the roof slopes forwards towards the nose, and backwards towards the pharynx: therefore the vertical depth is much greater in the middle than elsewhere. Notice the great thinness of the cribriform plate, and how easily an instrument might be thrust through this part of the roof into the brain. Herodotus*, in his excellent description of the process of embalming the dead, as practised by the ancient Egyptians, mentions that they drew out the brain through the nostrils with an iron hook, and filled up the vacuum by injecting drugs.

The "floor" is pretty nearly horizontal, and is formed by the palate plate of the superior maxillary and the palate bone. In the dry bones we notice, on each side of the septum, the orifice of the "anterior palatine canal."

MEATUS of the nose. The outer wall of the nasal fossæ is made irregular by the passages in the nose, and the numerous openings leading to the air cells, which are excavated in the neighbouring bones. It is formed by the ethmoid, the three spongy bones, the nasal, the superior maxillary, the lachrymal, the palate, and the internal pterygoid plate of the sphenoid: in fact, by all the bones of the face except the malar and the lower jaw. Here we have to observe the position of the spongy bones and the three "meatus" or passages of the nose† (Plate XV. *a*). The superior spongy bone is the smallest of the three. Beneath it lies the

Superior meatus. "superior meatus," into which open the posterior ethmoidal cells and the sphenoidal cell. At the back part of this meatus is the spheno-palatine foramen, which leads into the spheno-maxillary fossa.

Middle meatus. Below the middle spongy bone, you observe the "middle meatus." Into this open—1, towards the front, the frontal sinus (or cell), along a passage termed the "*infundibulum;*" 2, the anterior ethmoidal cells (distinct from the posterior); 3, the antrum or maxillary sinus. The orifice of the antrum, observe, is large and irregular in the dry bones; but in the recent state it is so narrowed by mucous membrane that it will just admit a crow-quill.

Inferior meatus. Below the inferior spongy bone is the "inferior meatus." No air-cells open into this meatus: there

* Euterpe, chap. 86, 87, 88.

† In some negro skulls there are four "meatus;" the fourth being above the superior spongy bone.

is only the termination of the nasal duct or channel which conveys the tears into the nose: this cannot be seen without removing part of the spongy bone.

To facilitate reference, we subjoin, in a tabular form, the respective openings into the several "meatus" of the nose—

The superior meatus	receives	The sphenoidal cells. The posterior ethmoidal cells.
The middle . . .	receives	The anterior ethmoidal cells. The frontal cells. The antrum maxillæ.
The inferior . . .	receives	The nasal duct.

Concerning the spongy bones, it should be noticed that the two upper (belonging to the ethmoid) are delicately channelled for the lodgment of the olfactory nerves. The lower one has nothing to do with the sense of smell, and is coarser in its texture. It is traversed by several canals and grooves, which run from before backwards, and in the recent state contain large veins. It is the swelling of these veins which blocks up the passage through the nose in a case of common cold. The spongy bones do not extend all the way along the outer wall. All the surface in front of a perpendicular line let fall from the frontal spine is smooth, as is also all the surface behind a perpendicular line from the spheno-palatine foramen.

Bony septum of the nose.

The bony septum of the nose (Plate XV.) is formed *chiefly* by the perpendicular plate of the ethmoid and the vomer. This septum is one of the principal supports of the nasal arch; a piece of architecture at once light and effective. Accurately speaking, however, we ought also to mention as assisting in the formation of the septum, the nasal spine of the frontal, the crests of the nasal, superior maxillary, and palate bones; and also the rostrum or crest of the sphenoid: making ten bones in all. The triangular interval left in the septum in the dry skull is filled up in the perfect one by the middle cartilage of the nose, which fits into a fissure in the bone.

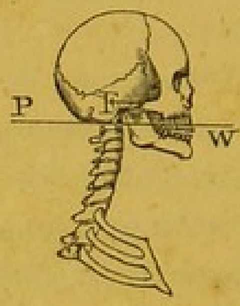
The posterior openings of the nasal fossæ have been already described in the "base of the skull" (p. 114). It only remains to be said that the anterior aperture is heart-shaped, with the broad part below. It is bounded on either side by the nasal bone, and by the nasal process of the superior maxilla: below it is bounded by the palatine process of this bone, which terminates in front by a sharp projection, termed the "anterior nasal spine."

GENERAL OBSERVATIONS ON THE SKULL.

The skull a lever of the first order.

The entire skull represents a lever of the first order. The fulcrum or point of support F (see the annexed cut) is at the occipito-allantoid articulation: the resistance is the weight of the head W: the power P is the mass of muscle attached to the occiput. The lever is not *exactly* balanced on the top of the spine, but very nearly so: and we admire this as one of the many adaptations of the human skeleton for the erect attitude.

Fig. 11.



Three tables of the skull.

The more one examines the skull, the more one sees reason to admire its construction as a case for the protection of the brain. Let us briefly notice a few of the more striking points of it. Look at the structure of the cranial bones. They consist of three layers—an outer, an inner, and an intermediate "diploe." The outer is formed of compact and tough bone; the inner is harder, but more brittle (hence called "tabula vitrea"); while the diploe is soft and spongy to prevent the transmission of shocks. Altogether, then, this structure may be coarsely compared to a case composed of wood outside, porcelain inside, and soft leather between the two.

The different structure of these three layers or "tables" of the skull is interesting to us, practically, as surgeons. In blows on the head, the inner table, in consequence of its greater brittleness, is likely to be broken more extensively than the outer. Cases indeed have occurred, where the inner table has been broken without any injury to the outer. In sabre cuts penetrating the skull-cap as deep as the inner table, Mr. Guthrie * says, that although the cut

* "Commentaries," Lecture xviii.

Fig. 2.

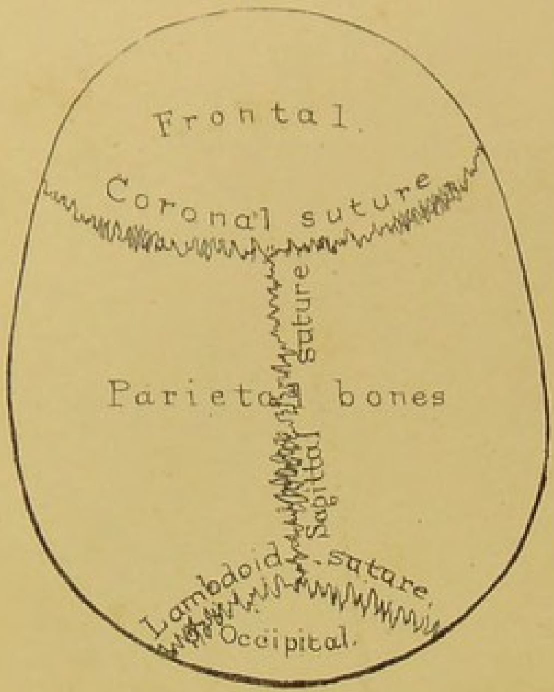
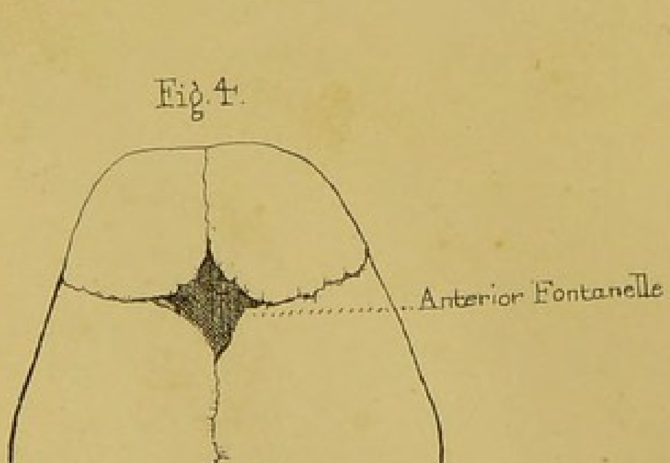
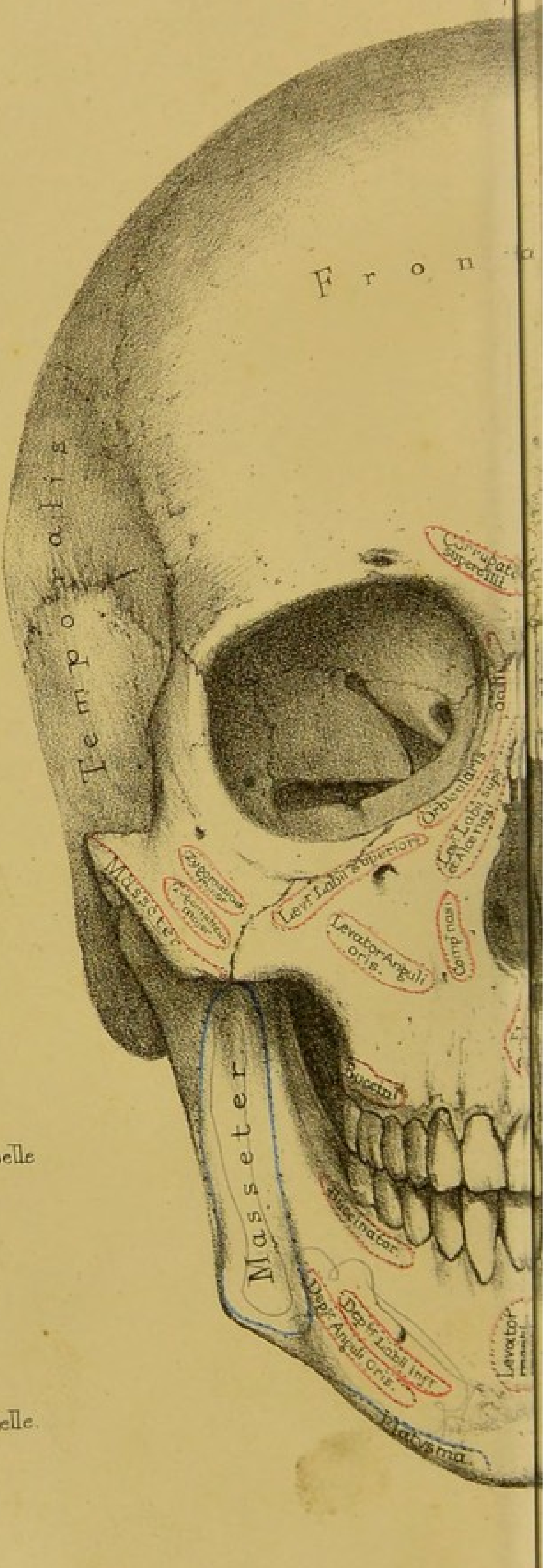


Fig. 4.



Fœtal Skull. full term.



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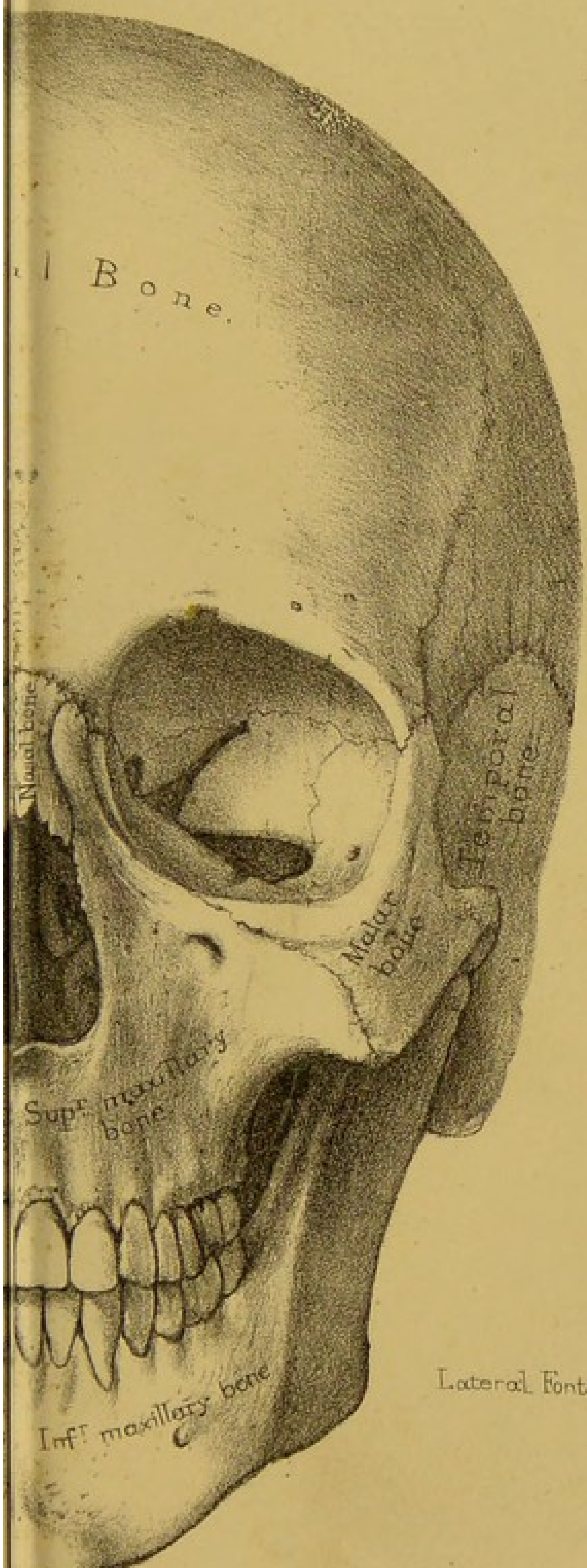


Fig. 3.

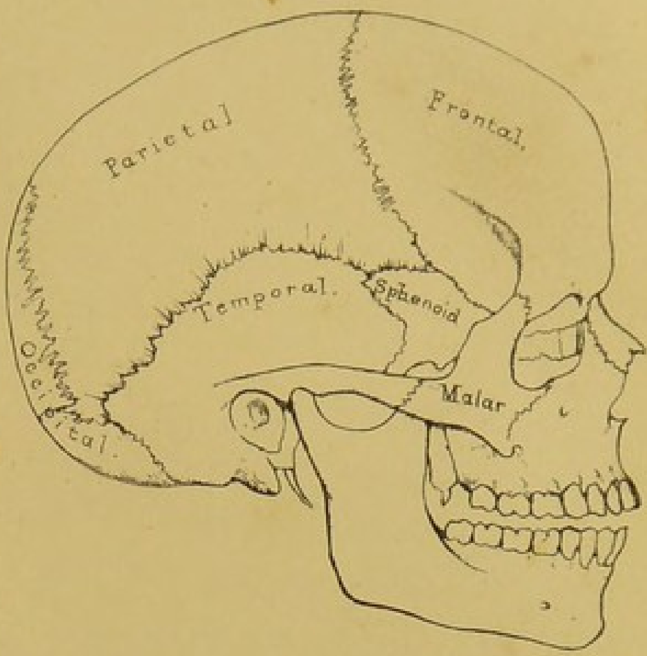
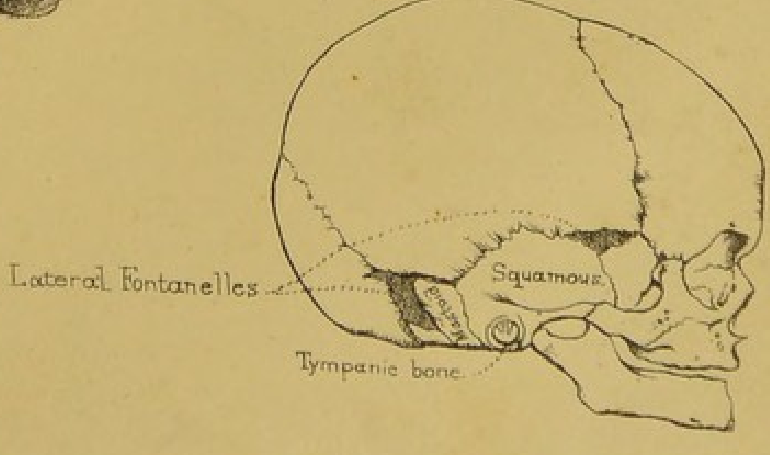


Fig. 5.



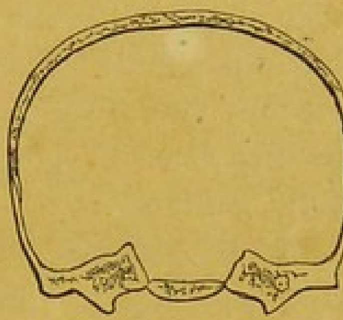
Foetal Skull, full term.

T. Godart Lith.

through the outer table may be only a simple incision without any depression, yet the inner table will be broken almost always to a greater extent than the outer: indeed it may be separated from it, and driven into the membranes if not into the substance of the brain. Hence the necessity of examining these cases very carefully, in order to ascertain if there be any parts of the inner table depressed, and to remove them.

Consider that the bones are mechanically locked together by the sutures; and that in the recent state there is a thin layer of animal matter between their edges, to prevent jarring. The Eddystone Lighthouse is constructed on the same plan. Look at the vaulted form of the cranium, the very best adapted to resist compression. Whoever knows the strength of an egg-shell, can understand what hard blows the cranium will bear. Most of the bones mutually support each other, by having their edges beveled alternately on opposite sides, as for instance in the frontal suture; or by one overlapping the other, as in the squamous suture, where the temporal prevents the "starting of the parietal bone (See cut, fig. 12). The effect of this is, that no single bone can be taken out of the cranium without separating the whole fabric. When we wish to separate the bones, we do so, not by force from without, but by force from within the skull; that is, by introducing peas, which, when moistened with water, swell, and, by pressing equally in all directions, disjoint the bones.

FIG. 12.



Notice how the interior of the dome is strengthened by ribs or groins of bone, which run in the line of the principal sinuses. One rib extends from the centre of the frontal bone to the foramen magnum, and spans the whole arch of the cranium. Another crosses transversely the back part of the occipital bone; the point of intersection of these two ribs being at the occipital protuberance, which is therefore the thickest and strongest part of the skull, for this, if for no other reason, that when a man falls backwards, it is the part which first comes to the ground.

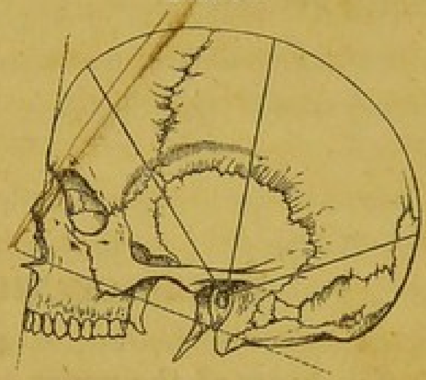
Buttresses of the skull.

Like all other arches, the cranium transmits shocks towards its buttresses; these are firmly wedged into the base, and all meet at the centre, that is, at the body of the sphenoid bone. Looking at the different regions, we find that the frontal part of the arch is supported by the wings of the sphenoid and the malar bones, the parietal part by the temporal bones, and the occipital part supports itself by running, wedge-like, into the base, and abutting on the sphenoid. A knowledge of the buttresses which support the respective parts of the skull cap, affords an explanation of the direction which fractures generally take along the base of the skull, according as the injury has been received on the frontal, the parietal, or the occipital region of the cranium.

Béclard, Velpeau, Malgaigne, and, generally, the older French school advocate the doctrine, that the cranium resists shocks after the manner of other spheres, namely, that a blow struck on one side is transmitted to the opposite one; as when a glass tumbler, struck smartly with the finger nail, cracks on the opposite side. This they call fracture by "*contre-coup*." But the modern school demurs to this doctrine, and contends that the cranium resists shocks like all architectural arches; and that vibrations, instead of going round to the base direct, are lost upon the supporting pillars. Now, what are these pillars? The frontal pillars are the malar and sphenoid bones — the parietal pillars are the temporal bones — the occipital pillars are the ribs of the occipital bone itself. When the head is struck, five times out of six the parietal region is the seat of injury. The bone breaks at the part struck, and the fracture runs on through the temporal, and most frequently through the tympanum, for the very good reason that the tympanum is the weakest part. Observe how many excavations there are in the bone which weaken it about this part: 1. there is the "meatus auditorius externus" — 2. the cavity of the tympanum itself — 3. the jugular fossa — 4. the carotid canal — 5. the Eustachian tube. This accounts for the frequency of hæmorrhage from the ear in cases of fracture of the base of the skull.

Common observation shows that the shape and relative dimensions of the cranium vary not only in different races of men, but also in individuals of the same race. English, French, and German anatomists have accurately measured the several dimensions of the cranium; but the fact that the statements differ, proves the influence of nationality. The development of the frontal, parietal, and occipital regions may be taken as a general expression of the development of the corresponding lobes of the brain. Upon this is founded the study of Craniology. The breadth and height of the frontal region is a measure of the degree of intelligence; the breadth and height of the parietal region measures the development of the moral feelings; and the breadth of the occipital region measures the animal propensities.* To measure the relative extent of these three regions, the meatus auditorius is taken as a centre from which lines are drawn to the frontal, parietal, and occipital eminences, respectively, as shown in the adjoining cut.

FIG. 13.



Facial Line and Angle.

The best method of determining the proportions between the cranium and face in man, and the vertebrate animals generally, is by taking what is called the "facial angle." Let a line (as shown in the cut) be drawn from the condyle of the occiput along the floor of the nostrils, and be intersected by another line touching the most prominent parts of the forehead and upper jaw: the intercepted angle gives, in a general way, the proportions of the cranial cavity, and the grade of intelligence. In the dog this angle is 20°; in the great chimpanzee it is 40°; in the Australian it is 85°; in the European it is 95.° The ancients,

* Craniology is nothing new. An Italian poet in the age of Dante, writes:—

"Nel Capo son tre celle,
Et io dirò di quelle,
Davanti è lo intelletto
E la forza d' apprendere;
In *mezzo* è la ragione
E la discrezione,
Che scherne buono e male.
Dirietro stà con gloria
La valente memoria," &c. &c.

in their impersonation of the beautiful and intellectual, adopted an angle of 100°.*

Buttresses of the upper jaw.

A few words about the architecture of the bones of the face. There are two points to be noticed—1st, the great strength of the nasal arch (Plate XV. *a*); 2d, how immoveably the upper jaw is fixed by its three buttresses on each side,—namely, the nasal, the zygomatic, and the pterygoid. The *nasal* buttresses rest against the internal angles of the frontal bone, and between them is the heart-shaped opening of the nose. The *zygomatic* buttresses are exceedingly strong: they are supported by the external angles of the frontal bone and the zygomatic processes of the temporal, and correspond to the molar teeth, which have to sustain the greatest pressure. The *pterygoid* buttresses descend perpendicularly from the base of the skull, and support the upper jaw behind.

BONES OF THE UPPER EXTREMITY.

The bones of the upper extremity consist of the "clavicle," the "scapula," the "humerus," the two bones of the fore-arm, namely, the "radius" and the "ulna," the bones of the carpus, the metacarpus, and the phalanges of the fingers. The length of the arm is always in exact proportion to the height of the individual. It is a curious fact that, if the arms are fully stretched in the same horizontal line, the space from the end of the middle finger of one hand to that of the other, is equal to the length of the body.

* Froriep (Charakteristik des Kopfes, Berlin, 1845) gives tables showing the relative size of the cranium and face in infancy, childhood, and adult age. They go to prove that the *base* of the skull, and the face, as contrasted with the capacity of the cranium, increase from infancy to old age.

THE CLAVICLE.

(Plates XXI. and XXII.)

The clavicle, so named from its resemblance to an ancient key, extends horizontally from the sternum to the scapula. Its chief use is to keep the shoulders apart, that the arm may enjoy a freer and wider range of motion. By moving the shoulder, you will find that the clavicle acts as a prop, the fixed end of the prop being at the sternal joint.* Hence in fractures of the clavicle, the shoulder generally drops *forwards*. The patient leans his head towards the injured arm so as to relax the muscles; and he supports the elbow with the sound hand to take off the weight of the limb. Besides its chief use, it serves secondary purposes,—such as affording attachment to many powerful muscles, and protection to the axillary vessels and nerves which pass under it.

The shape of the clavicle is like an italic *S*. It has two alternate curves, arranged so that, viewed from the front, the sternal half is convex, and the acromial half concave. The sternal curve is the larger of the two curves, obviously for the purpose of allowing plenty of room for the free passage of the great vessels and nerves of the arm. Another interesting point about the structure of the clavicle is, that the compact wall is much thicker on the concave side of each of its curves than elsewhere. It is about the junction of the two curves that the bone is most frequently broken. These curves not only make the bone stronger than if it were straight, but better able to resist shocks; since, by virtue of its elasticity, the force is partially broken at each of the curves. All clavicles are not equally

* All animals that use their fore limbs for other purposes besides support,—such as climbing, flying, burrowing, or holding objects,—have clavicles. Those that use them for support only, have no clavicles. In most birds, the clavicles are anchylosed in front and form a single bone called the "furculum," or merry-thought, while the other ends of the fork articulate with the scapula and the coracoid bone. The chief use of this elastic arch of bone is to resist the action of the great pectoral muscles, which tend to press the humeri inwards towards the mesial plane during the downward stroke of the wing.

curved: it is less curved in the female than in the male; and as a rule, its strength and degree of curvature depend on the amount of manual labour performed by the individual.

Sir Everard Home* states that French women have longer clavicles than English women, and then proceeds to say that on this account they carry themselves with more grace, the chest being more open. He measured the clavicles of some French women as they lay in bed in Hospital one very hot day, and found them all six inches long or nearly so. The clavicles of our English women are not quite so long.

Let us examine, first, the shaft, and afterwards the two ends of the clavicle.

The shaft of the clavicle bears the impressions of the muscles attached to it. Holding the bone in position, and looking at its upper surface, we observe, on the sternal curve, the origins of the "pectoralis major" and "sterno-cleido mastoideus," and on the acromial curve, the origin of the "deltoides" and the insertion of the "trapezius." On its under surface we notice —1, a longitudinal groove for the insertion of the "subclavius;" 2, a rough surface near the sternal end for the attachment of the costo-clavicular ligament; 3, near the acromial end, a tubercle, and a ridge for the attachment of the "conoid and trapezoid" ligaments (coraco-clavicular): the ridge is about one inch from the scapular end,—observe this, because fractures of the bone in this situation are apt to escape notice, in consequence of the ligaments preventing the separation of the fractured ends; 4, near the middle is a foramen for the nutrient artery of the interior.

The sternal end of the clavicle is thick, strong, and expanded, so as to form a base for the prop. It is oblong from before backwards, and articulates, through the medium of an interarticular fibro-cartilage, with the sternum. In the recent state, when crusted with cartilage, the articular surface is slightly convex from above downwards, and concave from before backwards; and, moreover, its circumference projects on all sides considerably beyond the articular surface of the sternum, in order to give more advan-

* "Lectures on Comparative Anatomy," vol. v. p. 236.

tageous attachment to the strong capsular ligaments which secure the joint. In consequence of this, dislocation is very rare, notwithstanding the small size of the articular surface of the sternum. A fracture of the clavicle is ten to one more common than a dislocation of it. In hard working persons, the sternal end of the bone becomes enlarged, rough, and disfigured.

The acromial end is broad and flattened, and presents an oblong surface, which looks forwards and slants a little, in order to articulate with the inner border of the acromion.

Like all the long bones, we find that its structure is spongy at the extremities, but compact in the middle of the shaft, where there is a small medullary cavity.

The clavicle begins to ossify sooner than any other bone in the body, and has only one centre of ossification for the shaft. The sternal end has an epiphysis which makes its appearance from the eighteenth to the twentieth year, and subsequently coalesces with the shaft.

THE SCAPULA.

(Plates XXI. and XXII.)

The scapula, or shoulder-blade, when the arm hangs loosely by the side, ought to extend from the 1st to about the 7th rib, and the lower angle should be a little further from the spine than the upper. Its use is to afford a moveable fulcrum for the motions of the arm, as well as an extensive surface for the attachment of the muscles which effect the movement. It is a flat triangular bone, and so thin in places as to be transparent. We have to examine its two surfaces, its three borders and angles, and its outstanding processes.

The "outer surface" of the scapula (sometimes called "dorsum scapulæ") is slightly convex, and divided into two unequal parts by a very prominent ridge or plate of bone, termed the "spine." The part above the spine is called the supra-spinous fossa, and gives origin to the "supra-spinatus" muscle; that below the spine is called the infra-spinous fossa, and gives origin to the "infra-spinatus." Near the axillary border there are distinct impressions, indicating the origins of the "teres major" and "minor" muscles. It is generally marked by the impressions of the "arteria dorsalis scapulæ."

Spine of the scapula.

The "spine" of the scapula commences at the posterior border of the bone by a smooth triangular surface over which the tendon of the trapezius plays. From this it soon rises into a high crest, which runs across towards the neck of the scapula, where it stands out from the rest of the bone, and, suddenly altering its direction at a right angle, which can be plainly felt in the living subject, projects forwards so as to form a lofty arch overhanging the "glenoid cavity." This arch is termed the "acromion" (ἄκρος ὦμος). Its obvious purpose is to protect the shoulder-joint, as well as to give greater leverage to the powerful "deltoides" which raises the arm. It is not only a defence, but prevents luxation upwards; without this the head of the humerus would not remain a moment in its socket. It is this process which gives breadth to the shoulder. On the inner border of the acromion is the surface which articulates with the clavicle. Observe that this surface slants from above downwards, so that the clavicle, once dislocated, is with difficulty kept in its place. The end of the acromion gives attachment to the coraco-acromial ligament, which bridges over the gap left in the dry bone between it and the coracoid process, and thus completes the arch for the shoulder. Through this coraco-acromial ligament we plunge the point of the knife, in excising the head of the humerus, and thus reach the shoulder joint in a moment. Reverting to the spine, we observe that it has thick rough borders for the insertion of the "trapezius" and the origin of the "deltoides."

The "inner surface" of the scapula is concave, and called the "subscapular fossa." It gives origin to the "subscapularis," and presents three or four slanting ridges for the attachment of the tendinous septa by which this muscle is intersected. The hollows between these ridges were mistaken, even by the great Vesalius, for the impressions of the ribs. On this surface also we observe the insertion of the "serratus magnus" along the posterior border, but chiefly at the rough surfaces on the superior and inferior angles.

Glenoid cavity. The "anterior angle" of the scapula is the strongest part of the bone, and here we find the "glenoid cavity" for the articulation of the head of the humerus. This cavity is very shallow, of an oval form, with the larger end downwards, and the long diameter vertical; above all, observe that it looks directly outwards; and the reason of this is plain when we consider that it is intended to receive a bone which has such an extensive range of motion. Its margins are rather prominent and rough, for the attachment of a collar of fibro-cartilage, which slightly deepens the socket. From the upper part of the margin arises the "long head of the biceps." Just below the cavity is the origin of the long head of the triceps. Immediately behind the cavity is a slight constriction termed the "neck" of the scapula.

When we speak of fracture of the neck of the scapula, we mean fracture behind the coracoid process. This kind of fracture is very rare. It happens to old persons from falling on the shoulder. The shock is received by the head of the humerus, and is thence transmitted to the glenoid cavity. The chief symptom of such an accident is slight lengthening of the arm and dropping of the shoulder. Whoever sees for the first time a fracture of the neck of the scapula, will probably mistake it for a dislocation of the head of the humerus into the axilla. There is in each case the same lengthening of the arm, prominence of the acromion, and flatness of the deltoid; in each case the head of the humerus can be felt in the axilla: but there is *this* important distinction, that in the case of fracture, the normal appearance of the joint can be restored by simply pushing upwards the arm at the elbow, by which means the head of the humerus, with the glenoid cavity, is at once raised to its proper position.

Coracoid process. From the upper part of the neck of the scapula, stands off a remarkable projection termed the "coracoid* process," from its fancied resemblance to the beak of a

* The coracoid process is a remarkable bone in birds. In them it is of great strength and solidity, and extends from the sternum to the junction of the scapula and clavicle, where it helps to form the glenoid cavity. It serves as a buttress to support the shoulder during the downward stroke of the wing. Being a *vertebral element*, it is in all animals developed from a separate centre.

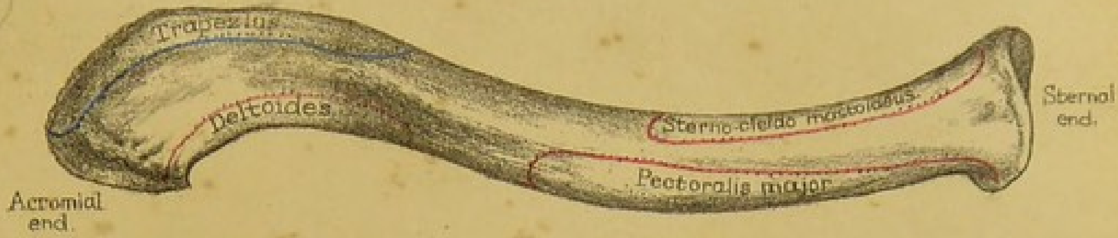
raven (κόραξ). Arising from a very broad base, it takes first a direction inwards, but soon curves forwards towards the acromion, like a half bent finger, and overhangs the glenoid cavity on the inner side. Its apex is about one inch and a half from the point of the acromion, and on a lower plane. It is necessary to be familiar with the direction of these points of bone, and their accurate bearing to the glenoid cavity and to each other, since they serve as landmarks to assist us in determining the nature of obscure injuries about the shoulder-joint. Into the front part of the coracoid process is inserted the tendon of the "pectoralis minor," and from the "apex" arises the common tendon of the "coraco-brachialis," and the "short head of the biceps." At the upper part of its root is a rough surface for the attachment of the "coraco-clavicular" ligaments, which bind down the clavicle; and the border next to the acromion gives attachment to the "coraco-acromial ligament," which extends across the interval between these points of bone, and completes the arch for the shoulder-joint.

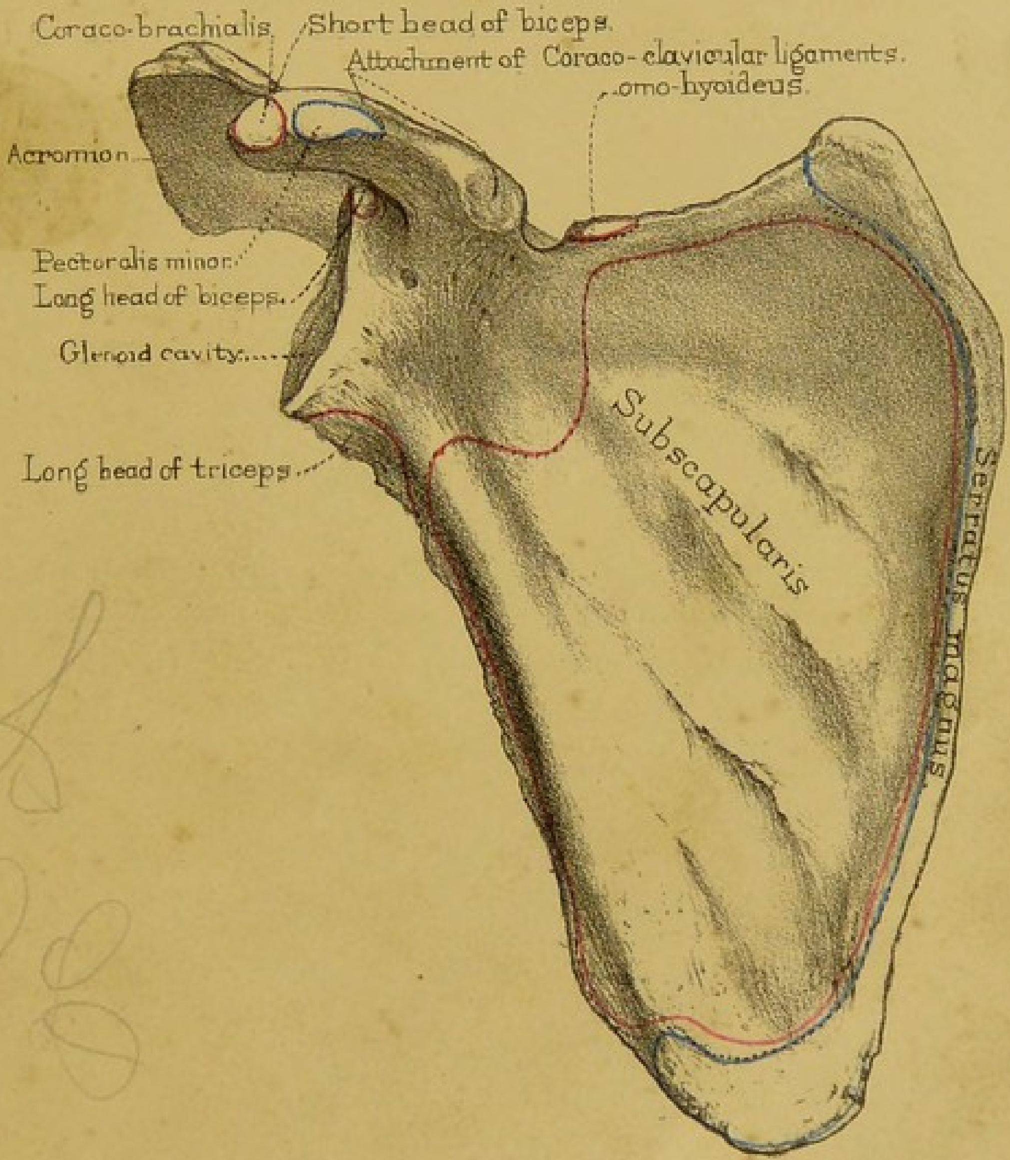
Borders.

The "superior border" of the scapula presents, near the root of the coracoid process, a small notch, which, in the recent state, is bridged over by a ligament. It gives passage to the supra-scapular nerve, and, sometimes, to the corresponding artery. Behind the notch is the origin of the "omohyoideus" muscle. The "~~posterior~~ border" is always the longest in man, and is therefore called the base of the scapula: in the lower animals it is generally the shortest. It gives insertion to the "levator anguli scapulæ," the "rhomboideus major" and "minor" muscles, and, as before mentioned, to the "serratus magnus." The "inferior or axillary border" is by far the thickest and strongest, in order to support the glenoid cavity. The deep groove along it gives origin to some of the fibres of the "subscapularis" muscle.

Centres of ossification.

The scapula has six centres of ossification. The "primary" centre forms all parts of the bone, except the coracoid process, the acromion, the inferior angle, and the base; these are cartilaginous at birth. The centre of the coracoid process appears soon after birth, and about the 15th year unites to the rest of the bone. About puberty, the other secondary centres appear; namely, — two for the acromion (one near the summit, Upper surface of clavicle





Inner surface of scapula.

L. Holden ad natur del.

T. Godart Lith.

the other near the base): one for the inferior angle; and, lastly, one for the border of the base. In a practical point of view it is well to remember that the acromion is not invariably united to the spine by bone. In some rare cases it remains permanently distinct, and is united to the spine only by ligament.

THE HUMERUS.

(Plates XXIII. and XXIV.)

The humerus is the longest and strongest of the bones of the upper extremity. It is a lever of the third order, the fulcrum being at the shoulder joint, and the power at the insertions of the several muscles which move the bone. It articulates with the scapula above, and the radius and ulna below. Like all long bones, we divide it into a body or shaft, and articular ends.

Head and neck. At the upper end, we observe the smooth eminence termed the "head." It forms about $\frac{1}{3}$ of a sphere, and articulates with the glenoid cavity of the scapula. Observe that the head is much larger than the socket in which it plays. This disposition, together with the shallowness of the socket, explains the great range of motion which the joint enjoys. It is the freest of all the joints, and resembles what mechanics call a "universal" joint, for there is no part of the body which cannot be touched by the hand. The head springs from the shaft by a slightly constricted base, called the "*anatomical* neck," to which the capsular ligament of the joint is attached. Although this is so short and thick as hardly to deserve the name of neck, yet it serves the very important purpose of removing the head a little away from the axis of the shaft. In consequence of this, the axis of the head and neck forms an acute angle with that of the shaft. Suppose the arm to hang quietly by the side, with the thumb in front, the precise direction of the axis of the head and neck of the humerus is upwards, inwards, and a little backwards from the shaft.

The object of this direction is to facilitate rotation inwards, which is the most useful movement: and it is interesting to remark, that this direction is reversed in the axis of the neck of the femur where the object is to facilitate rotation outwards.

Raise the arm of the skeleton to a right angle, and you will observe that much of the lower part of the head of the humerus is out of the socket. This is one of the reasons why the humerus is so liable to be dislocated into the axilla when the arm is extended; the head of the bone in this position being chiefly supported by the fibrous capsule of the joint. When the arm is raised to a right angle, there is another point worthy of notice. It is this, that the humerus *alone* cannot be raised higher, for the simple reason that the articular surface of the head of the bone does not admit of elevation beyond a right angle. When we *do* raise the arm beyond a right angle, the additional elevation is accomplished by the movement of the scapula upon the chest, an effect principally due to the action of the trapezius and serratus magnus muscles.

Greater and lesser TUBEROSITIES. At the root of the neck, or rather at the top of the shaft, are two projections, termed the "tuberosities," of which the use is to give greater leverage to the muscles which move the bone. They are separated by a perpendicular groove which runs some way down the shaft, and is called the "bicipital groove," because the tendon of the long head of the biceps plays in it. In the recent state this groove is bridged over by an aponeurosis, which makes it a complete canal. Of these tuberosities the "*greater*" is the more external; in a thin individual it can be plainly felt immediately below the acromion. It is useful to know this in determining the nature of injuries about the shoulder. It has three little impressions indicating the insertions of the "supra-spinatus," "infra-spinatus," and "teres minor" muscles. The "*lesser* tuberosity" is the more internal, and gives insertion to the subscapularis. Lastly, the tuberosities are supported by broad pedicles which run down the shaft, and form, respectively, the outer and inner margins of the bicipital groove.

SHAFT. We come next to the shaft. The first thing to be observed is, that the lower part of it is twisted inwards, nearly as much as $\frac{1}{4}$ of a circle; and that it is slightly curved forwards. The object of this is, to make the axis of motion at the elbow such, that the fore-arm may naturally bend towards the front of the body. Immediately below the tuberosities is the "*surgical* neck" of the humerus; so called, because, when we speak of a fracture of the neck, we refer to this part of the bone, and not to the "*anatomical* neck," of which a fracture is exceedingly rare. On the front of the shaft we notice the bicipital groove already alluded to, up which the long head of the biceps runs, in order to be attached to the top of the glenoid cavity, so that it may act like a strap to keep down the head of the bone. Up this groove, too, a little artery (a branch of the anterior circumflex), creeps to supply the joint. Into the outer margin of the groove is inserted the tendon of the "pectoralis major;" into the inner margin the tendon of the "teres major;" and into the bottom of it the tendon of the "latissimus dorsi." These muscles play an important part in causing displacement in fracture when it occurs through the surgical neck. There may be a double displacement: *i. e.* the upper fragment is drawn outwards by the muscles inserted into the tubercles, and the lower fragment is drawn upwards and inwards by the muscles which go from the trunk to the arm.

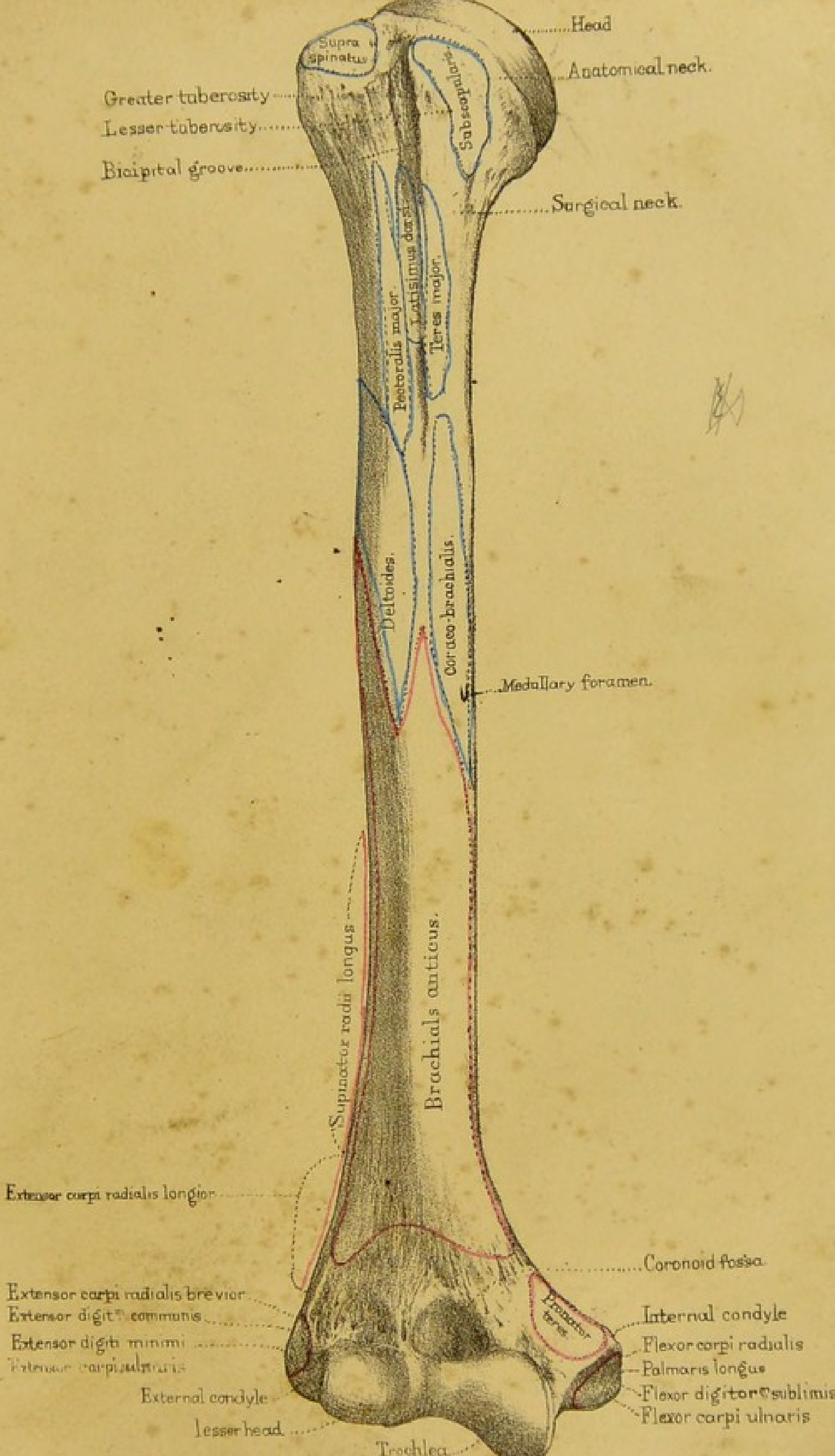
The middle of the shaft is marked by ridges and impressions adapted for the convenient action of the muscles. About the middle of the outer aspect there is a rough impression (deltoid ridge) for the insertion of the "deltoid" which raises the arm. Near this, on the inner aspect, is a smooth surface for the insertion of the "coraco-brachialis." Against this surface we compress the brachial artery in amputation of the fore-arm. Here also is generally situated the foramen for the nutrient artery of the marrow, which runs from above downwards. Below the deltoid ridge the shaft begins to be twisted, and becomes gradually flattened and expanded to prepare for the formation of the articular end. It is just below the insertion of the deltoid that one most frequently meets with ununited fractures of the humerus, partly on account of the injury to the nutrient artery of the medulla, and partly on account of the action of the deltoid in causing a riding of the upper fragment over the lower.

The lower half of the shaft presents, on each side, a ridge called, respectively, the "internal" and "external condyloid ridges," because they lead to the "condyles" or points of bone which project on each side of the elbow. The *external* ridge begins just behind the insertion of the deltoid, is the more prominent of the two, and gives origin to the "supinator radii longus," and the "extensor carpi radialis longior." It is called the *supinator* ridge, and its size throughout the vertebrate animals corresponds with the extent of the power of supination of the fore-arm. The *internal* ridge serves for the attachment of the "internal intermuscular septum." The front surface of this part of the shaft gives origin to the "brachialis anticus," which begins by two little tongues, one on each side the insertion of the deltoid.

The back part of the shaft is occupied by the origins of the "second" and "third heads of the triceps," which are separated by a slanting groove for the passage of the musculo-spiral nerve and superior profunda artery.

Lower end.

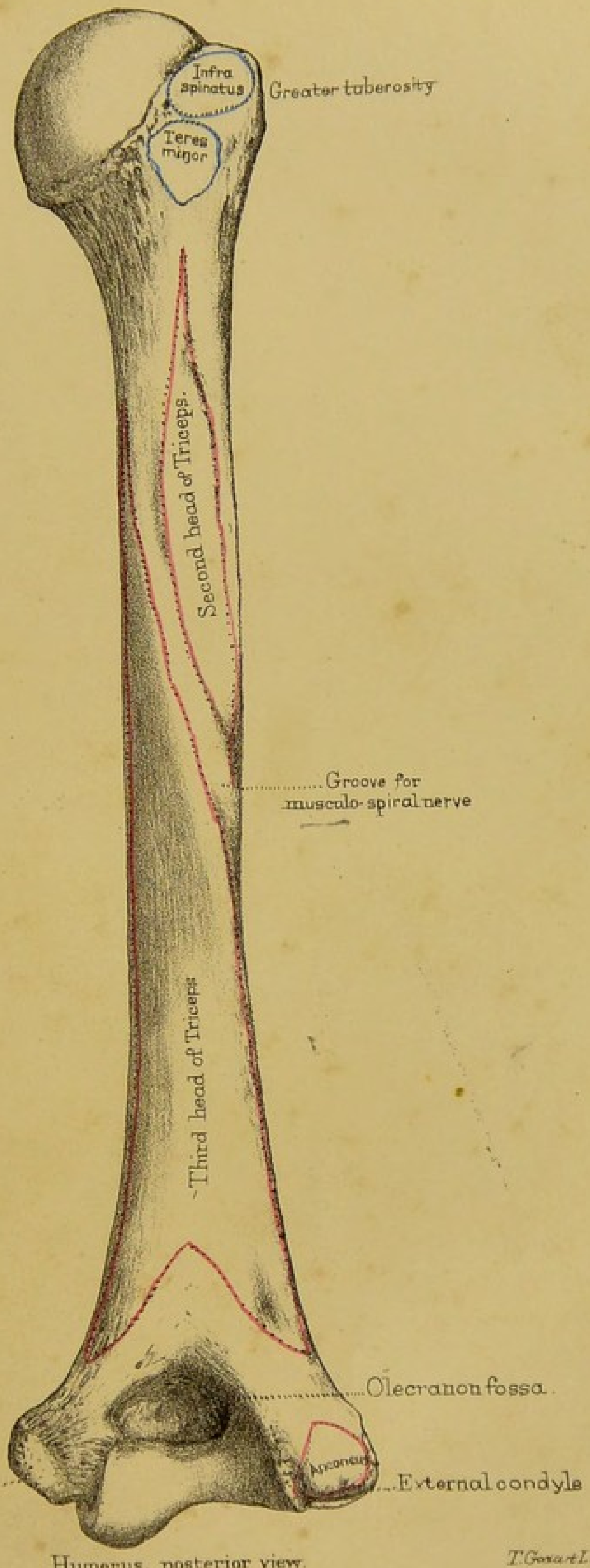
The lower end of the humerus curves slightly forwards, and presents a pulley-like surface, beautifully adapted to suit the flexion and extension, as well as the rotatory movement of the fore-arm. On the outer side, we observe the "lesser head" (capitellum) which corresponds with the shallow cavity at the end of the radius. The chief point about this head is, that it projects directly forwards, so that when the fore-arm is bent there is a smooth surface ready for the radius to rotate on. On the inner side is the "trochlea" or grooved pulley for the ulna. This admits of flexion and extension only. The direction of this pulley is oblique; that is, it slants from behind forwards, and from without inwards, so that the fore-arm, in the act of bending, comes naturally in front of the chest. Above the trochlea there is a deep cavity in front (coronoid fossa) to receive the coronoid process of the ulna in flexion; and a similar one behind (olecranon fossa), to receive the "olecranon" in extension of the fore-arm. Between these hollows the bone is thin enough to be transparent, as is well seen in the adjoining woodcut, fig. 14, which exhibits a section through the joint. In consequence of this thinning of the bone, a transverse fracture through the humerus in this situation is not uncommon. From the displacement produced so close to the elbow



L. Holden, ad natur. del.

Humerus, anterior view.

T. Godart Lith.



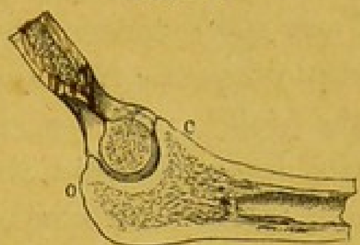
L. Holden ad natur del[t]

Humerus, posterior view.

T. Godart Lith.

joint this accident is very liable to be mistaken for a dislocation of the radius and ulna backwards. The celebrated French surgeon, Dupuytren, used to say "that there was nothing more common than such a mistake." However, the bearing of the condyles with respect to the olecranon enables us in most cases to determine the diagnosis. If the olecranon be higher than the condyles, there is dislocation of the fore-arm; if not higher, it is a case of fracture.

Fig. 14.



Section to show the trochlea of the humerus.

Respecting the condyles, we have to observe, that the *internal* projects by far the most, since it gives origin to the powerful pronator and flexors of the hand and fingers, namely, to the "pronator radii teres," "flexor carpi radialis," "palmaris longus," "flexor digitorum sublimis," and "flexor carpi ulnaris." The internal lateral ligament of the elbow is also attached to it. The *external* condyle gives origin, in front, to the common tendon of the extensor muscles; namely, the "extensor carpi radialis brevior," "extensor digitorum communis," and "extensor minimi digiti" and "extensor carpi ulnaris:" behind, it gives origin to the "anconeus." Lastly, the external lateral ligament of the elbow is attached to it.

Centres of ossification.

The humerus has seven centres of ossification. There is one for the shaft. About the second year after birth the centre for the head appears; and about the third year, the centre of the tuberosities. About the end of the fifth year, the centres for the head and tuberosities have coalesced, so as to form a large epiphysis on the top of the shaft. It is necessary to remember that this epiphysis includes the tuberosities (as shown in the adjoining wood-cut, fig. 15). On the inner side, the line of junction runs close to the cartilage on the head of the bone: therefore, in the event of separation, the shoulder joint would certainly be implicated. The epiphysis does not unite with the shaft till the 21st year; so that up to that age it is liable to be separated from the shaft by violence, as we often see in

Fig. 15.

Epiphysis of the head of the humerus.

practice. About the beginning of the third year ossification of the lower end commences by a fourth centre in the lesser head. About the fifth year, a fifth centre appears in the internal condyle. About the twelfth year, a sixth centre appears in the great sweep of the trochlea; and, lastly, about the fourteenth year, the seventh centre appears in the external condyle. At the close of the sixteenth year the lower end has completely ossified, and then unites to the shaft. A separation of the lower epiphysis of the humerus is by no means an infrequent accident in children. The lower fragment is carried backwards with the bones of the fore-arm, so as to cause considerable displacement.

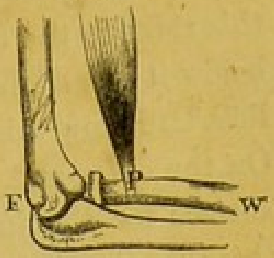
It is interesting to remark, that the epiphysis of the upper end, though it is the first to ossify, yet remains separate from the shaft about three or four years longer than that of the lower end. This is in accordance with the rule, that, of the two epiphyses of a long bone, that towards which the nutrient artery of the marrow runs is always the first to unite with the shaft. Remember that the nutrient arteries of the marrow of the bones of the upper extremity run *towards* the elbow. In the bones of the lower extremity, they run *from* the knee.

THE RADIUS.

(Plates XXV. and XXVI.)

The radius is the external of the two bones of the fore-arm, and is so called from its resemblance to the spoke of a wheel. In learning this bone, keep in mind that both its ends are constructed so as to rotate upon the ulna, and admit of the pronation and supination of the hand. The lower end of the radius is much larger than the upper, because it is the chief support of the hand: and since the radius receives all shocks from the hand, it is more liable to be broken than the ulna.

Fig. 16.



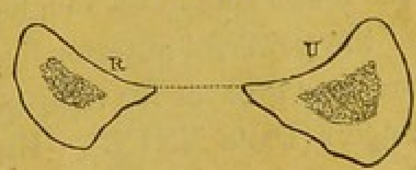
Bones of the fore-arm levers of the 3rd order.

Like the humerus, the radius and ulna are both levers of the third order, as seen in the cut, fig. 16. The fulcrum F is at the elbow joint—the weight W is the fore-arm—the power P is the insertion of the biceps. The biceps will act to the greatest advantage when the arm is bent to a right angle, because the power acts at a right angle to the lever.

Head, neck, and tubercle. The upper end of the radius is called the "head:" it has a shallow circular cup, which articulates (when the fore-arm is bent) with the lesser head of the humerus. Observe that the head has a smooth circular border, which is adapted to rotate in the lesser sigmoid cavity of the ulna. This rotation of the radius can be distinctly felt below the external condyle of the humerus in a natural depression of the skin which exists during life: we mention this because it is of use in determining the existence of fracture. Below the head is the constricted part termed the "neck;" and below this is the "tubercle" which gives insertion to the tendon of the "biceps." Notice that this tubercle projects on the inner side of the bone, so that the biceps can *supinate*, as well as *bend* the fore-arm.

Shaft. Respecting the "shaft," we observe that its outer side is thick and rounded; and that from this side, its front and hind surfaces gradually converge to a sharp edge, which faces the ulna (as seen in the annexed cut, fig. 17), and gives attachment to the interosseous ligament between the bones. The shaft is slightly arched outwards, and for two reasons—1, because it increases the breadth of the fore-arm; 2, because it gives more power to the "pronatór teres." The bones are furthest apart when the hand is placed vertically: hence, fractures of the fore-arm are put up with the hand vertical, that there may be less risk of the opposite bones uniting.

Fig. 17.



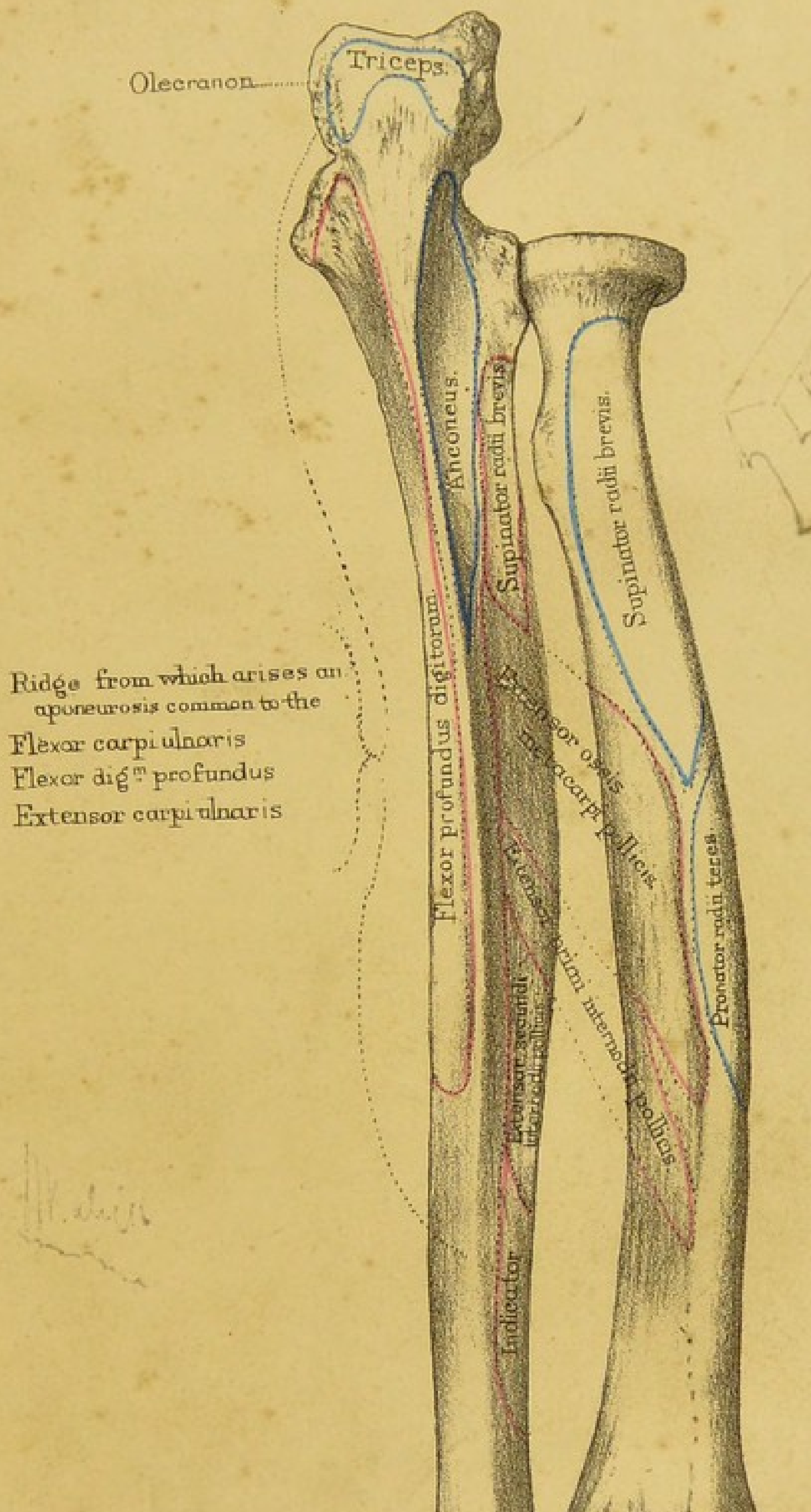
On the front surface of the shaft there is a blunt ridge leading from the tubercle obliquely towards the outer side of the bone.

It gives origin to part of the "flexor sublimis digitorum." Above this ridge is the extensive insertion of the "supinator brevis," and below it is a slightly excavated surface for the "flexor longus pollicis." Below this is the insertion of the "pronator quadratus." On the outer and *back* part of the middle of the shaft is a rough surface for the insertion of the "pronator teres." Observe that this insertion is into the *back* part of the shaft, in order that the muscle may act as a pronator. In amputation of the fore-arm, it is desirable to saw through the bones below the insertion of this muscle, that the stump may have the benefit of a pronator.

The posterior surface of the shaft is marked by the origin of the extensor muscles of the thumb; namely, the "extensor ossis metacarpi pollicis," and the "extensor primi internodii pollicis."

Lower end. The lower end of the radius has a surface slightly cupped transversely, as well as from before backwards, in order to articulate with the "scaphoid" and "lunar" bones of the carpus. In the recent state, if not in the dry bone, this surface is divided by a slight ridge: the part for the "scaphoid" is triangular, while that for the "lunar" bone is square. On its inner side is the concave articular surface, which rotates upon the lower end of the ulna. On its outer side is the conical projection, termed the "styloid" process, of which the apex gives attachment to the external lateral ligament of the wrist; while the base gives insertion to the tendon of the "supinator radii longus." In front, the lower end has a rough and elevated margin for the attachment of the powerful anterior ligament of the carpus: and behind there are four grooves for the passage of the extensors of the wrist and fingers (Plate XXIX.). Beginning from the outer side, we observe, 1, a groove for the "extensor ossis metacarpi pollicis," and the "extensor primi internodii pollicis;" 2, a groove for the "extensor carpi radialis longior" et "brevior;" 3, a very distinct and slanting groove for the "extensor secundi internodii pollicis;" 4, a groove for the "extensor indicis" and the "extensor communis digitorum." In the recent state these grooves are made complete canals by the "posterior annular ligament."

It is necessary to know that the lower end of the radius is composed of cancellous tissue protected by only a thin layer of compact



Posterior view.

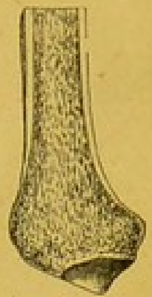
L. Holden ad natur. del.

T. Godart

J. Serrill, Imp.

bone, as shown in the adjoining cut, fig. 18. In falls, therefore, upon the palm of the hand, the lower end of this bone, which receives the full force of the shock, is very liable to be broken transversely about half of an inch or one inch above the wrist joint. This fracture of the lower end of the radius is commonly called Colles's fracture, after the Irish Surgeon who first accurately described it. The lower fragment with the hand is thrown backwards so as to make an unnatural swelling on the back of the fore-arm: the upper fragment protrudes on the palmar aspect of fore-arm just above the wrist. Now a fracture with such displacement is liable to be mistaken for a dislocation of the wrist. How are we to determine between the two injuries? We must feel for the styloid process of the radius. If the styloid process be in the same line with the shaft of the radius, the injury is probably a dislocation of the wrist backwards: if it be not in the same line, then the injury is probably a fracture of the lower end of the radius, which, by the way, is by far the most frequent accident of the two.

Fig. 18.



Section through the lower end of the radius to show the thinness of its compact wall.

The radius has three centres of ossification; one for the shaft, and one for each end. The upper end begins to ossify at the age of nine, and is united at twelve. The lower end begins about the second year, and is not united till the age of eighteen or twenty. This is in accordance with the general law, that epiphyses unite with the shafts in the inverse order of their ossification.

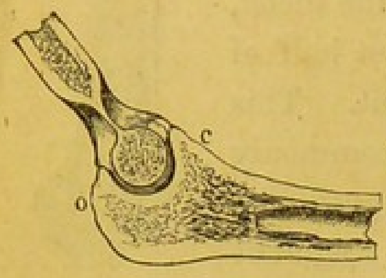
THE ULNA.

(Plates XXV. and XXVI.)

The ulna, so called because it forms the elbow (ωλενη), is the inner of the two bones of the fore-arm.

Upper end. Its upper end presents a deep semicircular cavity, with a smooth ridge at the bottom, which accurately fits on the trochlea of the humerus, and forms a perfect hinge-joint admitting of flexion and extension only. (See cut, fig. 19.) This is called the "greater sigmoid" cavity, in contradistinction to a smaller one, termed the "lesser sigmoid," which is placed on its outer side, and forms a socket for the head of the radius to rotate in. In front of the greater sigmoid cavity is a rough projection, termed the "coronoid process" (κορωνη, the top of a curve), which gives insertion to the "brachialis anticus" (a flexor of the fore-arm) and origin to the second head of the "pronator teres," and the second head of the "flexor sublimis digitorum." Besides this, it limits the flexion of the fore-arm; for when the arm is bent to an angle of about 40°, the point of the process strikes against the fossa at the lower part of the humerus. In dislocation backwards the coronoid process is very liable to be broken: this complication makes reduction more easy, but subsequent retention of the bones in their proper place more difficult. Violent action of the brachialis anticus is capable of breaking off the coronoid process: but this is a very rare case. Mr. Liston mentions an instance which happened to a boy about 8 years old, in consequence of hanging with one hand from the top of a high wall. When it *is* broken, the coronoid process unites by ligament, owing to the action of the brachialis anticus.

Fig. 19.



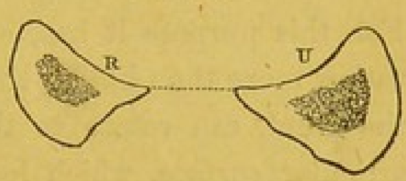
Section through the greater sigmoid cavity of the ulna.

Olecranon. Behind the sigmoid cavity is the "olecranon process" (ωλενη, elbow, and κρανον, head). This serves many purposes. It gives advantageous leverage to the "triceps" muscle, which is inserted into it and extends the fore-arm. It forms a convenient knob of bone for the protection of the joint when we lean on the elbow, and it limits the extension of the fore-arm. The surgical interest about it is, that it is sometimes broken by a fall upon the elbow; and the fracture generally takes place just at the slight constriction where the olecranon joins the shaft: so that the joint is involved in the mischief. Fractures of the olecranon, like those of the patella and coronoid process, unite, generally, by ligament, because it is so difficult to keep the fragments in apposition. But if the tendious expansion from the triceps be not torn, then the union may take place by bone.

In almost all injuries about the elbow-joint, however much the parts may be swollen, one can always feel the olecranon and the internal condyle of the humerus. In determining, therefore, the nature of obscure injuries about the elbow-joint, it is a useful practical rule to know that, when the arm is extended, the tip of the olecranon and the internal condyle are about one inch apart and in the same transverse line. When the arm is bent to a right angle, the olecranon is $1\frac{1}{2}$ inch from the condyle and below it. By this test we can distinguish between dislocation of the ulna backwards and fracture through the lower end of the humerus.

SHAFT. The shaft of the ulna is triangular, and tapers gradually from the upper towards the lower end, where it terminates in the little head round which the radius rolls. A transverse section, as seen in the accompanying cut, fig. 20, shows the shape of the radius and ulna about the middle. We observe that their sharp edges are turned towards each other, and that to these is attached the interosseous membrane which connects the bones. Together, they form a shallow concavity both above and below, convenient for the lodgment of the muscles of the fore-arm.

FIG. 20.



The greater part of the front as well as of the inner surface of the shaft is occupied by the origin of the "flexor profundus digitorum." On the front, too, we see the canal for the nutrient artery of the medulla. It runs *towards* the elbow like that in the radius. Lower down is the origin of the "pronator quadratus." The back part of the shaft is marked by ridges and surfaces for the muscles, as follows:—Near the elbow is the triangular surface for the insertion of the "anconeus;" next comes the ridge for the origin of the "supinator radii brevis:" observe that this muscle also arises from the depression just below the lesser sigmoid cavity. Below the supinator brevis arise in succession part of the "extensor ossis metacarpi pollicis," o[redacted] and "secundi internodii pollicis," and also the "indicator."

Of the three edges of the shaft, the *internal* gives attachment to the interosseous membrane; the *anterior* is covered by the origin of the "flexor profundus digitorum;" the *posterior* gives origin to a strong aponeurosis, which not only covers the muscles on the inner side of the fore-arm, but also affords additional surface for the origin of the "flexor carpi ulnaris," the "flexor digitorum profundus," and the "extensor carpi ulnaris." The posterior edge (or ridge of the ulna, as it is generally called,) deserves the more notice, because it is subcutaneous, and can be traced all the way down; so that, in a doubtful fracture, this is the proper place to feel for it. Before reaching the elbow the ridge bifurcates, and encloses a triangular space, which is also subcutaneous: here we feel for fractures of the olecranon.

Lower end. The lower end of the ulna is termed its "head." It forms a fulcrum upon which the radius rolls. For this purpose it has, on one side, a convex surface, forming rather more than half a circle, round which the radius, and with it the hand, can rotate to the same extent. It has also another articular surface, which looks towards the wrist-joint, and corresponds with the interarticular fibro-cartilage interposed between it and the cuneiform bone of the wrist. Observe that the ulna does not reach down quite so low as the radius, and that this fibro-cartilage partly fills up the interval. The reason why the ulna does not descend so low as the radius is, to allow more extensive horizontal movement of the wrist towards the ulnar side of the fore-arm.

The *styloid* process projects from the lower end of the *back* part of the ulna, that it may not interfere with the rotation of the radius, and gives attachment to the internal lateral ligament of the wrist. Between the process and the head there is a groove on the posterior aspect of the bone for the passage of the tendon of the "extensor carpi ulnaris" (Plate XXIX.); and inferiorly, the process is separated from the head by a depression for the attachment of the triangular fibro-cartilage of the wrist.

The styloid processes of the radius and ulna can be readily felt beneath the skin, and are important guides in the determination of injuries of the wrist, whether fracture of the radius or dislocation. The position of the styloid processes with regard to the axis of motion at the wrist will settle the question.

The ulna has three centres of ossification,—one for the shaft and coronoid process, one for the lower end, and a third for the olecranon. The lower end begins to ossify about the sixth year, and unites to the shaft about the age of twenty. The top of the olecranon remains cartilaginous until the age of eight, about which time it begins to ossify: it coalesces with the base about the age of puberty.

BONES OF THE HAND.

(Plates XXVII. XXVIII. and XXIX.)

The skeleton of the hand consists of twenty-seven bones. The first eight are the little bones of the carpus; the five succeeding bones constitute the metacarpus: these support the bones of the fingers. Each finger has three bones, termed, in order from the wrist, the first, second, and third or ungual phalanx. The thumb has only two phalanges,—namely, the first, and the third or ungual.

THE CARPUS.

(Plate XXIX.)

The carpus consists of eight little bones, arranged transversely in two rows of four each, so as to form a broad base for the support of the hand. It is sometimes asked, why are there so many bones in the wrist? The answer is, in order that there may be so many joints: for the structure of a joint not only permits motion, but confers elasticity. Remember that each articular surface is crusted with cartilage to prevent jarring. Suppose there had been a single bone instead of the eight carpal bones, how much more liable it would have been to fracture and dislocation. As it is, dislocation of one or more bones of the carpal range is a rare occurrence; but it does happen sometimes. Sir C. Bell tells us that "the boy that played the dragon in the pantomime at Covent Garden, fell upon his hands, owing to the breaking of the wire that suspended him, and he suffered dislocation of some of the carpal bones in both hands." The bones of the carpus are named as follow, beginning from the radial side:—

First Row . .	"Scaphoides," "lunare," "cuneiforme," "pisiforme."
Second Row .	"Trapezium," "trapezoides," "os magnum," "unciforme."

A separate description of each of these bones would be exceedingly tedious, and is not necessary. We hope to bring out a better idea of their general plan and arrangement by examining them collectively.

Carpal arch. As a whole, the outline of the carpus is oblong, with the broad diameter in the transverse direction. Its bones are wedged together so as to form an arch with the concavity towards the palm, beautifully adapted for the passage of the flexor tendons of the fingers. Fig. 3 in Plate XLVIII. shows that the piers of the arch are formed on one side by projections from the scaphoid and trapezium; on the other, by the pisiform and unciform bones. The arch is converted into a complete tunnel by the anterior annular ligament.

Radio-carpal joint. Excluding the pisiform, which is only an outstanding sesamoid bone, we observe that the other three bones of the first row form a convex articular surface, which corresponds with the lower end of the bones of the fore-arm. This joint is formed so as to admit not only of the movement of flexion and extension, but also of the horizontal movement of the wrist. We observe also that the articular surface of the carpal bones is prolonged much further down their dorsal than their palmar aspect: hence the free movement of extension at the wrist. Looking at the articular surfaces of the individual bones, we observe that those of the scaphoid and lunar correspond with the radius; while that of the cuneiform, which is by far the least extensive of the three, corresponds with the ulna, not *immediately*, but by means of the triangular fibro-cartilage attached to the lower end of the ulna.

INTER-CARPAL JOINT. The bones of the first row articulate with each other by plane surfaces crusted with cartilage, but they are so firmly connected by ligaments that there is very little movement between them. Collectively, however, they form, with the bones of the second row, an important moveable joint, which we call the "intercarpal." It is very different in form from the first joint of the wrist, since its outline is alternately convex and concave. Now the advantage obtained by this second joint is, that we get a greater range of flexion and extension at the wrist. If there had been only a single joint for this amount of motion, it would have been comparatively insecure, and very liable to dislocation, whereas dislocation of the wrist, as it is, happens very rarely indeed. By reference to Plate XXIX. it will be seen that the lower part of the scaphoid has a *convex* surface, which corresponds with the trapezium and trapezoid, and likewise a *concave* one, which, with a concavity in the lunar and cuneiform bones, forms a deep socket to receive the head of the os magnum and the unciform. We observe, also, that the scaphoid articulates with five bones inclusive of radius; the lunar with five inclusive of radius; and the cuneiform with four inclusive of ulna.

With respect to the bones of the second row, we have to observe that the trapezium and trapezoid form a shallow socket for the scaphoid, while the os magnum and unciform form a convexity, which fits into a deep socket in the three bones of the first row. Below, they support the metacarpal bones, as follow:—The trapezium supports the metacarpal bone of the thumb by a concavo-convex, or saddle-shaped surface; the trapezoid supports that of the fore-finger; the os magnum that of the middle finger; and the unciform those of the ring and little fingers. But this is not all. Observe that the trapezium supports, also, part of the second metacarpal bone; and the os magnum, also, part of the second and the fourth. The consequence is, that the metacarpal bones present different degrees of mobility,—that of the thumb being the most moveable.

Like the bones of the first row, those of the second articulate with each other by plane surfaces firmly connected by ligaments. In all, then, the trapezium articulates with four bones; the trapezoid with four; the os magnum with seven; the unciform with five.

How to distinguish the individual bones of the carpus.

Thus far we have examined the bones of the carpus collectively;—how are we to distinguish them individually? Whoever remembers what has been already said, will not have much difficulty in recognising the separate bones; but it requires some practice before one can pronounce to which hand a given bone belongs.

Scaphoid bone.

The "scaphoid" bone may be told by its boat-shaped socket (whence its name σκάφη), by its long narrow groove on the dorsal aspect between its two convex surfaces, and by its *tubercle* for the attachment of the anterior annular ligament.

Hold the bone horizontally, with the largest convex surface looking upwards, and the groove towards yourself: the tubercle will point to which hand the bone belongs.

Lunar bone.

The "lunar" bone may be told by its two "semilunes" below (whence the name): the larger being for the os magnum, the lesser for the unciform.

Hold the bone with its "semilunes" downwards, and the broadest *non-articular* surface forwards; the larger semilune will be on the side to which the bone belongs.

Cuneiform bone.

The "cuneiform" bone may be told by its little round articular surface for the pisiform bone, and its concavo-convex surface for the unciform.

Hold the bone with its concavo-convex surface downwards, and its round surface for the pisiform forwards; the broader end will be on the side to which the bone belongs.

Pisiform bone.

The "pisiform" bone may be told by its pea-shape (whence its name); and by its single articular surface for the cuneiform.

Hold the bone with the articular surface downwards, and the little overhanging projection towards yourself; the direction of a slight groove beneath the projection will show to which side the bone belongs.

Trapezium. The "trapezium" (so named from its shape) may be told by its saddle-shaped articular surface for the metacarpal bone of the thumb; by the deep groove through which the tendon of the "flexor carpi radialis" runs, and the ridge alongside it for the attachment of the anterior annular ligament.

Hold the bone with the groove upwards and in the antero-posterior direction, with the ridge nearest to you: its saddle-shaped surface will point tó which hand the bone belongs.

Trapezoid bone. The "trapezoid" bone (so named from its shape) may be told by its four articular surfaces and four angles.

Hold the bone perpendicularly with the larger end upwards. Let the angle dividing the two longest concave articular surfaces look *directly* forwards. The lower end of the bone will incline rather to the side to which it belongs.

Os magnum. The "os magnum" may be told by its large size, by its round "head" and slightly constricted "neck."

Hold the bone with the head pointing towards yourself, and the broadest non-articular surface upwards. The projecting angle in front will point towards the side to which the bone belongs.

Unciform bone. The "unciform" bone may be told by its hook-like process; whence its name.

Hold the bone with the unciform process downwards, and the articular surface with the two facets directed forwards. The convexity of the process will look towards the hand to which it belongs.

Ossification of the carpus. At birth the carpus is all cartilaginous. Ossification commences by a single centre for each bone. The os magnum and unciform begin to ossify about the first year; the cuneiform about the third; the trapezium and lunar about the fourth; the scaphoid and trapezoid about the eighth; and the pisiform about the fourteenth: this is the last bone in the body to ossify.

Muscles attached to the carpus. It will be observed that no muscles are connected with the "dorsal" surface of the carpus. The scaphoid gives origin by its "tubercle" to the "abductor pollicis.' The pisiform gives insertion to the "flexor carpi ulnaris," and origin to the "abductor minimi digiti." The trapezium gives origin by its "ridge" to the "opponens pollicis," and to a part of the "flexor brevis pollicis," of which the larger part arises from the trapezoid and os magnum. The unciform gives origin by its "process" to the "flexor brevis minimi digiti," and to the "opponens minimi digiti."

THE METACARPUS.

The metacarpus consists of the five bones which support the phalanges of the thumb and fingers. We speak of them as the first, second, third, &c., counting from that of the thumb. Considering them as "long bones," we speak of their shafts and their two ends; the upper end being termed the "base," the lower the "head" of the bone.

The "shafts" are slightly concave towards the palm, to form the hollow of the hand. They are more or less triangular, being made so by the impressions of the "interosseous" muscles which occupy the "interosseous spaces" between them. The apex of the triangle is on the palmar surface, the base on the dorsal surface for the convenient support of the extensor tendons of the fingers.

Their "bases" articulate not only with the bones of the carpus, but also, laterally, with each other: that of the thumb, however, stands alone, so as to oppose all the others: this being the great characteristic of the hand of man.

Their lower ends or "heads" have convex surfaces for articulation with the first phalanges of the fingers. These surfaces extend chiefly towards the palm for obvious reasons. They allow the fingers not only to be bent and extended, but also to be moved laterally. On each side of their heads is a projection for the attachment of the lateral ligaments.

The shaft of each metacarpal bone has a canal for the nutrient artery of the medulla. In the second, third, fourth, and fifth metacarpal bone, the direction of this canal is upwards; but in the metacarpal bone of the thumb its direction is downwards. This is in accordance with the law which regulates the union of the epiphyses.

How to distinguish the metacarpal bones.

The metacarpal bone of the thumb is distinguished by the characteristic saddle-shaped surface at the base, which articulates with the trapezium. Besides which, its shaft is shorter, broader, and stronger than the others, in accordance with the many and powerful muscles which act upon it. There are no less than nine muscles to work the thumb. Observe that the great mobility of the thumb depends upon this saddle-shaped joint at its base; and that its power of antagonizing the fingers is owing to its base being set off on a plane anterior to them.

Hold the bone with the base towards you, and the dorsal surface uppermost. The facet on one side of the base (indicating the insertion of the extensor ossis metacarpi pollicis) will look away from the side to which the bone belongs.

The metacarpal bone of the fore-finger is distinguished by its zig-zag surface at the base, so as to be immoveably wedged with three of the carpal bones; also by having only one lateral facet.

Hold the bone with the base towards you and the dorsal surface upwards: the lateral facet will be on the side to which the bone belongs.

The metacarpal bone of the middle finger may be known by its having a smooth surface at the base for the os magnum, and an angular projection at the corner of it for the insertion of the "extensor carpi radialis brevior." It has also lateral facets on each side.

With the base towards you, and the dorsal surface uppermost, the corner of the base which has no projection will be on the side to which the base belongs.

The metacarpal bone of the ring-finger articulates with the unciform and part of the os magnum. It may be distinguished by its smaller size; by the absence of the angular projection at the base, which is flat, and by its having lateral facets on each side.

With the base towards you and the dorsal surface uppermost, the base has a slight inclination towards the side it belongs to.

The metacarpal bone of the little finger may be recognised by its concavo-convex surface at the base to articulate with the unciform bone, and by its having only one lateral facet.

With the base towards you and the dorsal surface uppermost, the side of the base which has no facet will look to the side to which the bone belongs.

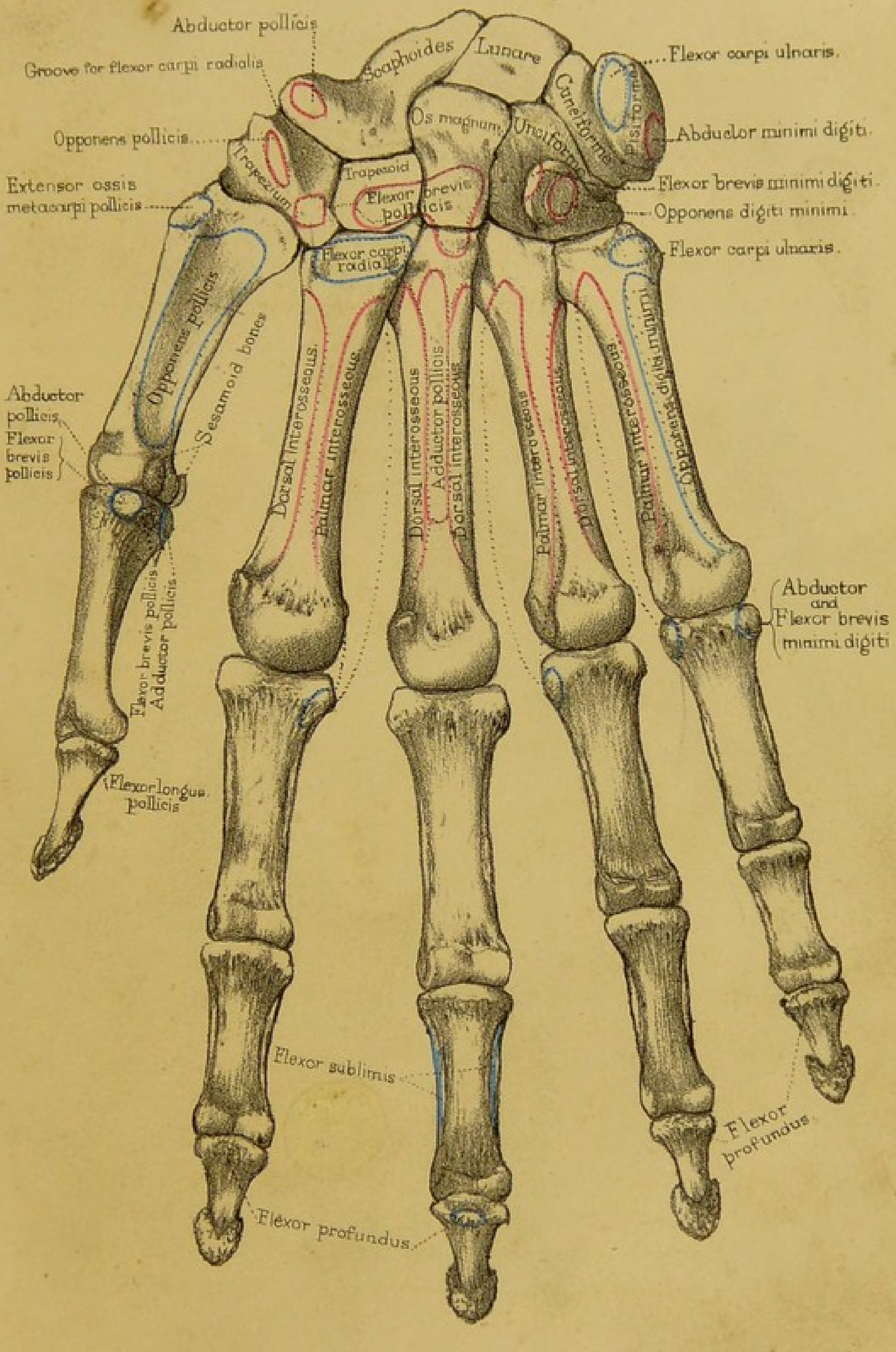
Ossification of metacarpal bones. The structure of each metacarpal bone is precisely like that of the great long bones; and a longitudinal section through one of them would display the medullary cavity, and the great thickness of the compact wall of the shaft. Hence a broken metacarpal bone is comparatively rare. Like all the long bones, each metacarpal bone has a centre of ossification for the shaft and one for each of the articular ends. In the first metacarpal, the artery of the marrow runs towards the lower end, therefore the lower epiphysis unites sooner than the upper to the shaft. This is just the reverse of what takes place in all the other metacarpals, in which the artery of the marrow runs towards the upper end.

THE BONES OF THE FINGERS.

Each finger consists of three bones, successively decreasing in size, and termed, respectively, the first, second, and last or ungual "phalanx." The thumb has only two phalanges, and these correspond to the first and last of those of the fingers. A general description will suffice for all.

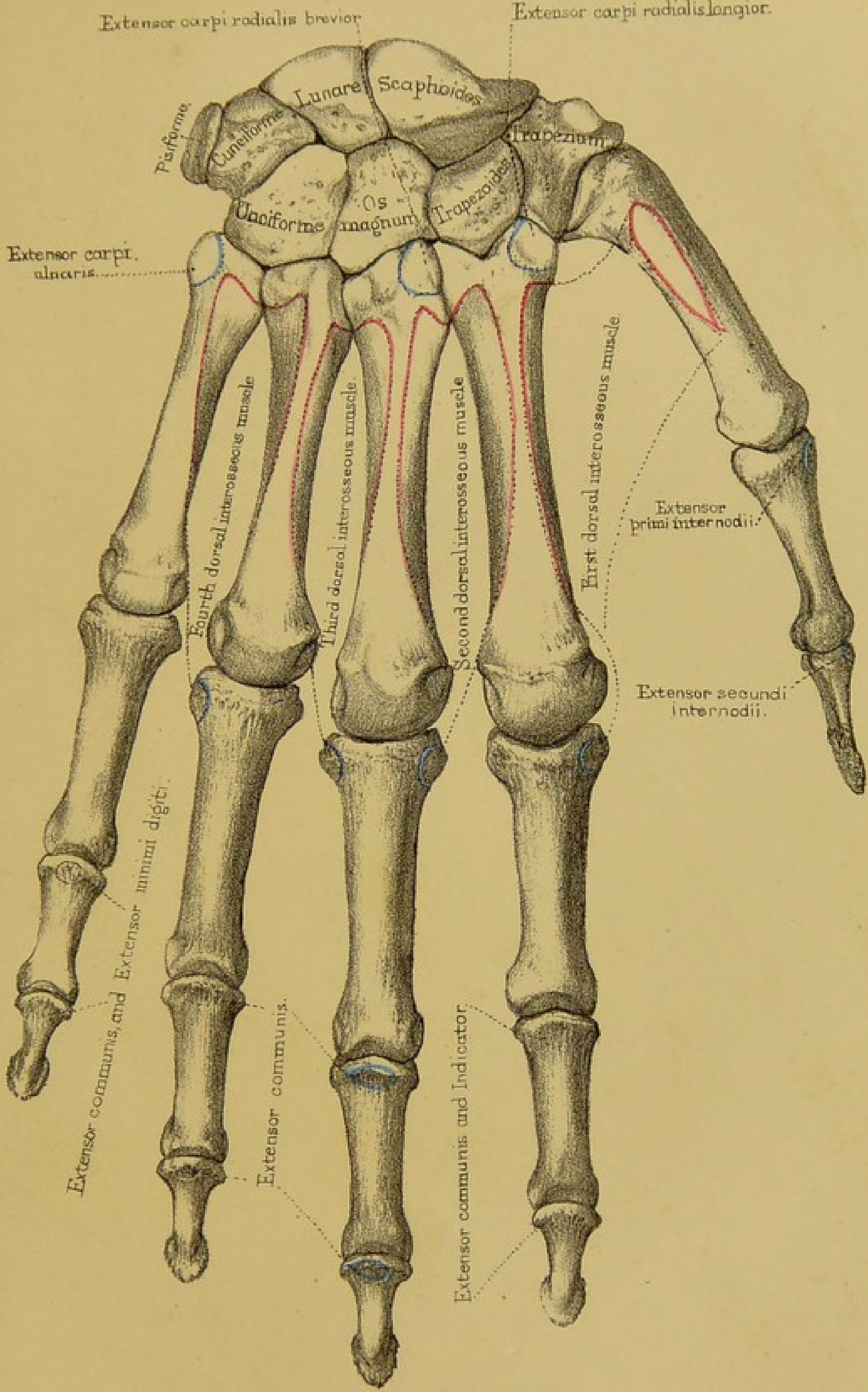
The structure of each phalanx is precisely like that of the great long bones, and a longitudinal section through one of them would display the great thickness of the compact wall of the shaft. A broken phalanx is comparatively rare.

Considering the phalanges as "long" bones, we speak of their shafts and their articular ends. The shafts are convex on the dorsal surface, and flat on the palmar, for the convenient play of the flexor tendons: and here we have to observe, that on each side of this flat surface there is a slight ridge for the attachment of the fibrous sheath (theca), which keeps the tendons in their place.



L. Holden ad naturam del.   **Palmar surface.**   T. Godart Lith.

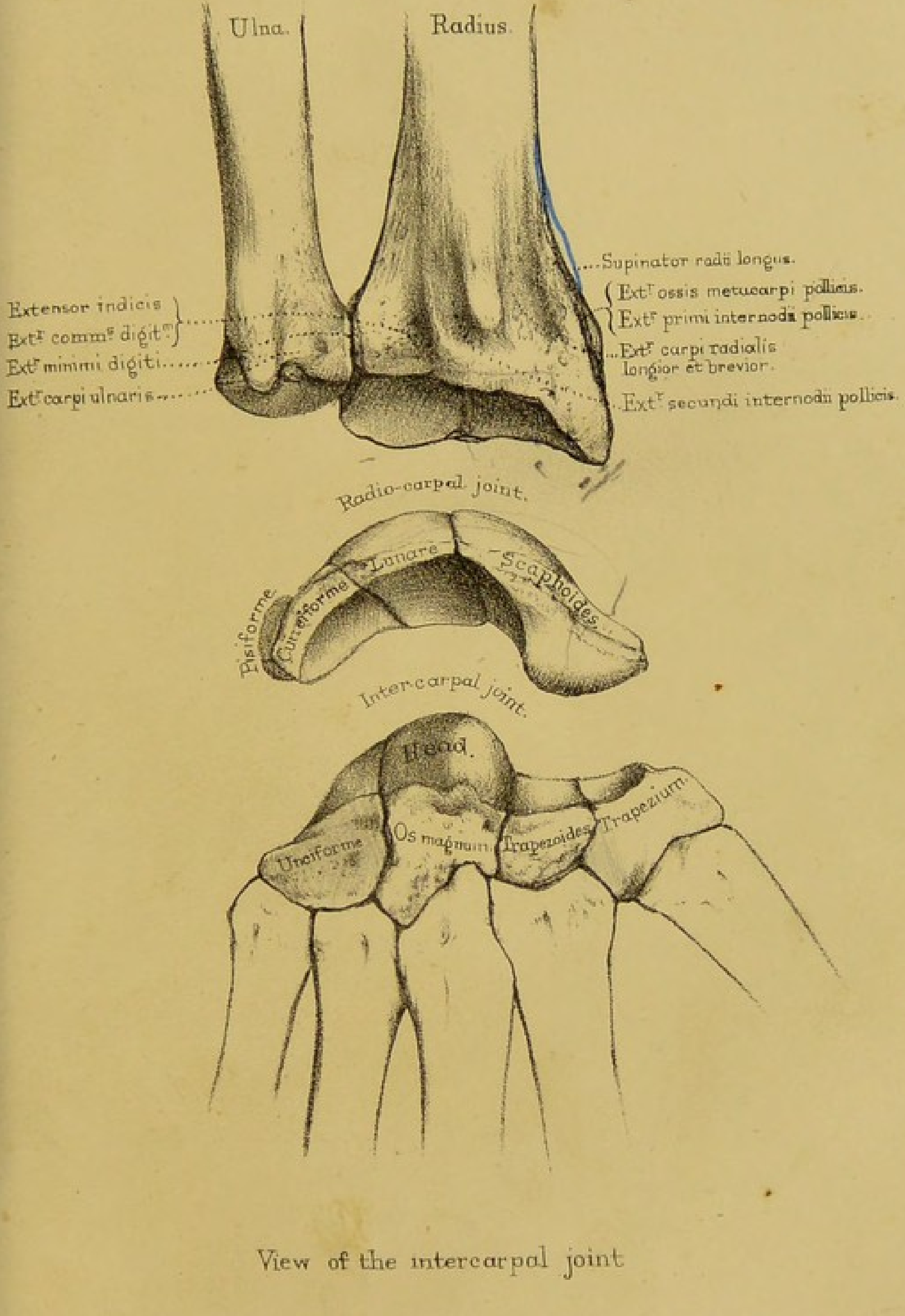
J. Sarrill, Imp.



L. Holden ad natur del.

Dorsal surface.

T. Godart Lith.



View of the intercarpal joint

L. Holden ad natur del^t

T. Godart Lith.

The first phalanges are distinguished by their greater length; but chiefly by the shape of their upper (metacarpal) ends, which do not form strictly hinge-joints, but have concave oval surfaces, with the long diameters transverse, adapted for lateral movement as well as flexion on the heads of the metacarpal bones. In accordance with this lateral movement, we observe, on each side, a tubercle for the advantageous insertion of the interosseous muscles which produce it. With this exception, all the other joints of the fingers are strictly hinge-joints.

The second phalanges are recognised by the shape of their upper ends, which have two surfaces, with an intervening ridge, so as to form a hinge with the first phalanges. They have also tubercles behind for the insertion of the extensor tendons.

The last or ungual phalanges are the shortest. Their ends expand into a horse-shoe shape, smooth on one surface for the support of the nails, and rough on the other for the support of the pulp of the fingers.

It may, perhaps, be interesting to some persons to know that the "middle digit" is the most constant of all the digits in the vertebrate series. Few are aware that the bones forming the three joints of this finger answer to those called "great pastern bone," "little pastern bone," and coffin bone in the horse; and that the nail in this finger represents the hoof.

Each phalanx has two centres of ossification: one for the shaft and the lower end; the other for the upper end, which remains an epiphysis till about the twentieth year.

SESAMOID BONES.

These little bones are so called from their resemblance in size and shape to the grain "*sesamum*." They are met with in the substance of tendons in the neighbourhood of joints,—the "patella," or "knee-pan," being the best example. Their use is to increase the leverage of the tendons. The thumb has two of these bones beneath its metacarpal joint, to increase the leverage of the "flexor brevis pollicis." We rarely find any for the fingers.

Of all animals, the mole has the most remarkable apparatus of "sesamoid" bones. Its prodigiously strong digging feet are richly provided with them, in order to increase the leverage of the brachial muscles, which enable the animal, as it were, to swim through the earth.

MUSCLES ATTACHED TO THE SKELETON OF THE HAND.

EXTENSORS OF THE WRIST (Plate XXVIII.)

Extensor carpi radialis longior	O. External condyloid ridge of humerus. I. Base of second metacarpal bone.
Extensor carpi radialis brevior	O. External condyle of humerus. I. Base of third metacarpal bone.
Extensor carpi ulnaris	O. External condyle of humerus. I. Base of fifth metacarpal bone.

FLEXORS OF THE WRIST (Plate XXVII.)

Flexor carpi radialis	O. Internal condyle of humerus. I. Base of second metacarpal bone.
Flexor carpi ulnaris	O. Internal condyle of humerus, ridge of ulna. I. Base of fifth metacarpal bone.

Here we must remark, that in consequence of the flexors and extensors of the wrist being inserted below the second row of the carpal bones, they necessarily act on the "intercarpal" as well as on the "radio-carpal" joint. Thus, a greater amount of motion is provided for the wrist than it otherwise could have had with safety; for if so free a motion had been given to one joint, the angle of flexion must have been very great, and the ligaments must have been looser than would have been consistent with the security of the joint.

EXTENSORS OF THE THUMB.

Extensor ossis metacarpi pollicis	O. Back of radius, ulna, and interosseous ligament. I. Base of first metacarpal bone.
Extensor primi internodii pollicis	O. Back of radius, ulna, and interosseous ligament. I. Base of first phalanx.
Extensor secundi internodii pollicis	O. Back of ulna. I. Base of third phalanx.

MUSCLES OF THE BALL AND FLEXORS OF THE THUMB.

Abductor pollicis	O. Tubercle of scaphoid, annular ligament. I. Base of first phalanx.
Opponens pollicis	O. Trapezium, annular ligament. I. All along first metacarpal bone.
Flexor brevis pollicis	O. Trapezium and annular ligament; 2, trapezoid and os magnum. I. Both sides of base of first phalanx.
Flexor longus pollicis	O. Front surface of radius. I. Base of last phalanx.
Adductor pollicis	O. Shaft of third metacarpal bone. I. Base of first phalanx.

EXTENSORS OF THE FINGERS.

Extensor communis digitorum	O. External condyle of humerus. I. Second and third phalanges of all the fingers.
Indicator	O. Back of the ulna. I. Second and third phalanges of fore-finger.
Extensor minimi digiti	O. External condyle of humerus. I. Second and third phalanges of little finger.

FLEXORS OF THE FINGERS.

Flexor sublimis digitorum	O. Internal condyle; 2, coronoid process; 3, ridge of radius. I. Sides of second phalanges of all the fingers.
Flexor profundus digitorum	O. Front and inner side of ulna. I. Third phalanges of all the fingers.

MUSCLES OF THE BALL OF THE LITTLE FINGER.

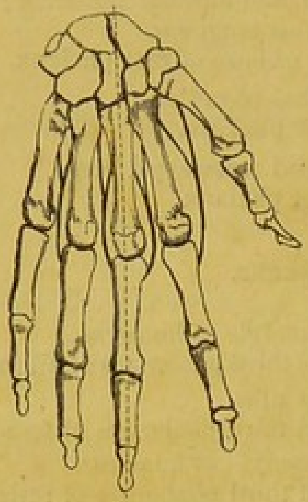
Abductor minimi digiti	O. Pisiform bone. I. Base of first phalanx.
Flexor brevis digiti minimi	O. Unciform bone. I. Base of first phalanx.
Opponens digiti minimi	O. Unciform bone. I. All along fifth metacarpal bone.

INTEROSSEOUS MUSCLES.

There are eight interosseous muscles: four on the dorsal aspect, and four on the palmar aspect of the hand. The *dorsal* interosseous arise from the opposite sides of the metacarpal bones, and are inserted into the first phalanges of the fingers, so that they separate the fingers from each other; in other words, they draw the fingers *from* a stationary line supposed to pass down the centre of the middle finger, as represented by the dotted line in fig. 21, on the other side of this page.

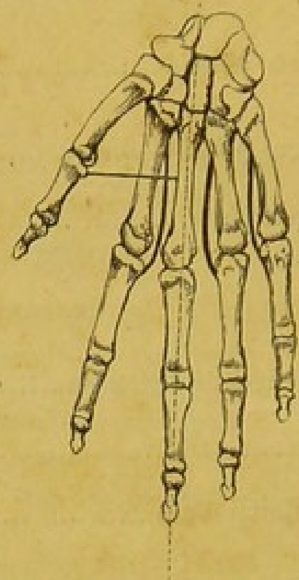
The palmar interossei arise each from one metacarpal bone, and are inserted into the fingers, so that they bring them together; in

Fig. 21.



Four dorsal interossei drawing from the middle line.

Fig. 22.



Four palmar interossei drawing towards the middle line.

fact, they draw *towards* the stationary line down the centre of the middle finger, as shown in cut, fig. 22.

BONES OF THE LOWER EXTREMITY.

The bones of the lower extremity consist of the "femur," the "patella," the two bones of the leg, namely, the "tibia" and "fibula," the bones of the "tarsus," the "metatarsus," and the "phalanges" of the toes.

The femur articulates with the pelvis. Now the pelvis itself is composed of several bones,—namely, the "os sacrum," the "coccyx," or terminal piece of the spine, and the two "ossa innominata," one on each side. These are wedged together, so as to form a solid arch. The weight of the spine is supported by the sacrum, or key-stone of the arch; and the weight of the trunk is transmitted from the sides of the arch on to the thigh-bones. We shall therefore describe, first, the constituent bones of the pelvis, beginning with the "os innominatum."

OS INNOMINATUM.

(Plate XXX.)

Division into Ilium, Ischium, and Pubes. The "os innominatum," so named by Galen, is made up of three bones, distinct in childhood, but united in the adult, and termed the "ilium," "ischium," and "pubes." Thus its constituents have received appropriate names, but the bone, consolidated, remains "nameless." The "ilium" is the expanded part which supports the flank (ilia); the "ischium" supports the body in the sitting posture (*ἰσχία*, the buttocks); the "pubes" is the front part,—so called from its being covered with hair. All three contribute to form the "acetabulum," or socket for the thigh-bone, and in the following proportions (fig. 3):—the ischium contributes rather more than $\frac{2}{5}$th, the ilium rather less than $\frac{2}{5}$ths, and the pubes about $\frac{1}{5}$th. In childhood they are united, at the bottom of the acetabulum, by a piece of cartilage, shaped like the letter Y. In the adult, however, little trace is left of the original division, so that, for practical purposes, it is better to consider the bone as *one*, and to describe successively its iliac, pubic, and ischial portions. In studying the relative bearings of these several parts in the erect position of the body, the bone should be held at such an inclination that the "notch" be at the lowest part of the acetabulum.

Ilium. The ilium (os ilii) forms a broad expanse for the support of the abdominal viscera, and gives a powerful leverage to the great muscles which balance the pelvis on the head of the thigh-bone. We must examine its outer and inner surface, and its borders.

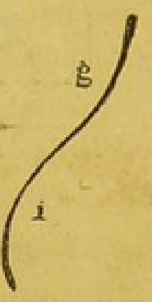
Outer surface. The outer surface of the ilium (dorsum ilii) is slightly undulating, being convex on its anterior and concave on its posterior half. In a well-marked bone, we discern the traces, termed the "superior and inferior curved lines," which map out the origins of the gluteal muscles. These lines commence, the one at the "anterior superior spine," the other at the "anterior inferior spine," and extend backwards to the "greater ischiatic notch." The surface above the superior line gives origin to the "gluteus medius;" that between the lines to the "gluteus minimus." A rough surface further back indicates the origin of a part only of the "gluteus maximus." Just above the acetabulum is the second origin of the "rectus" (femoris), the first being at the "anterior inferior spine."

Inner surface: Iliac fossa. The inner surface of the ilium is slightly excavated, so as to form the "iliac fossa." This fossa is one of the characteristics of the human skeleton, and its purpose is to support the abdominal viscera. It gives origin to the "iliacus internus." Hold the bone to the light and observe that the bottom of the fossa is the thinnest part of the ilium, for the good reason, that it is out of the line of the weight of the body. The fossa is bounded below by the "linea ileo-pectinea," which forms the true brim of the pelvis. We are not surprised that this brim is the thickest and strongest part of the bone, since it is the "line of the pelvic arch," along which the weight of the trunk is transmitted to the head of the thigh-bone. No one can form an adequate idea of the massive architecture of this part of the pelvis without inspecting a longitudinal section such as we have made in Plate XXXIII. But we must postpone for the present the mechanism of this beautiful arch. Behind the iliac fossa is the articular surface for the sacrum (sacro-iliac symphysis). The front part of this is shaped like a little ear, and, in the recent state, crusted with cartilage, which acts as a "buffer" to the joint, while the hinder part is exceedingly rocky for the attachment of the strong "interosseous" ligament which secures it. Lastly, on the inner surface is the large foramen, which transmits nutrient blood-vessels and a nerve into the cancellous texture.

Crest and spines.

The upper border of the ilium is termed the "crest." Looking at it from above, we observe that its outline is alternately concave and convex, like the adjoining figure (23), in adaptation to the general surface of the ilium, which undulates at the one part to form the "iliac fossa" (i), and at the other, to form what may be termed the "gluteal fossa" (g), for the convenient lodgment of the muscles of the buttock. The crest is rough and broad, and is spoken of in the "schools" as presenting three "lips,"—an "outer," an "inner," and a "middle," for the origin of the muscles which form the lateral walls of the abdomen. The outer lip gives origin to the "obliquus externus abdominis" and the "latissimus dorsi;" the middle lip gives origin to the "obliquus internus;" and the inner lip to the "transversalis abdominis," the "quadratus lumborum," and a part of the "erector spinæ."

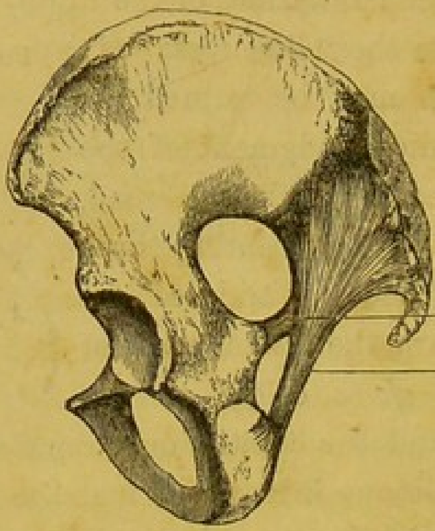
Fig. 23.



Along the front border of the ilium we have to notice the "anterior-superior" and "anterior-inferior spines," with the shallow notch between them. The superior spine, and the edge of the notch below, give origin to the "sartorius," and the inferior spine to one head of the rectus. Below this spine there is another notch, for the passage of the iliacus and psoas muscles, and then we come to the "ileo-pectineal eminence," where the ilium and pubes join. This eminence is interesting, practically, as the part over which the femoral artery passes into the thigh, and against which it can be effectually compressed.

Along the posterior border of the ilium are the "posterior-superior" and "posterior-inferior spines," with the little notch between them. These spines are for the attachment of ligaments. Below the spines is the "greater ischiatic notch," which transmits the great vessels and nerves from the pelvis to the buttock and back of the thigh. Lower still is the "spine of the ischium," and then we come to the "lesser ischiatic notch." In the recent state the notches are converted into complete holes by the "sacro-ischiatic ligaments," greater and lesser respectively, as shewn in the cut, fig. 24. These ligaments deserve attention because they answer three important purposes—1. they mainly contribute to the fixation of the sacrum, which is the keystone of the pelvic arch; 2. they afford an extensive surface for the origin of the

FIG. 24.



great muscle of the buttock (glutæus maximus); 3. they help to form the floor of the pelvis, and support the pelvic viscera, without adding much to the weight of the cavity. Returning to the notches, we must bear in mind the several objects which pass through them. These objects are as follow:—

The greater ischiatic notch transmits	Glutæal vessels and nerve. Pyriformis muscle. Greater and lesser ischiatic nerves. Ischiatic vessels. Pudic vessels and nerve (out of pelvis).
The lesser ischiatic notch transmits	Tendon of the obturator internus. Pudic vessels and nerve (into pelvis).

PUBES. The "pubes" is usually described as having a "body" and two branches: one of which, called the "horizontal ramus," joins the ilium at the ilio-pectineal eminence; the other, called the "descending ramus," joins the ramus of the ischium. Here it is necessary to observe, that the terms "horizontal" and "descending," as descriptive of the direction of the "rami," are erroneous. But they have crept into general use, and therefore we must use them. The error has arisen from the pelvis having been described as if it were horizontal, which it is not. Only look at a properly articulated skeleton, or hold the pelvis inclined at its proper angle (50°) to the horizon, and you will soon see that the pelvic rami run in a direction almost the reverse of that which is implied by their names.

The "horizontal ramus" of the pubes is somewhat triangular. Its upper surface gives origin to the "pectineus," and is marked by the continuation of the true brim of the pelvis, or ileo-pectineal line, which gives insertion to the "psoas parvus" when there is one, and also to that part of the "crural arch" termed "Gimbernat's ligament." The inner surface forms part of the wall of the true pelvis, while its lower surface bounds the obturator foramen, and is grooved for the passage of the obturator vessels and nerve.

Pubic arch. The "descending ramus" of the pubes inclines outwards and backwards, and forms, with its fellow of the opposite side, what is called the "arch of the pubes." The margin of the arch slopes a little outwards, so as to form a groove for the attachment of the "crus penis" or "clitoridis," as the case may be; but this shelving of the arch is especially considerable in the female, to facilitate the passage of the child. Behind the groove is the origin of the "compressor urethræ."

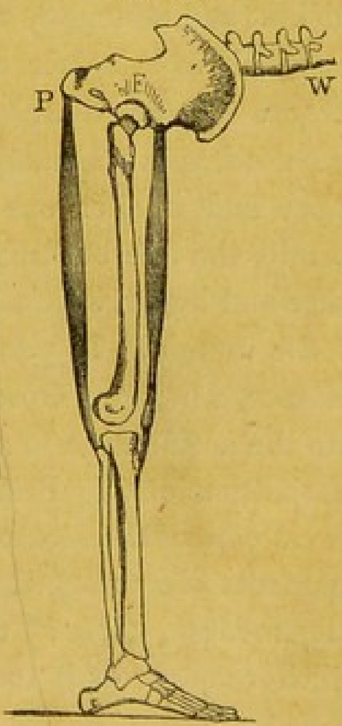
Body of the pubes. The "body" of the pubes (Plate XXXII.) is connected along a rough and somewhat oval surface to the answerable part on the opposite bone. This union is termed the "symphysis pubis." Observe the bones are not here in immediate apposition, but united by fibro-cartilage of at least $\frac{3}{8}$ths of an inch in thickness in front, which is elastic, like that between the bodies of the vertebræ, and while it completes the pelvic arch below, serves also to obviate the effects of concussion. The summit of the pubes is a most important part in relation to the anatomy of hernia. The chief point of interest here is the "spine." This is for the attachment of the "crural arch" (Poupart's ligament), and is our guide to the external abdominal ring. From the spine we trace outwards the beginning of the linea ileo-pectinea, where "Gimbernat's ligament" is attached. Between the spine and the symphysis lies the part called the "crest," to which so many muscles are attached. There is, namely, proceeding from the front, the insertion of the conjoined tendon of the "internal oblique" and "transversalis," the origin of the "pyramidalis," and that of the "rectus abdominis." The posterior surface of the body forms part of the lower wall of the pelvic cavity; and you should observe that its angle of inclination, as well as that of the "symphysis," is such as to present a gently sloping plane for the support of the pelvic viscera. Lastly, its anterior surface is rough for the origin of muscles; namely, the "adductor longus," "brevis" and part of the "magnus," also the "obturator externus" and the "gracilis."

Ischium. The ischium completes the lower part of the innominate bone. It serves both to support the trunk in sitting, and projects advantageously for the origin of the hamstring muscles. If, in imagination, we separate it from the rest of the bone, then we should point out a "body," which is the most bulky part of it, for the formation of the acetabulum: from this, the bone drops vertically to form the "tuberosity" upon which we sit; and then, curving forwards like a hook, it forms the "ascending ramus," which unites with the corresponding part of the pubes, and thus completes the "foramen ovale." Leaving the acetabulum for separate study, we pass on to notice the "spine of the ischium," which separates the "greater" from the "lesser ischiatic notch." There is much to be said about this spine. Its outside gives origin to the "gemellus superior;" its inside gives origin to the "coccygeus" and a small part of the "levator ani:" the front part of the levator ani, you should observe, arises from the body of the pubes, while the intermediate part of it arises from a kind of tendinous arch thrown across from one point of bone to the other. Reverting to the spine, we must remember that the lesser sacro-ischiatic ligament is attached to it, and that the internal pudic artery crosses over its outer surface, so that, in case of severe hæmorrhage after lithotomy, it would be possible in a thin subject to compress the artery against the bone.

Foramen ovale or obturatum. It matters little what part of the ischium we examine next; but let us take the "foramen ovale" or "obturatum." The wide opening is of an oval form in the male, but triangular, with rounded angles, in the female. It is closed in the recent state by the "obturator membrane," everywhere except at the top, where a small aperture is left for the passage of the obturator vessels and nerve into the thigh. The chief purpose of the hole is to lighten the pelvis. The closing membrane serves for the origin of the obturator muscles just as well as if it had been a plate of bone: besides which, it gives a little during the passage of the head of the child. Externally, the border of the hole gives origin to the "obturator externus;" and, at the mention of this muscle, one naturally points to the groove between the acetabulum and the tuberosity, along which its tendon runs to be inserted into the thigh-bone.

Behind the foramen ovale, the ischium presents a smooth and extensive surface, forming much of the lateral wall of the pelvic cavity. Observe that it inclines so as to form a gentle slope towards the lower opening of the pelvis. Now it is this "slope of the ischium" which guides the head of the child after it has entered the brim of the pelvis, and makes it turn so that the longest diameter of the head corresponds with the widest part of the outlet. The greater part of the slope gives origin to the "obturator internus." This muscle also arises from the margin of the obturator foramen, as well as the membrane closing it; and with this muscle we must associate the lesser ischiatic notch, because it forms the beautiful pulley, crusted in the recent state with cartilage, round which the many tendons of this muscle turn, in order to rotate the thigh-bone.

Fig. 25.



The tuberosity of the ischium, a lever of the first order.

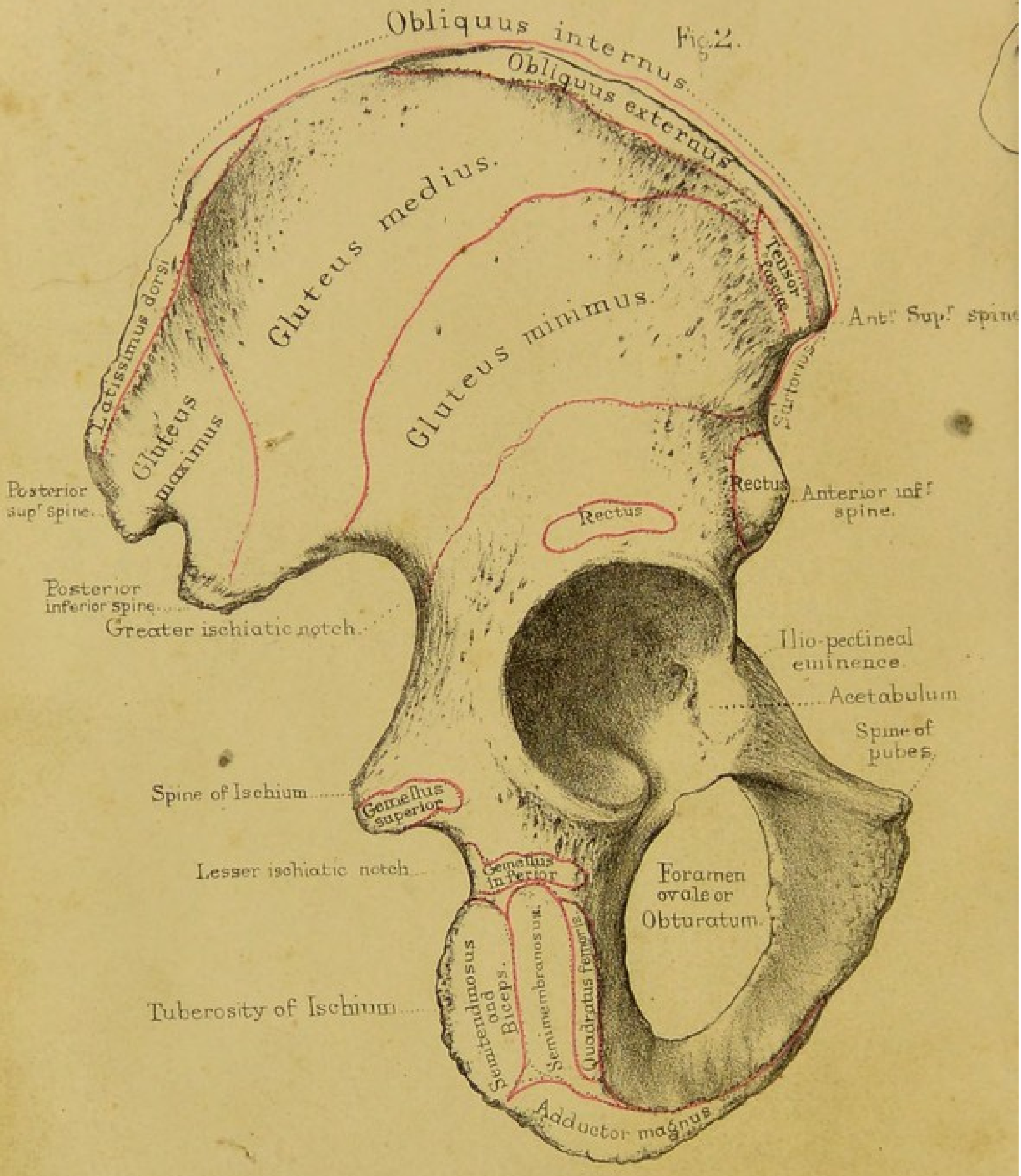
Tuberosity. The tuberosity of the ischium is obviously intended to answer a double purpose — 1. it serves to support the trunk in the sitting position; 2. it forms a lever for the action of the hamstring muscles, of which one important function is to restore the body to the erect position after stooping, as seen in the annexed cut, fig. 25. This is a lever of the first order. The fulcrum F is at the hip-joint; the weight W is the trunk of the body; and the power P is at the tuberosity of the ischium, where the hamstring muscles arise. On the "tuberosity" itself there is nothing to remark beyond the rough impressions made by the strong muscles attached to it. At its back part there is the conjoined origin of the "semitendinosus" and "biceps," the origin of the "semimembranosus" and the "quadratus femoris," and still higher that of the "gemellus inferior." At its lowest part begins the origin of the "adductor magnus," which is continued a long way up the ramus, nearly to the body of the pubes. Along the inner side of the tuberosity is a rough ridge to which the greater ischiatic ligament is attached: anterior to this, but in the same line, is the origin of the "erector penis," and that of the "transversalis perinei superficialis."

Acetabulum.

Lastly, we come to the "acetabulum." This is so named from its resemblance to an ancient vinegar cup. Observe its great depth and hemispherical form adapted for the secure lodgement of the head of the thigh-bone, and for more or less movement in any direction. It looks downwards and outwards so as to transmit the weight of the trunk directly on to the head of the thigh-bone; and the upper or iliac portion of it is by far the thickest and strongest, since it has to support the whole weight of the trunk in the erect posture. All these points are of interest, because they are characteristic of the human skeleton. There are two notches in the margin or "brim" of the acetabulum. The upper and smaller one is near the ileo-pectineal eminence, and permits the free bending of the thigh towards the abdomen. The other and larger, specially called "*the* notch," is at the lowest part of the margin. It permits the "adduction" of the thigh, as, for instance, when we cross the legs, and also lets blood-vessels run into the acetabulum to supply the ligamentum teres, and the fat at the bottom of it. Besides which, there is no need of bone at the lowest part of the socket, which never has to support weight. Two ligaments are attached to the borders of the notch: one is the "ligamentum teres;" the other is the "transverse ligament,"* which runs across it to complete the margin of the acetabulum.

* The transverse ligament is sometimes ossified in extreme old age. See a preparation in the Hunterian Museum, No. 5524.

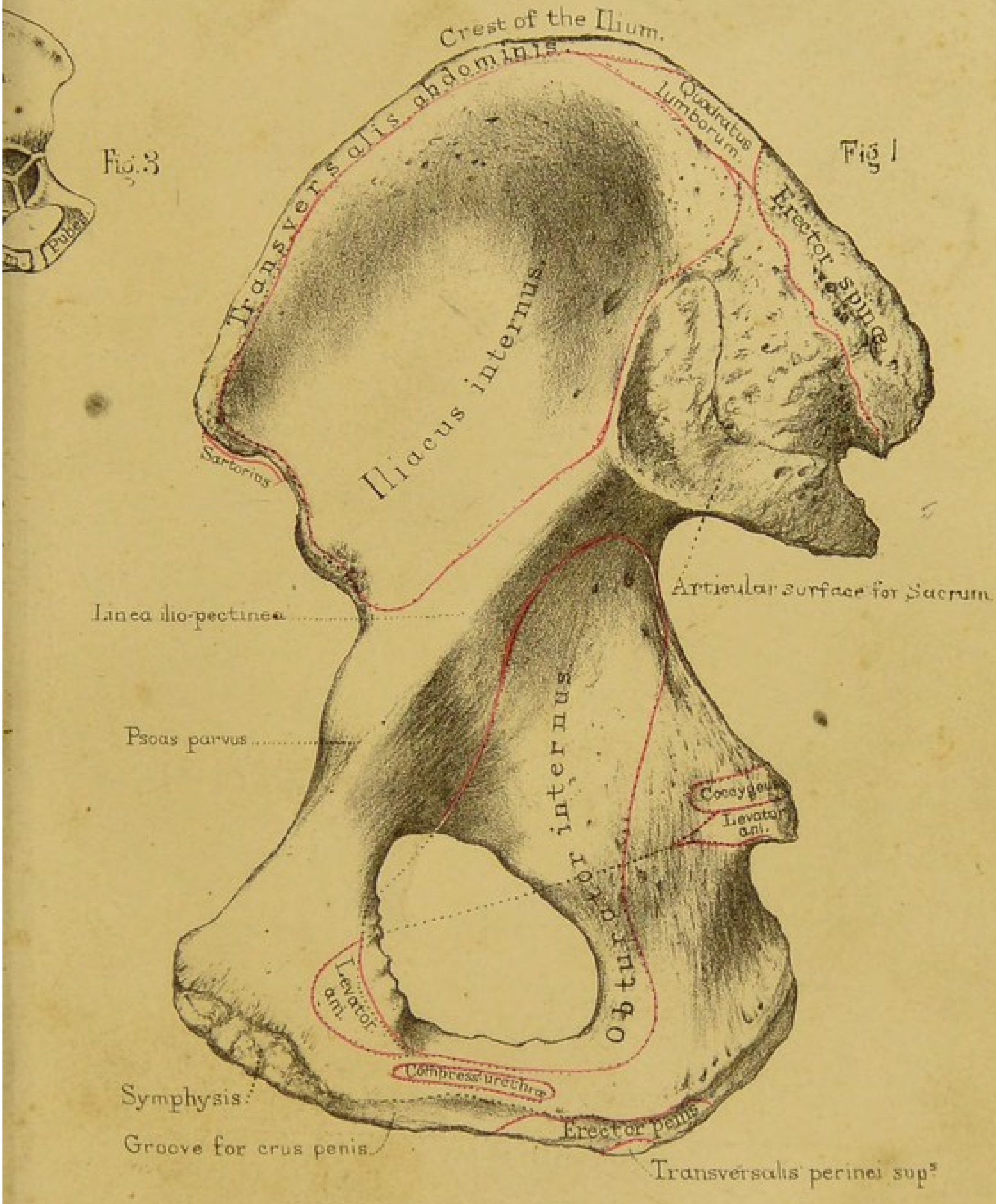
Os innominatum.



Outer surface.

L. Holden, ad naturr del.t

Os innominatum.



Inner surface.

T. Godart Lith.

Deep as it is, even in the dry bone, the acetabulum is made still deeper in the recent state by a rim of fibro-cartilage, called the "cotyloid ligament," which, besides increasing its depth, serves as a "sucker" to keep the head of the bone in the socket.

Looking into the socket, we observe that it is smooth everywhere, except at the bottom, where there is an irregular excavation continuous with the notch below. This is to allow the free play of the ligamentum teres within the joint, and is partly occupied by fat and synovial fringes. If the socket be held up to the light, the bottom of it will be found thin enough to be transparent. This thinness explains why, in some cases of diseased hip-joint, the matter makes its way through the socket into the pelvic cavity.* It likewise explains why a fall on the trochanter major is able to fracture the bottom of the acetabulum. We have a preparation † in the museum of St. Bartholomew's Hospital in which a fracture, caused by a fall on the trochanter a few months before death, extended in several directions from the centre of the acetabulum to its circumference.

Besides the three pieces of which it is originally formed, the os-innominatum has four "epiphyses," which begin to appear about the age of puberty. One skirts the crest of the ilium. There is a second for the anterior-inferior spine; a third along the tuberosity of the ischium: and a fourth, which forms a thin plate, at the symphysis pubis.

* See museum of St. Bartholomew's Hospital. Second Series, B. 18.

† Third Series, No. 62.

THE SACRUM.

(Plates XXXI. and XXXI. *a.*)

The "sacrum"* is situated at the back of the pelvis, and is wedged in between the two innominate bones, so as to form the "keystone" of the arch which supports the spine, and transmits the weight of it to the lower limbs. Observe that it inclines backwards, and forms, with the last lumbar vertebra, a rounded angle, termed the "promontory" of the sacrum. This inclination answers a double purpose: it not only makes more room in the pelvis, but breaks the force of shocks transmitted from the pelvis to the spine.

Composed of five vertebræ.

Its general shape is triangular; and a simple inspection of it proves that it consists of five vertebræ†, with their bodies and processes all consolidated into a single bone. We have to examine its anterior and posterior surface, its sides, base, and apex.

Its *anterior* surface is concave, not only from above downwards, but also from side to side, in adaptation to the pelvic cavity. This

* It is not easy to say why this was called the "sacred bone" (ἱερόν ὀστέον). The reason generally assigned is, that it was the part used in sacrifices. The following is another:—It appears the Jewish Rabbis entertained a notion that this part of the skeleton, which they called the "luz," would resist decay, and become the germ from which the body would be raised. Hence Butler has it—

> "The learned Rabbins of the Jews
> Write there's a bone, which they call 'Luz,'
> I' the rump of man, of such a virtue
> No force in nature can do hurt to:
> All th' other members shall, they say,
> Spring out of this, as from a seed
> All sort of vegetals proceed;
> From whence the learned sons of art
> '*Os sacrum*' justly call the part."
>
> HUDIBRAS, cant. ii. part iii.

† It is not uncommon to meet with six sacral vertebræ. Sometimes there are but four.

SACRUM. PLATE XXXI

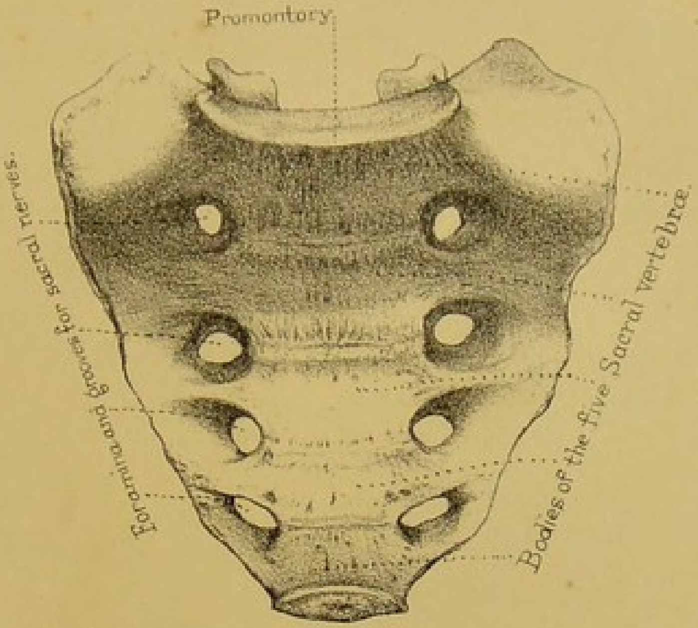


Fig. 1.

Anterior view.

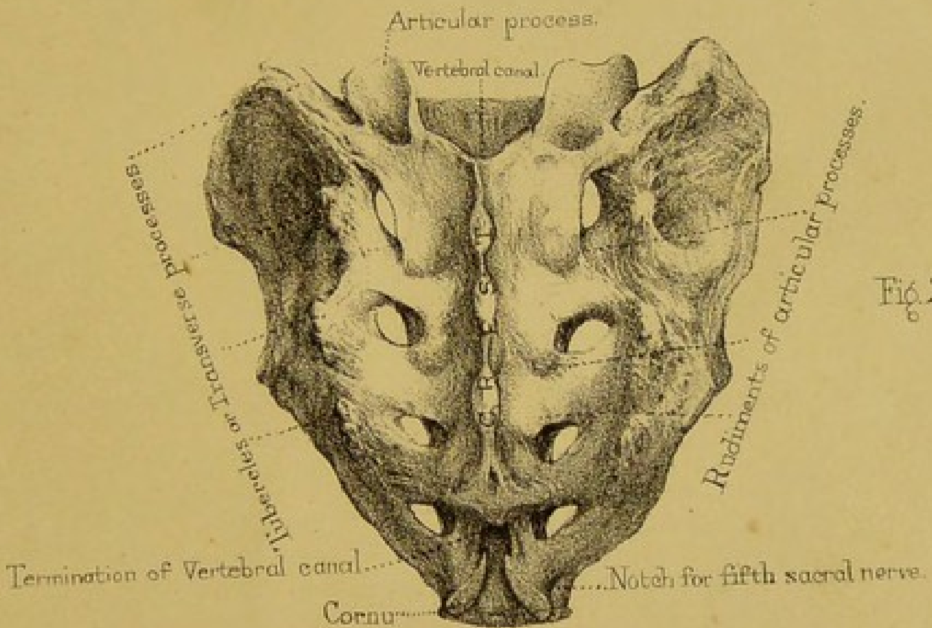


Fig. 2.

Posterior view.

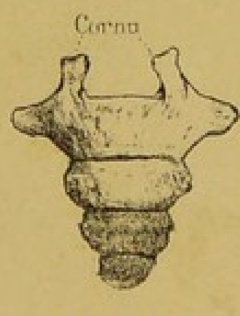
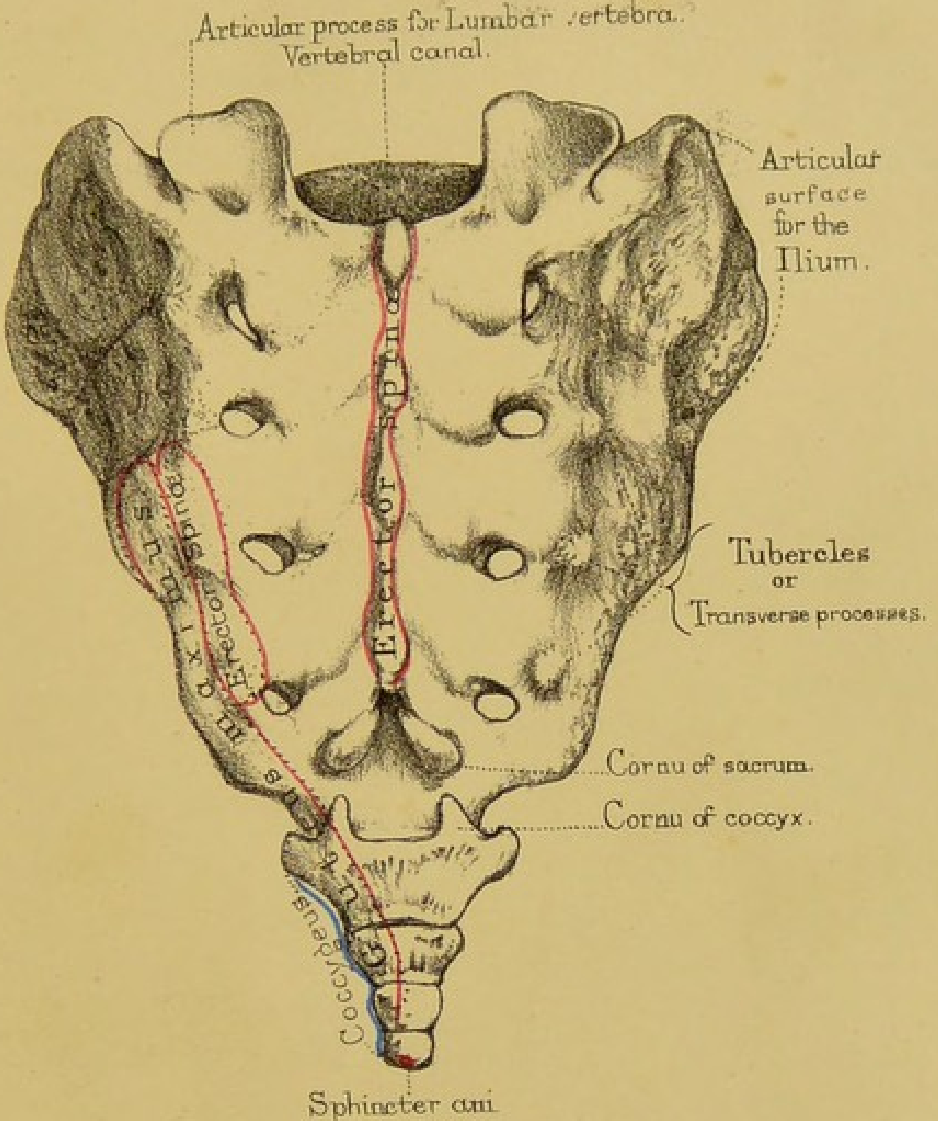


Fig. 3.

Coccyx.

L. Holden ad natur del. T. Godart Lith.



Posterior surface of Sacrum.
with muscles attached.

L. Holden Delᵗ. T. Godart Lith.

curvature of the bone forwards, not only assists in supporting the pelvic viscera, but also permits us to sit, which we could not have done, had the bone projected like a tail. In the middle, we see the bodies of the five sacral vertebræ decreasing in size from above downwards, and the four transverse ridges indicating their union. On each side of the ridges are the four anterior sacral foramina, with grooves leading from them for the passage of the anterior branches of the sacral nerves.

The bone exterior to the foramina, on each side, is made up of parts which answer to ribs. These are united to the bodies, to each other, and also to the transverse processes behind, so as to form a solid lateral mass. Here the "pyriformis" arises. (Plate XLVII.)

The *posterior* surface of the sacrum is convex, and presents, in the middle line, the spines of the four upper sacral vertebræ, coalesced into a vertical crest for the origin of the "erector spinæ." Observe, however, that the last sacral vertebra, and sometimes the last two, have no spines, and that even their arches are more or less deficient, so that the termination of the vertebral canal is here left unprotected in the dry bone; and in the recent state it is only covered by a fibrous membrane. This explains the serious effects that are apt to follow an injury to this part. Sloughs from bed-sores upon this part are sometimes deep enough to expose the vertebral canal. On each side of the crest is the vertebral groove; and here are the faint traces of the anchylosed articular processes of the sacral vertebræ. The most conspicuous of these processes are those of the last vertebra: they project like two knobs of bone, and are called the "cornua" of the sacrum: they correspond with the cornua of the coccyx, with which they are connected by ligaments.

Next to the articular processes are the four foramina for the transmission of the posterior sacral nerves. These posterior sacral foramina are directly opposite the anterior. Béclard, in his lectures, relates the case of a sharp instrument running through both into the pelvic cavity. The fifth sacral nerve emerges through the little "notch" beneath the sacral cornu. Still more externally are the "tubercles," indicating the anchylosed transverse processes. These, like the crest, give origin to the tendon of the "erector spinæ."

The *base* or upper end of the sacrum presents the oval surface of the body of the first sacral vertebra, which articulates with the last lumbar, a thick fibro-cartilage intervening. Holding the bone properly inclined backwards, we notice that this surface slants downwards and forwards, forming, with the lumbar vertebra, the sacro-vertebral angle, or promontory, to which allusion has been already made. On each side of the body are its enormously thick and strong lateral masses, expanded like two wings, in order to transmit the weight to the iliac bones. Each wing has a rounded edge in front, which forms part of the brim of the true pelvis. Behind the body is the triangular opening of the vertebral canal formed by the vertebral arches. Lastly, on each side of the canal are the articular processes for the last lumbar vertebra. They are set wide apart, in order to give a broad base of support to the spine, look backwards and inwards, and are slightly concave from side to side, so as to permit a slight rotatory movement. In front of each articular process is the indication of the notch for the passage of the last lumbar nerve.

The *apex* of the sacrum is formed by the diminutive body of the last sacral vertebra, and has an oval articular surface for the coccyx.

Sacro-iliac symphysis.

At the sides of the sacrum, we have to notice the surface which is connected to the ilium, forming what is called the "sacro-iliac" symphysis. Three sacral vertebræ concur to form it.* The connection is effected, partly by cartilage and partly by ligament. The cartilaginous part is in front, and is mapped out on the dry bone in the shape of a little ear: hence called the auricular surface of the sacrum. Behind this is the rough excavation denoting the attachment of the strong interosseous ligament connecting the two bones. Separation of the "sacro-iliac" symphysis does sometimes, though rarely, take place as the result of injury. It is an accident of the gravest kind, and one rarely sees recovery in such a case, since it is almost sure to be accompanied with other injury to the pelvic viscera. Lastly, the

* In the chimpanzee the sacrum has only the first two transverse processes fully developed and united to the iliac bones: hence, the trunk is less firmly connected to the pelvic arch, and therefore needs additional support from the arms.

side of the sacrum below the auricular part gives origin to some of the fibres of the "gluteus maximus."

Development of the sacral vertebræ. The sacral vertebræ are developed like the others, with the addition of an independent centre on each side of the first three for the formation of the lateral mass. Now, since every vertebra has three primary centres (one for the body and two for the laminæ, or arches), and two secondary centres for the body (the discs on the upper and lower surfaces), the number of centres for the five sacral vertebræ stands thus:—

3 × 5 = 15 centres for the bodies.
2 × 5 = 10 centres for the arches.
2 × 3 = 6 additional centres for the lateral masses of the first three vertebræ.
= 31

To this we must add two discs, one on each side, for the auricular surface,—making in all 33.

The component parts of each vertebra unite together first. Thus complete, each vertebra remains separate till about the 15th year, when they begin to unite; not all at once, but in regular succession from below upwards. The lateral masses unite before the bodies. The "auricular" disc does not appear till about the 20th year, and the whole bone is not consolidated before the 26th year, or thereabouts. However, even in advanced age, one sometimes finds the bodies of the upper sacral vertebræ still united in the centre by cartilage only.

THE COCCYX.

(Plate XXXI.)

The coccyx derives its name from a fancied resemblance to the beak of a cuckoo (κόκκυξ). It consists of four or sometimes five rudimentary vertebræ, articulated (or anchylosed) together, and successively decreasing in size, the last being a mere nodule of bone. As a whole, it is triangular. The body of the first coccygeal vertebra articulates by an oval surface with that of the last sacral: and it has two little articular processes which project under the name of "cornua," to be connected with the "cornua" of the sacrum, either by fibrous tissue or cartilage. The first vertebra has also two rudimentary transverse processes, and two "notches" (one beneath each cornu), for the last sacral nerve.

The first coccygeal vertebra articulates with the lower end of the sacrum by an intervening fibro-cartilage, and the succeeding ones are also separated by a fibro-cartilage. Thus the coccyx admits of being bent backwards and forwards, which is of great advantage in parturition, and gives as much as one inch more space in the antero-posterior diameter of the outlet of the pelvis. About the age of 45 or 50, and indeed sometimes earlier, these little bones become anchylosed to each other, and to the sacrum. This is one of the causes of difficult labour. Dr. Ramsbotham says it is generally met with in women bearing a first child late in life, and in those who have been accustomed to sit during the greater part of the day, as in the case of milliners. Under these circumstances the bone will sometimes break in labour. It is a most distressing accident, and causes great pain when the bowels are acting.

Dr. Hunter says that anchylosis of the sacrum and coccyx is common in females who ride much on horseback, and thus explains the comparative frequency of hard labours in English women. Father Dobritzhofer, who lived a long time a missionary among the Abiponians, speaks of the difficult labours of the women there, who spend the greater part of their time on horseback.

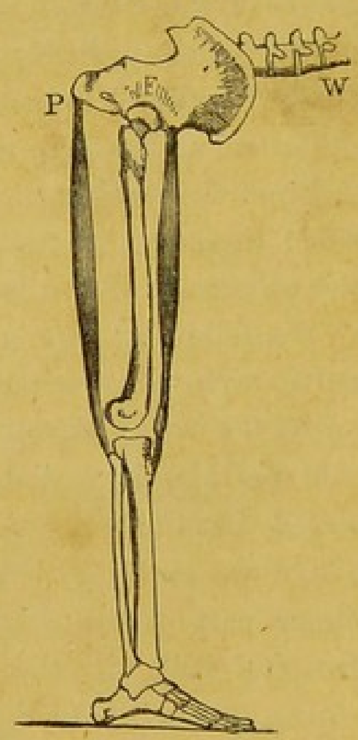
Each bone of the coccyx is ossified from a single centre. The first begins to ossify soon after birth; the second about the 5th year; the third about the 10th; and the fourth about the 15th or 20th year.

THE PELVIS IN GENERAL.

The pelvis is named from its resemblance to a basin (πέλυξ). The French call it "le bassin," and in old English works it is often spoken of as "the basin." When midwives speak of the *true* pelvis, they mean all below the brim. All above the brim they call the *false* pelvis. By the brim is understood the "linea ileo-pectinea." Again, they speak of the upper opening or "inlet," and the lower opening or "outlet" of the pelvis.

Pelvis a lever of the first order. The pelvis forms a great arch of bone which supports the trunk, and transmits the weight of it to the lower limbs. It contains and protects the pelvic viscera, and some of the abdominal. It acts as a lever of the first order in balancing the trunk on the head of the thigh-bone, as when we stand upon one leg. But the most obvious action of the pelvis as a lever of the first order that we can adduce, is when we raise the body from the stooping to the erect attitude. In this action the fulcrum F, as seen in the cut, fig. 26, is at the hip-joint; the weight W is the trunk of the body; and the power is fixed to the tuberosity of the ischium, P. The power in this case is the contraction of the hamstring muscles. This, by the way, is a very good example of a muscle answering a double purpose. The hamstring muscle, represented in the cut, is the biceps. When its fixed point is below, *i.e.* at the fibula, the muscle can raise the body from the stooping position. When its fixed point is at the pelvis, it serves to bend the knee. In the latter case, however, the muscle acts upon a lever of the third order.

FIG. 26.



The pelvis a lever of the first order.

Under the head of pelvis in general comes—1. its mechanism as an arch; 2. its obliquity with regard to the spine; 3. its axis; 4. the diameters of the inlet and outlet; 5. the difference between the male and the female pelvis.

Pelvic arch: its strength. Its mechanism as an arch is best displayed by sawing off the wings of the ilia, as we have done in Plate XXXIII. Such a section shows the following points:—The sacrum forms the broad keystone of the arch, and supports the weight of the spine. Now the sacrum being set very oblique, the weight tends to thrust it downwards and backwards. To resist this tendency, the sacrum is doubly wedged, that is, wedged from above downwards, and also from before backwards: thus, unless the ilia give way, which they never do, the sacrum cannot be dislocated *backwards*. But this is not all; there is a provision to prevent dislocation of the sacrum *forwards;* namely, a reciprocal irregularity, or slight "dovetailing," between the articular surfaces of the sacrum and ilium, and in all cases a "bite" in front formed by the edge of the ilium. So much for the security of the crown of the arch.

Observe, in the next place, that the inclination of the arch is such that the weight is transmitted in a perpendicular plane to the heads of the thigh-bones. Again, the thickest and strongest part of the arch is precisely in the line of pressure. Lastly, there are three "buffers" to break shocks; one at the pubic symphysis, the other two at the sacro-iliac symphyses.

From the main arch, two secondary arches proceed, one on either side: these are the "sitting arches," and the summit of each is at the tuberosity of the ischium.

The following is a good instance of the enormous weight the pelvic arch will bear without injury, provided the weight be applied *along the arch*. A waggon wheel passed over a man's pelvis from side to side, immediately over the symphysis pubis. The man stated that the waggon with the load in it weighed 5 tons 7 cwt. There was no injury beyond an ecchymosis of the scrotum and the upper part of the thighs. After three weeks, the man left the Hospital well, with the exception of a slight lameness.

Obliquity of the pelvis.

In the erect attitude the line of gravity of the spine falls perpendicularly on the sacrum, as shown in the line *a. b.* fig. 27. With this perpendicular, the inclination of the pelvis forms an angle (*a. b. c.* fig. 28) of 140° in the female, and 145° in the male. Now this angle is such, that the line of gravity falls through the acetabulum, and consequently the weight is transmitted directly on to the heads of the thigh-bones. For all practical purposes, one may ascertain the proper obliquity of the pelvis by holding it so that the "notch" shall be the lowest part

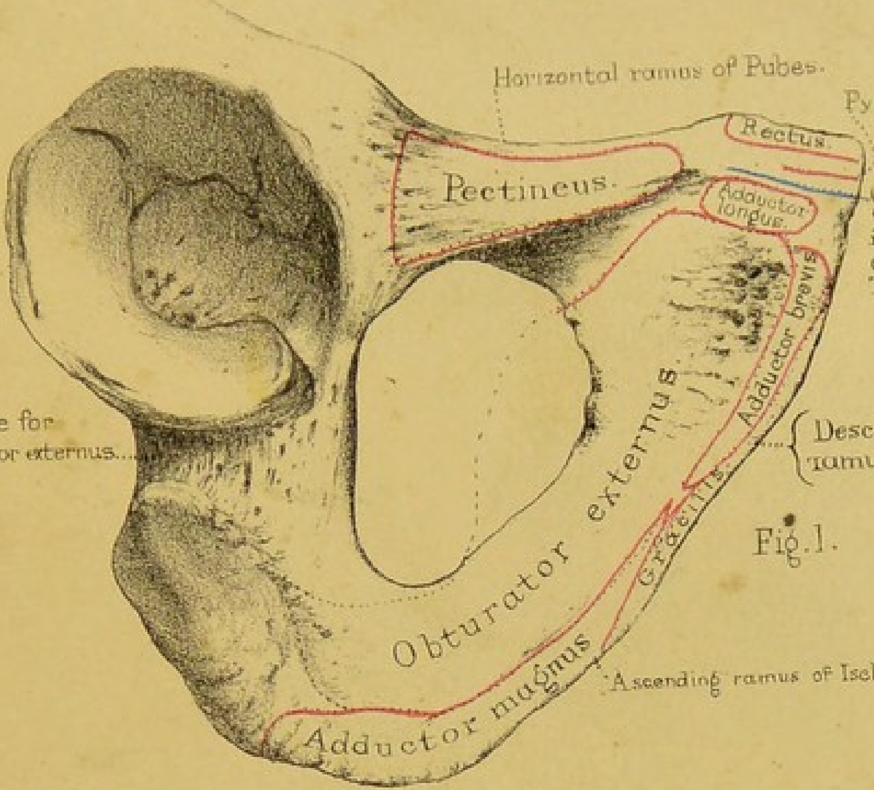


Fig. 1.

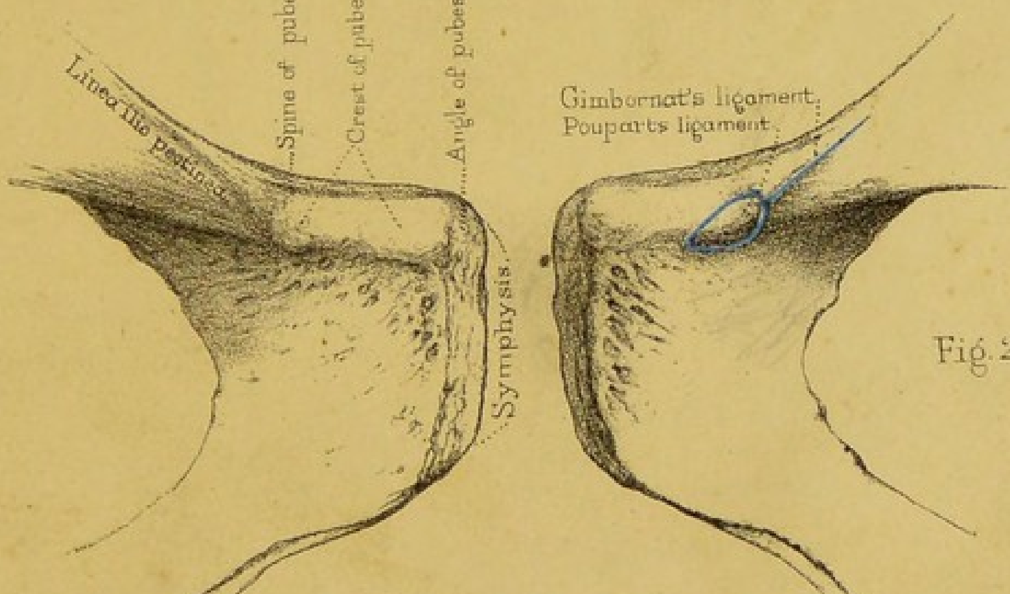
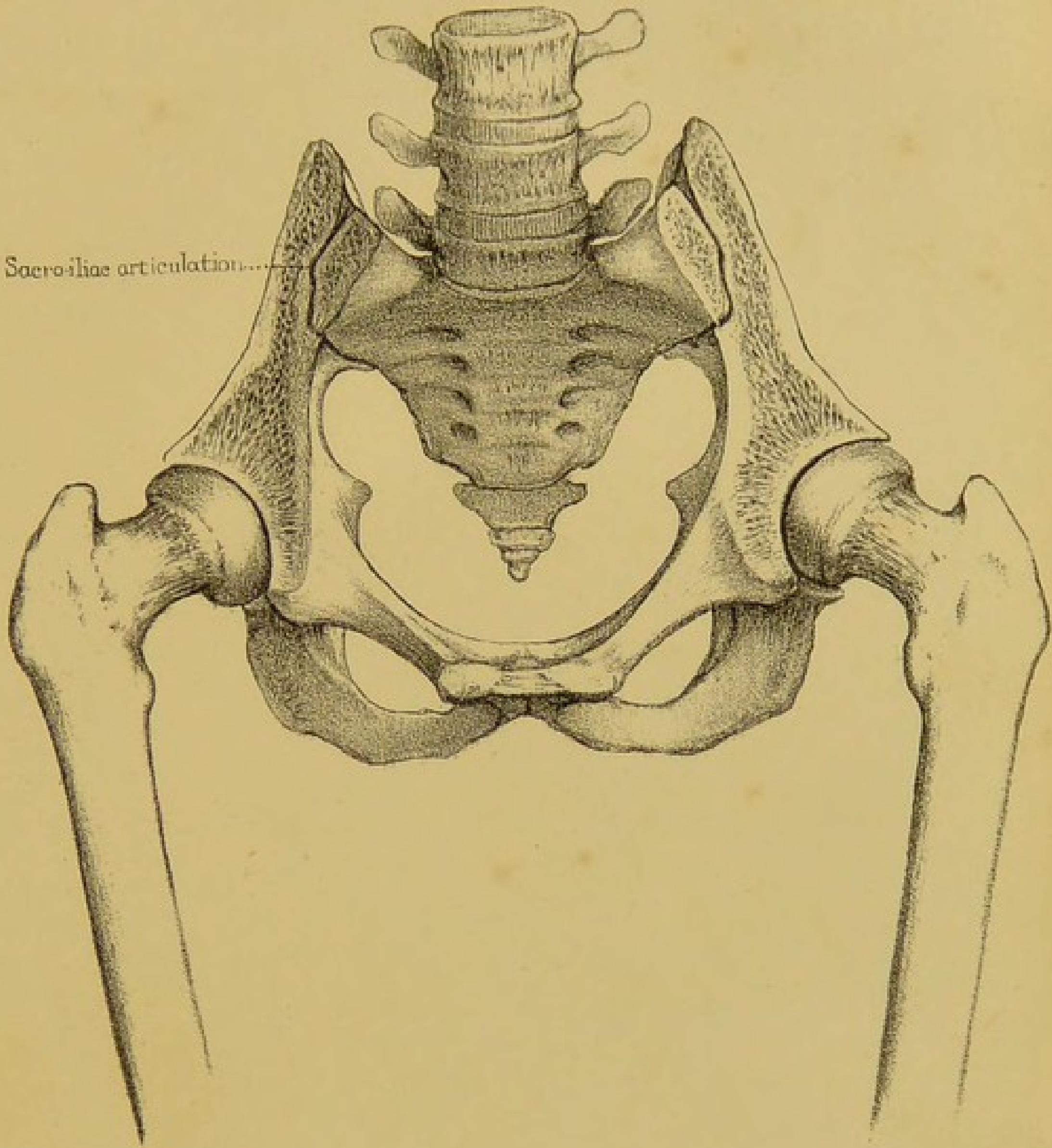


Fig. 2.

Front view of body of Pubes.

L. Holden ad natur del^t

T. Godart Lith.



Section through the upper part of the Sacrum and Ilia,
so as to exhibit the construction of the
PELVIC ARCH.

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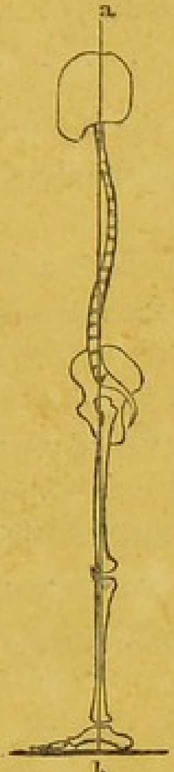
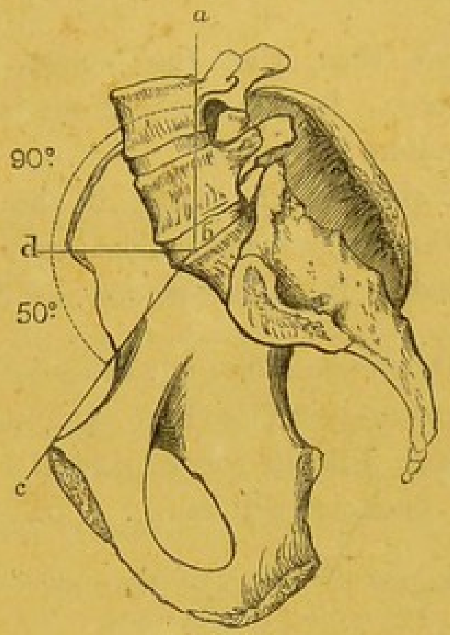
of the acetabulum. The end of the coccyx will then be about half an inch higher than the lower part of the symphysis pubis.

Fig. 27.



Line of gravity of the body.

Fig. 28.



Axes of the pelvis. The *axis of the brim* of the pelvis, that is, a line passing at right angles through the centre of its plane, if prolonged, would pass from the coccyx to the umbilicus. The *axis of the outlet* would fall on the promontory of the sacrum. The *axis of the cavity* would form a curve pretty nearly corresponding with the curve of the sacrum. In all operations about the pelvis, it is of great importance to bear in mind its different axes. As a useful practical rule, we may, therefore, lay down, that the axis of the pelvis corresponds with a line drawn from the anus to the umbilicus.

Diameters of the pelvis. The next point is the diameters of the pelvis; and it is interesting because it concerns parturition. The inlet or brim of the pelvis is somewhat heart-shaped. Its diameters vary more or less in different cases: in the recent state, with all the soft parts undisturbed, the following are about the average:—

	Inches.
Antero-posterior or conjugate	4
Oblique (from sacro-iliac symphysis to acetabulum) . .	$4\frac{5}{8}$
Transverse	$4\frac{6}{8}$

Observe, then, that the longest diameter of the *brim* is the transverse. In this direction the long diameter of the head of the child enters the pelvis.

The shape of the *outlet*, in the recent state, is like a lozenge, since the two ischiatic notches are blocked up by the sacro-ischiatic ligaments. Its diameters are as follow:—

	Inches.
Transverse (from one tuber ischii to the other) . . .	4
Antero-posterior (from symphysis to coccyx)	$4\frac{1}{2}$
And, with the coccyx pushed back, the antero-posterior diameter will be	$5\frac{1}{2}$

The longest diameter of the outlet therefore is from before backwards.

Now the head of the child enters the pelvis in the *transverse* diameter, but descends in the *oblique*, till it presses upon the spines of the ischia. Here its further progress is arrested by the spines. As the uterus goes on contracting, the slope of the ischium on each side compels the head to turn, so that the face comes to lie in the hollow of the sacrum. Consequently, the long axis of the head is brought into the long axis of the outlet, and is thus easily expelled.

Difference between the male and female pelvis.

The female pelvis differs very little from that of the male till puberty, at which period it has a heart-shaped form in both sexes. After puberty the female pelvis begins to assume its sexual characters, which are the following:—

1. The sacrum is wider and less curved*; the promontory less projecting; and the coccyx more moveable than in the male.

2. The cavity is shallower, and all its diameters broader, than in the male.

* Some authors state the reverse. But Albinus (de sceleto) says truly:—"Sacrum feminis latiùs, per longitudinem rectius, infra non æque incurvatum in priora."

3. The spines of the ilia, the acetabula, and the tuberosities of the ischia, are wider apart than in the male.

4. The symphysis pubis is not so deep: the pubic arch has a much wider span, and its branches are more shelving than in the male, in order to facilitate parturition.

THE FEMUR.

(Plates XXXIV. and XXXV.)

The thigh-bone is the longest and strongest of all the bones. Its great length, in comparison with the other bones of the leg, is characteristic of the human skeleton. In consequence of this great comparative length, and of the shortness of the arms, the ends of the fingers in man do not reach lower than the middle of the thigh-bone. In the chimpanzee the fingers reach down to the knee; and in the orang, down to the ankle.

The direction of the thigh-bone is not quite perpendicular, but slants, so that the knees are nearer together than the hips; obviously for the purpose of bringing the knee-joint nearer the line of gravity of the body. This obliquity is necessarily greater in women, on account of the greater breadth of the pelvis, and accounts for their peculiar gait. We have to examine the head, the neck, the trochanters for the attachment of muscles, the shaft, and the condyles.

HEAD. The head forms rather more than half a sphere, smooth and convex on every part, except at a point a little behind and below its centre, where there is a depression for the attachment of the "ligamentum teres." It forms a perfect ball-and-socket joint with the acetabulum. When crusted with cartilage the ball fits so accurately into its socket, that it is retained in it by atmospheric pressure alone. It has been ascertained by experiment that this pressure is about 26 pounds; that is, more than equal to sustain the weight of the entire limb with all its soft parts. More than this, the Brothers Weber * have shown that, in walking,

* Mechanik der mensch. Gehwerk., Gott. 1836.

the legs act like pendulums, and that we require scarcely any muscular force to advance one leg before the other. This is a beautiful provision. The limb hangs freely in its socket, and the muscles do not expend any of their power in keeping it there. Boerhaave might well say, "in mirabili articulatione femoris Creatorem adoramus."

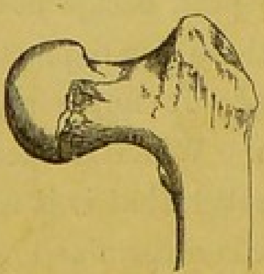
NECK. The general direction of the "neck" is upwards, inwards, and a little forwards from the shaft. The reason why the neck of the thigh-bone is directed a trifle forwards is, that the lower extremity may naturally turn a little outwards. Everything in the bones of the lower limb and the insertion of its muscles conforms to this object. It is this which gives elasticity, freedom, and grace to the motion of the body; and we owe this to nature, and not, as some suppose, to the dancing master.

In the adult the neck is set on to the shaft at a very open angle, about 125°. But the angle varies at different ages, in harmony with the requirements of the age. In children the neck of the thigh-bone is so oblique that it forms almost a gentle curve from the axis of the shaft, as seen in the cut (fig. 29). Therefore the trochanters do not project nearly so much as in the adult (fig. 30). This is one reason why it is sometimes difficult to determine the precise nature of accidents about the hip in children. As old age advances the neck drops to nearly a right angle with the shaft, as shown in fig. 31: besides which its compact walls become thinner, and its cancellous tissue becomes expanded. No wonder, then, the neck of the femur is so liable to break in old persons. Observe how much broader the neck is in its vertical diameter, and how much thicker the lower wall is than the upper, in order to resist vertical pressure. The part where

FIG. 29.

FIG. 30.

FIG. 31.



Comparative obliquity of the neck of the thigh-bone in the child (fig. 29), the adult (fig. 30), and the aged (fig. 31).

the neck springs from the shaft we call the "base." In falls on the trochanter, the neck is sometimes broken here, and driven into the shaft between the trochanters, forming what is called an "impacted" fracture of the neck. The symptoms of such a fracture are, more or less shortening of the limb, diminished projection of the trochanter major, and no crepitus.

Since the great length and obliquity of the neck of his femur is quite peculiar to man, let us consider for a moment what advantage his skeleton gains by it. In the first place, it widens the base of support for the trunk. It disengages the shaft of the thigh from the hip-joint, and thus increases the range of motion. What animal can separate its legs so widely as man? But this is not all. Greater space is made for the adductor muscles, which balance the pelvis on the inside of the thigh; and the great trochanter being removed to a distance from the hip-joint, gives greater leverage to the powerful gluteal muscles which balance the pelvis on the outside. Again, the weight of the trunk, in place of falling vertically on the shaft of the femur, is transmitted to it by an arch.

TROCHANTER, major and minor.

As aforesaid, the trochanter "major" and "minor" are outstanding processes for the purpose of giving greater leverage to the muscles which rotate the thigh (τροχάω, verto). Observe, they project behind the axis of rotation (which is the centre of the head of the bone). This is another of the provisions for the outward rotation of the lower limb as the natural position. It is well to remember that the top of the great trochanter in the adult is about ¾ of an inch lower than the head of the bone. Take the muscles inserted into the trochanter major first. Suppose the trochanter to be square, which it is nearly if you look at it sideways. Into the *anterior* border is inserted the "gluteus minimus:" into the *superior* border, the "obturator internus, the gemelli, and the pyriformis;" into the *posterior* border, the "quadratus femoris;" the *inferior* border (base of the trochanter) gives origin to the strong tendon of the "vastus externus." Draw a diagonal from behind forwards across the square (there is a faint trace of it in nature), and you will find that the upper triangle gives insertion to the "gluteus medius," while the lower remains smooth for the play of the tendon of the "gluteus maximus."

Behind the neck of the femur, and beneath the projecting angle of the trochanter major, you will find a deep excavation, called the "digital fossa." No muscle is inserted here except the "obturator externus;" and this insertion is at the bottom of the fossa.

The bearings of the great trochanter deserve particular attention, because it is our great land-mark in determining the nature of injuries about the hip. For instance, when the trochanter is lower down than it ought to be, we know that the head of the bone is dislocated inwards; when it is higher than its proper place, nearer to the spine of the ilium, and so fixed that it cannot be moved, we know that the head is dislocated on the dorsum of the ilium; when it is higher and freely movable, we know that the neck of the bone is broken.

The trochanter minor projects from the inner and *back* part of the shaft, just below the base of the neck. It gives insertion to the "psoas magnus" and the "iliacus internus." Observe that the trochanter minor is directed backwards in order that the muscles inserted into it may turn the toes outwards at the same time that they raise the leg. These are the muscles which, in fracture of the upper third of the shaft, it is so difficult to prevent from raising the upper fragment.

Inter-trochanteric ridges. Two oblique ridges extend from one trochanter to the other, the one in front of, the other behind, the neck of the femur. The purpose of the anterior "inter-trochanteric ridge" is to give attachment to the powerful ligament which covers the front of the capsule of the hip joint, limits the extension of the thigh, and is one of the chief safeguards of the erect position, since it prevents the pelvis and trunk from falling backwards. The posterior "inter-trochanteric ridge" is mainly for the support of the great trochanter.

SHAFT. Respecting the shaft of the femur we have to notice that it is slightly arched with the convexity forwards, by which a double advantage is gained: first, it is more springy than if it were straight; and, secondly, more room is gained for the flexor muscles behind, and more power for the extensors in front of the shaft. The shaft is smooth and cylindrical all round, except behind, where there is a longitudinal ridge termed the "linea aspera." This ridge serves as a buttress to the shaft, but its chief purpose is for the attachment of powerful muscles. The linea aspera is most prominent about the middle third of the shaft: here it appears at first sight a single ridge, but if you look more carefully you will probably find traces of two borders, termed its "lips." About the lower third of the shaft these lips diverge from each other, and may be traced more or less distinctly to the "tuberosities" of the condyles. The triangular interval between their bifurcation is called the popliteal surface of the femur, and upon it the popliteal artery rests in its passage through the ham. Turning to the upper end of the linea aspera*, we notice that here also its two lips branch off: one runs to the root of the lesser trochanter, the other to the root of the greater.

So much about the linea aspera and the upper and lower divergence of its two lips, will help us towards understanding the muscles attached to it. Take the outer lip first. The "vastus externus" arises from it all the way down. Along the upper third is a very rough surface for the insertion of the gluteus maximus. This part may very properly be called the *gluteal* ridge: it is sometimes so prominent as to resemble the third trochanter of animals. The lower two-thirds gives origin to the short head of the biceps.

The inner lip of the linea aspera gives origin all the way down to the "vastus internus." Into its upper part is inserted the "pectineus," then comes the insertion of the "adductor longus," and behind both is that of the "adductor brevis." Lastly, the insertion of the "adductor magnus" extends all along the shaft from the base of the trochanter major to the tuberosity of the inner condyle, where we notice a projection of bone for its better insertion.

Along the course of the linea aspera are the orifices of two

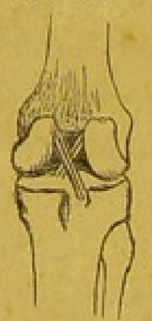
* These "lineæ asperæ" are nothing more than partial ossifications of the tendons inserted there. A very rough "linea aspera" is a character of age. It puts one in mind of the "bone tendons" which one sees in the regular anatomy of birds.

canals which convey nutrient blood-vessels to the marrow. Both these canals run obliquely *upwards* through the walls of the bone.

The front and outer surface of the shaft gives origin to the "crureus," and to the little muscle below it, the "sub-crureus;" the inner surface gives origin to part of the "vastus internus" (the other and stronger part arising from the linea aspera). Observe, the origin of these muscles does not occupy the whole of the shaft. Along the lower part, but more especially on the inner side, no muscular fibres arise. Here the bone is simply covered by the fibres of the "vasti" on each side. The point of this observation is, that it accounts for the great extent to which an inflamed knee-joint swells beneath the vasti: there being no resistance to the distension of the synovial membrane in this direction.

CONDYLES. The lower part of the femur gradually expands to form the condyles for the knee-joint (κόνδυλος, a knuckle). The inner condyle projects much more, and is full half an inch lower than the outer, when the bone is perpendicular; but when the bone slants, as it naturally does, you find both condyles on the same plane. This must needs be, as the plane of the knee joint is horizontal in adaptation to the erect posture. The condyles are separated behind by a deep notch, the "intercondyloid," which is for the lodgment of the two "crucial" ligaments, which prevent the knee from being extended beyond the straight line; for the requirements of this joint will not admit of any bony prominence to limit extension, such as we find in the elbow. These ligaments (as shown in the cut, fig. 32) are attached to the rough surfaces of the condyles facing each other, the anterior crucial to the external condyle, the posterior crucial to the internal.

FIG. 32.

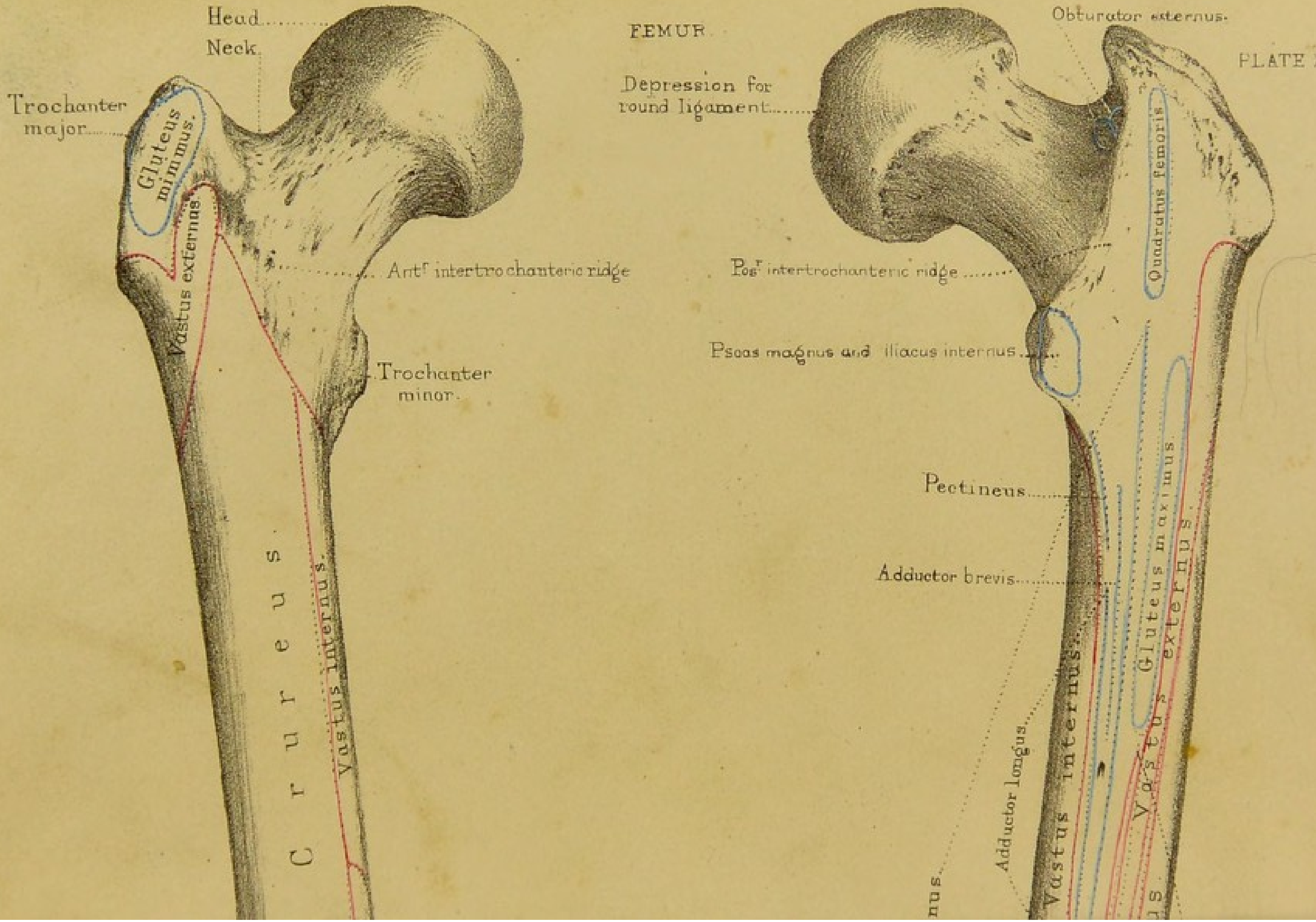


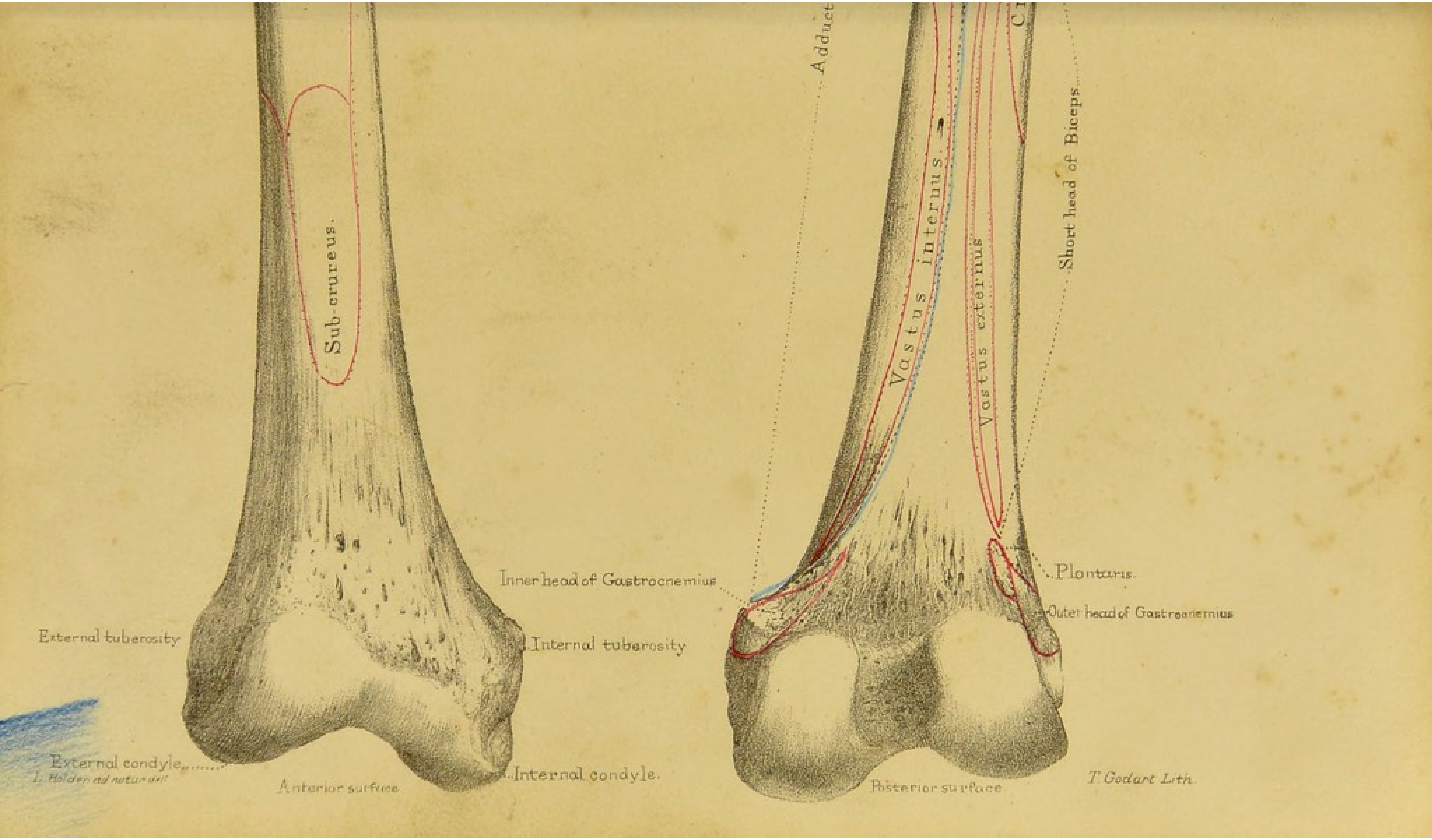
Crucial ligaments of the knee.

The articular surfaces of the condyles unite in front to form the pulley over which the "patella" plays. The larger share of the pulley is formed by the external condyle, and it mounts not only higher, but projects more, to prevent the tendency of the patella to be dislocated outwards. In an antero-posterior section, each articular surface would present something like the long half of an

PLATE XXXIV.

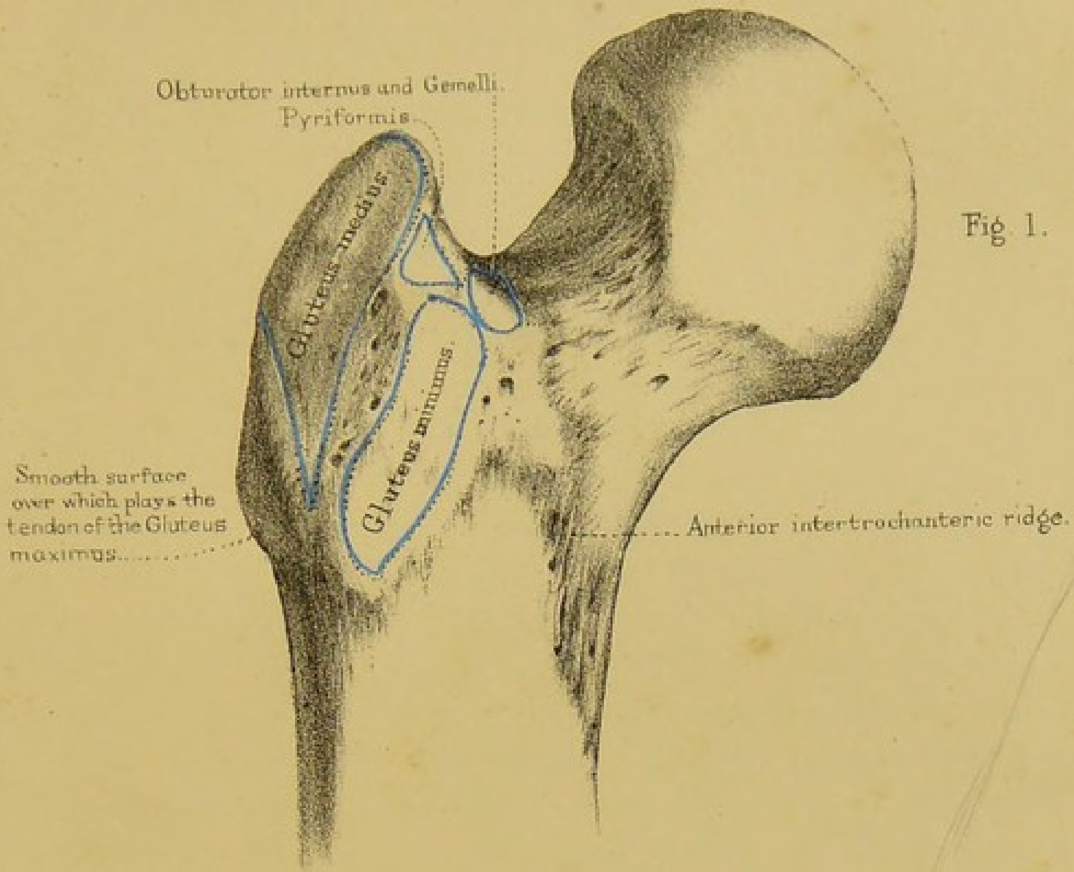
FEMUR.




Sub-crureus.
External tuberosity
Internal tuberosity
External condyle.
Internal condyle.
Anterior surface
Inner head of Gastrocnemius
Adduct
Vastus internus.
Vastus externus
Cr
Short head of Biceps
Plantaris.
Outer head of Gastrocnemius
Posterior surface
L. Holden ad natur. del.
T. Godart Lith.

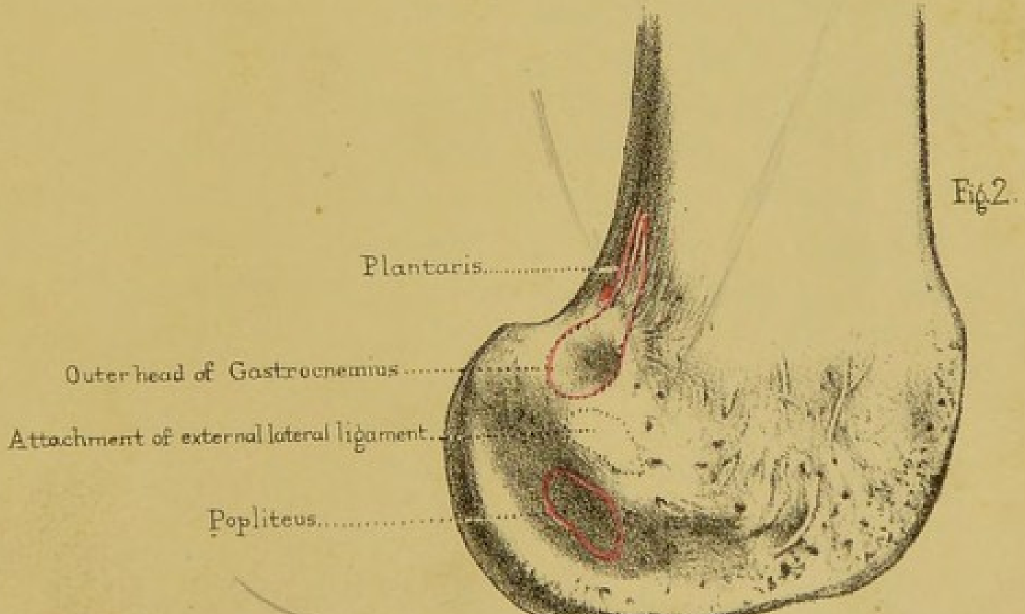
FEMUR.

Fig. 1.



Trochantor major seen obliquely

Fig. 2.



External condyle.

L. Holden ad natur delt T. Godart Lith.

ellipse (as seen in the adjoining cut, fig. 33).* In the erect attitude, the flatter part of the ellipse rests on the shallow excavation of the tibia, and all the ligaments are on the stretch; but when the knee is bent, the more convex part of the ellipse rests on the tibia, and admits of a certain amount of rotation, all the ligaments being loose.

Fig. 33.

The "tuberosities" of the condyles are for the attachment of the lateral ligaments of the joint. Observe that these tuberosities are situated nearer to the back than the front part of the condyle. The result of this is, that the ligaments are fixed behind the centre of motion, so that they become stretched when the joint is extended. This is another provision for the strength of the knee.

There is a rough surface behind the internal condyle for the origin of the inner head of the "gastrocnemius," and another, behind the external condyle, for the outer head of this muscle and the "plantaris." On the outer surface of the external condyle is a depression for the origin of the "popliteus."

Development of the femur.

The femur is ossified from three primary centres (one for the shaft and neck, and one for each articular end), and two secondary centres, one for each trochanter. (See plate D). The centre of the shaft appears very early (between the 40th and 60th day after conception), but that of the lower end not until within the last fifteen days of the full term of gestation. Hence the existence of this centre enables us to pronounce with something like certainty as to the age of a fœtus.† It is the only epiphysis in which ossification commences before birth. As this is the first of all the epiphyses to ossify, so it remains the longest a separate piece, in accordance with the general law that epiphyses unite with the shafts in the inverse order of their ossification. The

* The two woodcuts show very well the attachments and the direction of the crucial ligaments, *a b*, *a c*. Being attached to the condyles behind the centre, they necessarily limit extension beyond the straight line. But they do more; by crossing like braces they prevent lateral displacement of the tibia.

† Concerning the bearing of Osteogeny on forensic medicine, see "Médecine Légale," by M. Orfila.

centre of the head appears about one year after birth. The great trochanter begins to ossify about the third or fourth year; the lesser about the fourteenth. All the pieces have united about the age of twenty-one.

THE PATELLA.

(Plate XXXVI.)

The patella is a little bone developed in the extensor tendon of the knee, in order to protect the knee joint, and to increase the leverage of the extensor muscle by making it act at a greater angle. It is a principle in mechanics that the efficiency of a force which acts upon a lever is greatest when its direction is at right angles to the lever, and decreases as the obliquity of that direction is increased. The patella is the best example of a "sesamoid" bone. In shape, it is somewhat triangular, with rounded angles, the apex being downwards.

Its anterior surface is convex, and marked by longitudinal streaks, indicative of the insertion of the fibres of the extensor tendon.

Its posterior surface is smooth, and crusted in the recent state with cartilage, in order to play upon the trochlea of the femur. It is divided by a vertical ridge adapted to the groove in the femur, and on each side of the ridge are the articular facettes corresponding to the condyles of the femur. The external articular facette is the larger of the two in adaptation to the external condyle, and by this we may distinguish the right patella from the left. Besides this, the outer edge of the patella is much thinner than the inner edge, which is also another good distinction. Below the articular surface — that is, at the apex — there is a rough surface for the attachment of the "ligamentum patellæ," or continuation of the extensor tendon. The base of the bone is thick and irregular, for the insertion of the extensor tendon.

The patella is developed from a single centre, which appears about the second year. It is not fully ossified until about the age of fourteen or fifteen.

The patella being developed actually in the substance of the extensor tendon of the knee is very liable to be broken by a sudden and violent action of the extensor muscles, as when we attempt to preserve the balance of the body when it is in danger of falling backwards. In this position—that is, when the knee is *half-bent*—the upper part of the patella is not supported by its trochlea: there is a hollow under it, and here consequently the patella snaps transversely, like a stick broken across the knee. The broken ends are separated widely, and therefore in the vast majority of cases their reunion takes place by ligamentous substance, not by bone.

But even when the knee is *extended*, violent muscular contraction is able to snap the patella. Desault speaks of both patellæ being broken by convulsions in a patient after he had been cut for the stone. Opera dancers sometimes break the patella in practising the step called the "Entrechat."

THE TIBIA.

(Plate XXXVI.)

The tibia is the larger of the two bones of the leg, and is placed on the inner side. It entirely supports the condyles of the femur, and transmits the weight of the body to the foot. Its direction is not oblique like the femur, but vertical; so that in well-formed legs the two tibiæ should be parallel. Let us examine in succession the upper end, the shaft, and the lower end.

HEAD. The upper end is generally called the "head" of the tibia. It is very broad in the transverse direction for the support of the condyles of the femur: and we point to this great breadth as one of the peculiarities of the human skeleton. The articular surfaces for the condyles are very shallow in the dry bone, but deepened in the recent state by discs of fibro-cartilage (termed the "semilunar cartilages"). These cartilages convert the shallow articular surfaces of the tibia into *variable* sockets; that is, sockets which adapt themselves to the varying forms of the condyles in flexion and extension of the knee. The outer articular surface (facette) is round, but the inner is oval, with the long diameter from before backwards, in adaptation to the internal condyle. Between the articular surfaces is a projection termed the spine, which is generally topped by two little tubercles. In front of the spine is the depression in which the anterior crucial ligament is attached, and behind the spine is another much larger one, in which the posterior crucial ligament is attached. These depressions serve also for the attachments of the semilunar cartilages.

Tuberosities, external and internal. The lateral masses which support the articular surfaces are called the "tuberosities" of the tibia. The *external* tuberosity presents at its back part a small articular surface for the head of the fibula: this articular surface is on a kind of bony ledge, and its direction is oblique. The *internal* tuberosity is much larger, and projects more than the other. It has a groove behind for the insertion of the "semi-membranosus." About one inch and a half below the head of the tibia is the "tubercle" for the insertion of the common extensor tendon of the leg (ligamentum patellæ). You will observe that the insertion takes place into the lower part of the tubercle, which is rough; the upper part is smooth, to allow the easy play of the tendon (a bursa being interposed between the tendon and the bone).

Shaft. The shaft of the tibia is triangular. It is a little twisted outwards, to determine the obliquity of the foot; consequently the inner malleolus advances a little before the ankle joint, and the outer one recedes a little behind it. This, observe, corresponds with the obliquity of the neck of the thigh bone, the position of its trochanters, and the oblique direction of the muscles; the object of all being to give a natural inclination *outwards* to the lower extremity. The narrowest part of the shaft is about the lower third; hence the frequency of fracture here. Let us examine each of its surfaces.

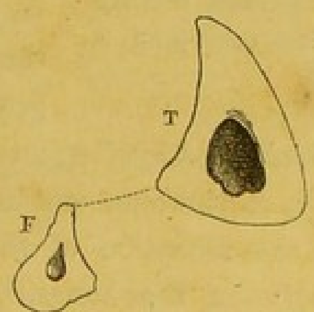
The *internal* surface is subcutaneous. We notice on it, below the internal tuberosity, the insertions of the "sartorius," "gracilis," and "semitendinosus." Behind these is a rough surface for the attachment of the internal lateral ligament of the knee.

The *external* surface is slightly hollowed along its upper half for the origin and lodgment of the "tibialis anticus:" its lower part is turned forwards, so as to present a smooth surface adapted for the play of the tendons which run over the front of the ankle-joint.

The *posterior* surface presents along its upper third a rough line, slanting from the outer towards the inner side. It indicates part of the tibial origin of the "soleus;" the remainder of this origin runs down the inner edge of the shaft to the extent of about three inches. This origin is an important piece of anatomy since it concerns the operation of tying the posterior tibial artery. Above the "oblique line" is a triangular surface, indicating the insertion of the "popliteus." The surface of the bone below the ridge is occupied by the origin of the "flexor longus digitorum," and part of the "tibialis posticus." Just below the line is the canal for the medullary artery. It is the largest of all the canals in the long bones, runs very obliquely from above downwards, and when divided in amputations sometimes occasions troublesome hemorrhage. I have many times traced a nerve through this canal with the artery into the medullary cavity.

The crest or "shin" of the tibia is the densest and strongest part of the bone (see cut, fig. 34); for this reason, that the chief pressure on the tibia is at the anterior part; which is at once obvious if we consider the direction of the force in walking, running, or leaping. This form of the tibia, therefore, is not a mere matter of accident, or the result of the pressure of the muscles which surround it.

FIG. 34.



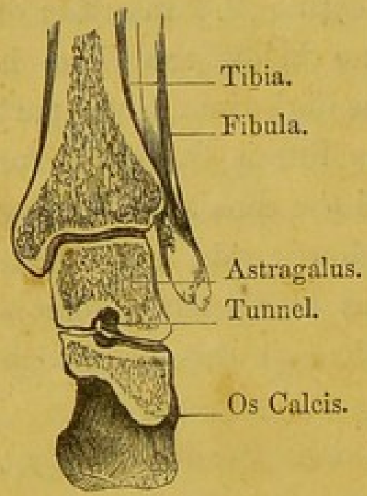
Section through the tibia, T, and fibula, F, to show the thickness of their walls.

With regard to the edges of the tibia, the *anterior*, called the "crest," is very sharp, and readily felt beneath the skin, but only along the upper two-thirds of the shaft: along the lower third the front of the bone is round, for the passage of the extensor tendons and the anterior tibial vessels and nerve. The *external* edge is turned towards the fibula, and gives attachment to the interosseous membrane (represented by the dotted line in the cut) which connects the two bones. The *internal* edge runs from the hinder part of the head of the tibia down to the inner malleolus. It gives attachment to the deep fascia covering the muscles of the back of the leg, beneath those of the calf.

Lower end.

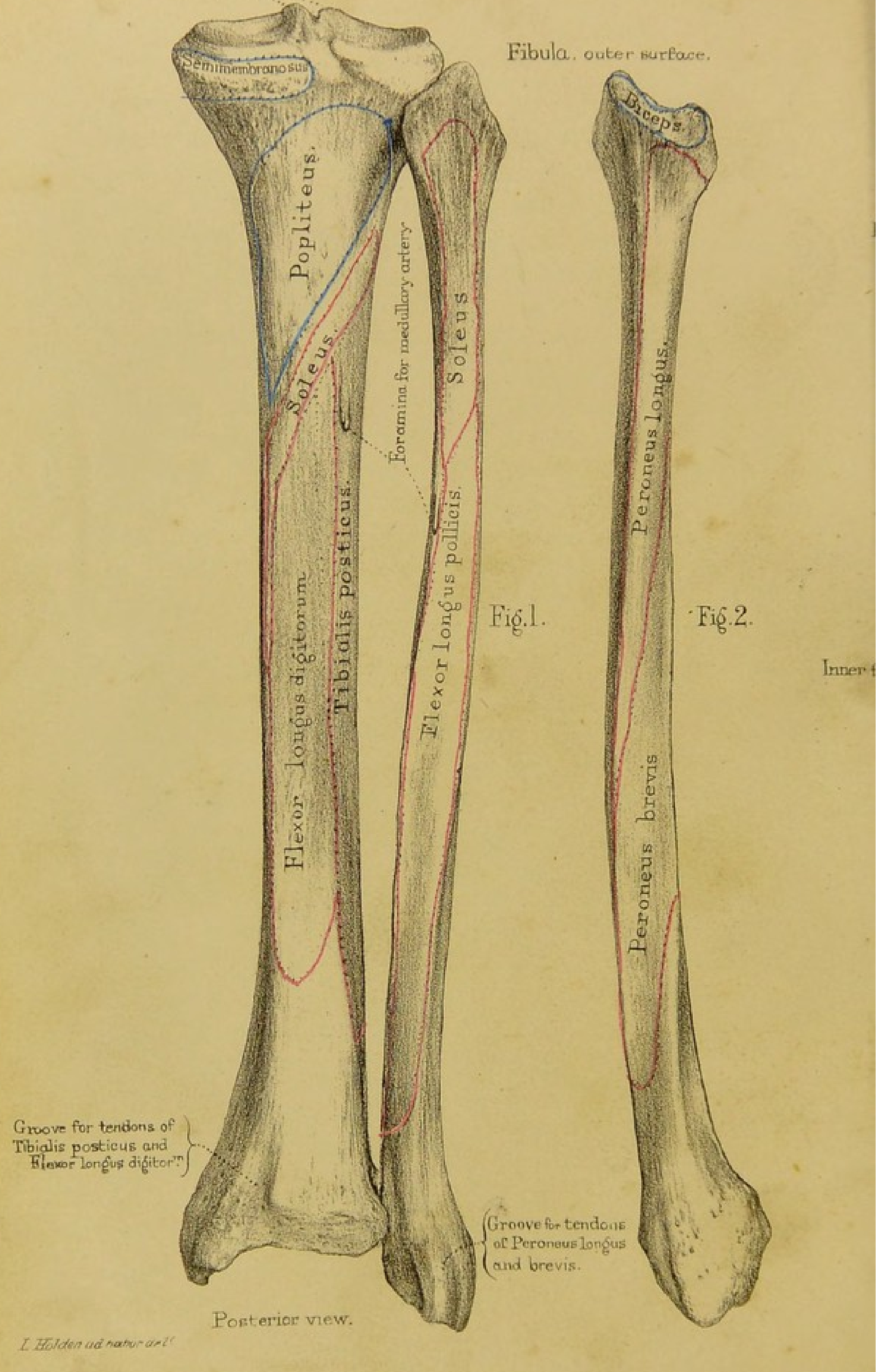
The lower end of the tibia is expanded transversely in order to form a hinge-joint with the astragalus. For this purpose its articular surface is uniformly concave from before backwards; but the plane of the joint is horizontal (as seen in cut, fig. 35), like that of the knee, for the advantageous support of the weight of the body. The joint is secured on the inner side by the massive projection termed the "malleolus internus." One side of this is smooth and crusted with cartilage, to articulate with the lateral surface of the astragalus; the other is subcutaneous. At its apex there is a deep notch for the attachment of the very powerful internal lateral ligament of the ankle; and behind is a longitudinal groove, which transmits the tendons of the "tibialis posticus" and the "flexor longus digitorum."

Fig. 35.



Section to show that the plane of the ankle-joint is horizontal.

Lastly, on the outer surface of the lower end is the rough excavation for the reception of the fibula. There is no sensible movement between the bones, but only just enough to give a slight amount of elasticity. The security of the angle requires that they be firmly rivetted together by a strong interosseous ligament; and their contiguous surfaces are rough accordingly.



Fibula. outer surface.
Semimembranosus
Popliteus.
Soleus.
Foramina for medullary artery
Soleus
Biceps.
Peroneus longus.
Flexor longus digitorum
Tibialis posticus.
Flexor longus pollicis.
Fig.1.
Fig.2.
Peroneus brevis
Groove for tendons of Tibialis posticus and Flexor longus digitor.m
Groove for tendons of Peroneus longus and brevis.
Posterior view.
L. Holden ad natur del.t
Inner

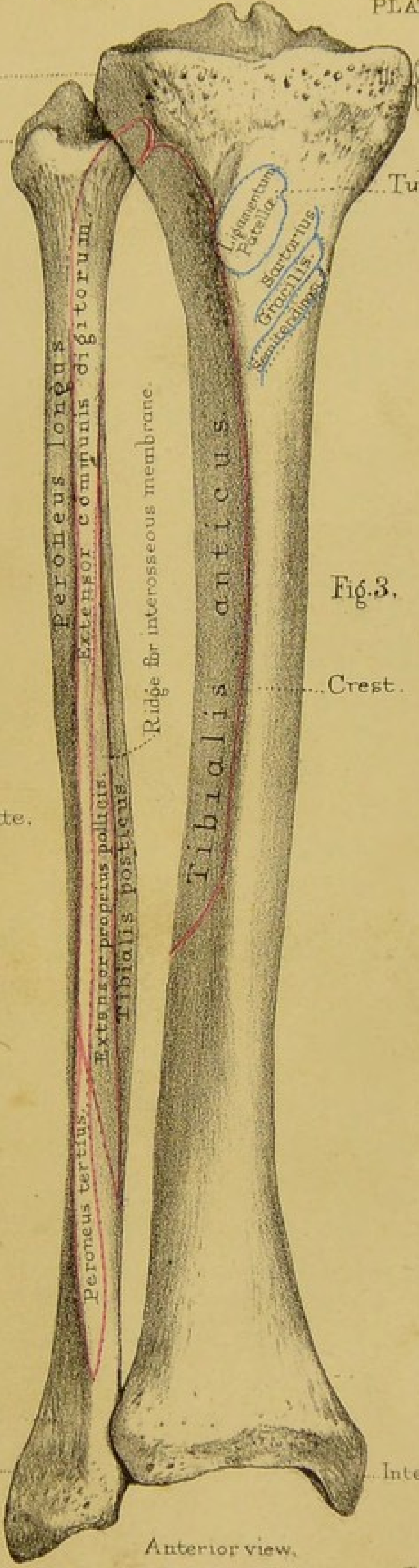


Fig.3.

Anterior view.

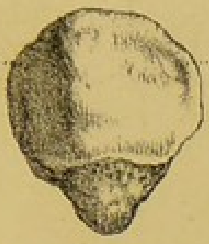


Fig. 5.

Patella. posterior view.

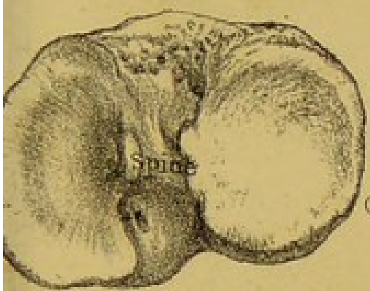


Fig. 4.

Upper surface of Tibia.

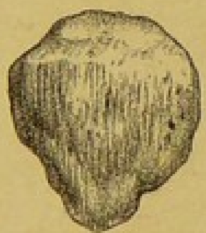
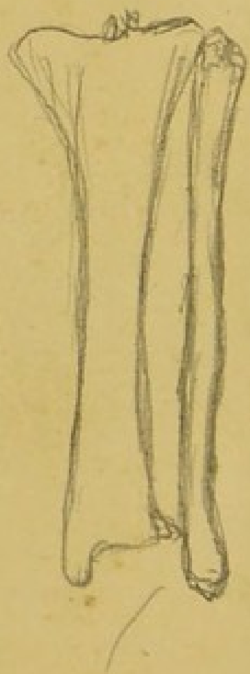


Fig. 6.

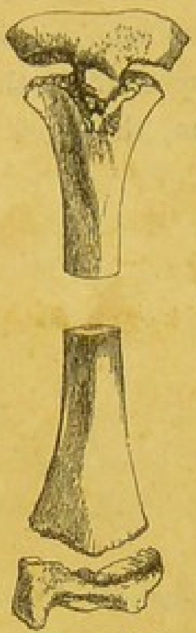
Patella. anterior view.

T. Godart Lith.



The ankle-joint is such a perfect hinge that when the foot is at right angles to the tibia, as when we are standing, no *lateral* movement whatever is permitted; but when the foot is extended, then a very slight lateral movement is possible between the tibia and the astragalus, owing to the astragalus being so much narrower behind than it is in front.

FIG. 36.



Epiphyses of the Tibia.

The tibia is ossified from three centres: one for the shaft, and one for each end. The centre of the upper end, which, observe, includes the tubercle (see cut, fig. 36), appears about the first year after birth. The centre of the lower end appears about the second year. The epiphyses do not unite with the shaft till the age of twenty or upwards.

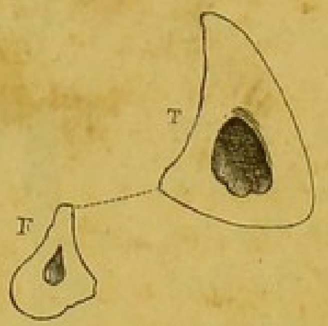
THE FIBULA.

(Plate XXXVI.)

Relative bearing of the tibia and fibula.

The fibula (a clasp) is the outer of the two bones of the leg. Though quite as long as the tibia, it is a slender bone, and does not sustain any of the weight of the body. The upper end is placed on a lower level than the knee-joint, and forms no part of it; but the lower end projects considerably below the tibia, and constitutes the outer ankle. The chief use of the bone is to give additional extent of origin to the powerful muscles of progression. Look well at the relative position of the two bones of the leg. Observe that the fibula articulates with the outer and back part of the head of the tibia, and that the shaft of the fibula arches *backwards*, while that of the tibia arches *forwards*: the result of this is, that the fibula lies quite in the background, except at its lower part, where it advances to form the outer ankle. A knowledge of this relative bearing of the two bones is important in the adjustment of fractures, but more especially in the performance of flap-amputations; and for this reason, that the knife, introduced from the tibial side, is apt, unless properly directed, to pass *between* the two bones, instead of behind them: and this is the more likely, since the plane of the posterior surface of the tibia slants considerably in front of the fibula. The relative position of the two bones, as well as their relative thickness, are shown in the adjoining woodcut (fig. 37). The dotted lines represent the interosseous ligament.

Fig. 37.



Head. The upper end of the fibula is called its "head," and can be felt plainly beneath the skin. On its inner side is the small oval surface which articulates with the tibia. Its outer side is very prominent, and rises behind into a short projection termed the "styloid process." This little process apparently *insignificant*, is really significant, because it tallies with the olecranon. It forms a little lever* for the insertion of the biceps (one of the hamstring muscles). Besides this the outer part of the "head" gives attachment to the external lateral ligament of the knee-joint.

Shaft. The shaft of the fibula is more easy to understand when connected to the tibia. Immediately below the head, the shaft is rounder and thinner than elsewhere. The lower three-fourths of the shaft is triangular, like that of the tibia, for the more convenient origin and course of the muscles. Its three surfaces are placed so, that one (internal) looks towards the tibia; another looks outwards; the third looks backwards. The inner or tibial surface is divided into two unequal parts by a longitudinal ridge. Observe this ridge carefully, because it gives

* Owen proposes to call the styloid process the "fibella." To see this developed into a lever of great power, look at the skeleton of the Echidna.

attachment to the interosseous ligament which divides the muscles on the front from those on the back of the leg. Now the grooved surface behind the ridge in question gives origin to part of the "tibialis posticus;" that in front of it gives origin to the "extensor communis digitorum," (which arises also from the head of the fibula and even the tibia,) to the "extensor proprius pollicis," and to the "peroneus tertius." Thus, four muscles arise from the *inner* side of the shaft; namely, three in front of the interosseous membrane, and one behind it.

The *outer* surface of the shaft gives origin to the "peroneus longus" and "brevis." Towards the lower end of the bone this surface inclines backwards, because the tendons of these two muscles play along the groove behind the external malleolus.

The *posterior* surface gives origin to two muscles only; namely along its upper third to the "soleus," and its lower two-thirds to the "flexor longus pollicis." Here we observe the canal for the medullary vessels: like that in the tibia, it runs downwards.

With regard to the angles of the shaft, the anterior is the sharpest, like that of the tibia. Trace it down the bone, and you will find that it bifurcates about three inches from the lower end, and encloses a triangular surface, which is subcutaneous. Here we feel for fractures of the lower part of the fibula. The other angles do not require special notice.

LOWER END. The lower end of the fibula descends below the tibia in order to form the "malleolus," for the security of the ankle-joint on the outer side. It is not only longer than the inner malleolus, but projects more, so as to give more power to the tendons of the "peronei," which play in a groove behind it. On its inner side is the smooth, slightly convex surface which articulates with the side of the astragalus; and just above this is the rough surface which fits into the groove of the tibia, and gives attachment to the interosseous ligament which rivets the two bones together. The apex gives attachment to the external lateral ligament of the ankle. On the inner side of the apex is a deep hollow for the attachment of the transverse ligament of the ankle.

The tibia and fibula are so fixed together at the ankle, that there is no sensible motion between them, only just enough to give a sort of elasticity which yields to slighter sprains. The office of guarding the ankle is performed so well by the fibula, that lateral dislocation cannot take place unless the fibula be broken. Fractures of the fibula generally occur about $2\frac{1}{2}$ inches from the lower end, and most frequently happen in consequence of a very violent outward twist of the foot. The outer surface of the os calcis comes to press against the end of the fibula; the result of which is, that the shaft of the bone gives way at the weakest part—that is, just above the ankle. The same accident may happen from a violent twist of the foot *inwards:* but in this case it is the astragalus, which, by its pressure outwards, causes the fibula to give way. This kind of fracture, accompanied, as it usually is, with more or less injury to the internal lateral ligament of the ankle, or possibly with fracture of the tip of the internal malleolus, is by far the most frequent dislocation about the ankle received into a London Hospital. Such an accident is commonly called "Pott's fracture," after the surgeon who first accurately described it.

The fibula has three centres of ossification; one for the shaft and one for each end. The lower end begins to ossify about the second year; the upper about the third or fourth. Contrary to the rule, the lower end unites the first to the shaft; the reason of this exception would appear to be the necessity of the early solidity of the ankle-joint.

THE BONES OF THE FOOT.

(Plates XXXVII. and XXXVIII.)

There are twenty-six bones in the foot. In the tarsus, seven,—namely, the "astragalus," "os calcis," "os scaphoides," three "cuneiform bones," and the "os cuboides;" in the metatarsus, five: the remaining fourteen belong to the toes.

The first question that arises, is, why should there be so many bones in the foot? The answer is the same for the foot as for the hand,—in order that there may be so many joints. The structure of a joint not only permits motion, but confers elasticity. Suppose there had been only a single bone, like a shoemaker's last, instead of seven in the tarsus, how much more liable it would have been to fracture and dislocation!

Double arch of the foot.

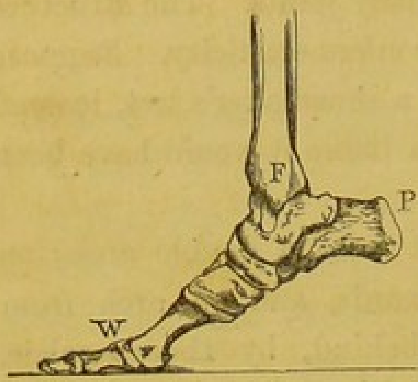
The bones of the foot form a double arch; an arch from before backwards, and an arch from side to side. The arch is supported, behind, by the os calcis, and in front by the ends of the metatarsal bones. Its height and span are greatest on the inner side of the foot; and gradually decrease towards the outer side. The weight of the body falls perpendicularly on the astragalus, which is the key-bone or crown of the arch. Concerning the astragalus, two points must be always borne in mind:—1, a part (the head) of it is supported below by an elastic ligament (calcaneo-scaphoid), which admits of its rising and falling like a spring; 2, it is articulated with the os calcis and the scaphoid in such a way as to allow the lateral motions of the foot (adduction and abduction). Flexion and extension of the foot, observe, is performed at the *ankle*-joint. But, besides these beautiful provisions, all the bones of the foot are more or less moveable on each other, so as to break shocks and increase elasticity; and yet their mutual connection is so well provided for, that dislocation of any one bone is extremely rare.

It is wonderful what habit and necessity will make the foot accomplish. We who coop it in tight boots, can hardly believe when we hear of persons carving, writing, and even painting with the toes. "Pes altera manus" is not so far off the mark. Not long ago, a French artist, Ducornet (né sans bras), died, who used to paint with his toes pictures worthy of a place in the French Exhibition.

The foot a lever of the first order.

The foot is a lever for raising the body. It is generally described as a lever of the second order; that is, with the fulcrum at the toes. But this is not correct. The foot is a lever of the *first* order. The fulcrum (which is a moveable one), is at the ankle-joint F, (cut, fig. 38); the weight W is at the toes; and the power (which is the contraction of the muscles of the calf) is at the heel P. All the conditions are those of a lever of the first order. The power and the weight act in the *same* direction on *opposite* sides of the fulcrum. The pressure upon the fulcrum is equal to the *sum* of the pressures applied, *i. e.* P × F + W × F.

FIG. 38.



THE ASTRAGALUS.

(Plate XXXVII.)

The astragalus (ἀστράγαλος, talus, the huckle-bone, with which the ancients used to play at dice,) is the key-stone of the arch of the foot, and supports the whole weight of the body, which falls perpendicularly upon it from the tibia. As it is the chief bone concerned in the mechanism of the spring of the foot, the Germans do well to call it the "spring bone." To examine it thoroughly we must make six aspects.

Its *superior* aspect, broad and *horizontal*, the best adapted for the erect posture, is convex from before backwards, so as to articulate with the tibia, and admit of the flexion and extension of the ankle. Observe that this pulley-like surface is at least one-fifth of an inch broader in front than behind. The object of this is to prevent a dislocation of the astragalus backwards, which would otherwise be a more frequent occurrence, considering the direction of the force in walking, running, or leaping. In consequence of this greater narrowness of the astragalus behind, the ankle-joint admits of a very slight lateral movement at the ankle, when the foot is extended. But there can be no lateral movement at the ankle when the foot is at right angles to the tibia, *i. e.* when we stand upon it.

Each *lateral* aspect presents an articular surface adapted to the corresponding malleolus. The outer is much the larger, slightly concave, and triangular, with the apex below: the inner is comparatively small, and occupies very little of the bone, so that a large rough space is left below it, for the attachment of the enormously strong internal lateral ligament of the ankle.

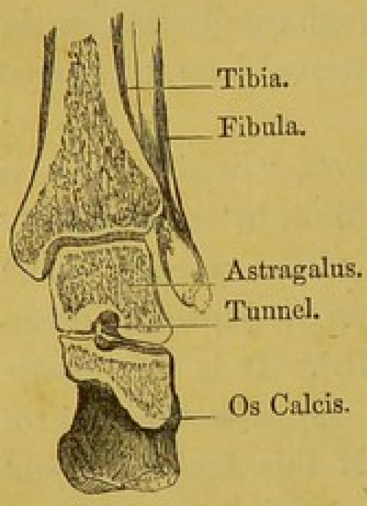
Its *posterior* aspect presents nothing remarkable beyond a groove for the tendon of the flexor longus pollicis, and a projection on the outer side of it for the attachment of the external lateral ligament of the ankle.

The *anterior* aspect presents a large convex "head," which is received into an ample socket, formed, in front, by the scaphoid; below, by the "sustentaculum tali" (part of the os calcis); and also by a strong elastic ligament which fills up the gap left between these bones in the skeleton (Plate XLVIII.). It is this elastic ligament (calcaneo-scaphoid) which mainly supports the arch of the foot, and gives it its beautiful spring. If this ligament yield more than it should do, as is sometimes the case in weakly persons, or, for instance, in opera-dancers, from excessive straining, or in bakers, from carrying heavy weights, down goes the arch,—the foot becomes flat, and the astragalus may sink low enough to touch the ground.

The *inferior* aspect rests on the os calcis by two articular surfaces, one behind the other, and separated by a groove directed obliquely outwards and forwards. Of these surfaces, the posterior is by far the larger, and placed a little more external than the anterior. Observe, also, that the posterior is concave, the anterior flat, and that both of them slant downwards and forwards. The consequence of this is, that when the foot sustains the weight of the body, the astragalus slides a little forwards on the os calcis, and presses with its head firmly against the elastic ligament, which yields a little, so that the foot becomes about half an inch longer. But this is not all. When we step forward, while the foot is raised, the bones (calcaneum and scaphoid) roll easily below the astragalus, so that the toes may be directed according to the inequalities of the ground we are to tread upon: but when the foot is planted, and the body rests perpendicularly on it, then the astragalus sinks into its socket, presses the os-calcis backwards and the metatarsal bones forwards, so that we have a steady base of support.

The groove just now alluded to, as running between the articular surfaces of the astragalus, corresponds with another between those of the os calcis. When the bones are together, the grooves form a complete tunnel (canalis tarsi) beneath the astragalus, wide on the outside, but narrow on the inside, of the foot (see cut, fig. 39). This beautiful tunnel is occupied in the recent state by fat and by the strong interosseous ligament which connects the two bones: and its direction is obliquely from before backwards in order to permit the free *lateral* movements of the foot, which take place, not at the ankle-joint proper (which is a simple hinge), but between the astragalus and the bones with which it articulates *below*. The astragalus cannot be displaced from the os calcis without rupture of the interosseous ligament.

FIG. 39.



Section to show the tunnel of the tarsus.

OS CALCIS.

(Plates XXXVII. and XXXVIII.)

The os calcis, or calcaneum, is the longest and strongest of the tarsal bones, because its office is to transmit the weight of the body to the ground, and form a powerful lever for the muscles of the calf. The great projection and horizontal direction of the heel are peculiar to the skeleton of man, in adaptation to his erect position. There is a constant relation in the human subject between the projection of the os calcis and the size of the muscles of the calf: namely, if the heel be short, the calf will be large; and *vice versâ*, if the heel be long, the calf will be small, as in the negro. The reason is obvious; a short heel or lever requires the stronger muscle, and the reverse.

We must examine six different aspects on the os calcis.

Its *superior* aspect presents the two surfaces which support the astragalus.* Of these, the posterior is convex and much larger than the anterior, which is flat. The plane of both these surfaces is horizontal *transversely*, the better to support the weight, but, like those of the astragalus, they slope a little, so that the weight is transmitted obliquely downwards and forwards upon the arch of the foot. Observe the groove between the articular surfaces for the attachment of the interosseous ligament: this groove makes, with the astragalus, a complete tunnel, as shown in the wood-cut (fig. 39).

If a perpendicular section be made through the os calcis, it will be seen that the compact wall is thickest at the articular surfaces for the astragalus; and that, from these, the principal septa of the cancelli radiate towards the back and under part of the bone, that is, precisely in the line of pressure.

The *anterior* end presents a smooth vertical surface, which articulates with the cuboid bone. The articular surface would be quite flat but for a slight projection on the inner side, which deserves notice chiefly because it is apt to be in the way in the performance of "Chopart's"† operation. The projection supports the third articular surface for the astragalus, when there is a third. The rough tubercle, projecting on the dorsum of the foot, gives origin to the "extensor brevis digitorum."

The *posterior* end forms the heel. The lower rough part indicates the insertion of the "tendo-Achillis;" the smooth part above indicates the position of the bursa between the tendon and the bone.

* Sometimes, and chiefly in old bones, there are three articular surfaces for the astragalus. But the third is very small, and placed near the anterior end.

† Chopart's operation consists in the removal of all the bones of the foot, except the os calcis and astragalus.

The *external* surface is broad, flat, and nearly subcutaneous. About the middle, there is a tubercle (peroneal tubercle) for the purpose of keeping the peroneal tendons in place, the shorter tendon being above, the longer below the tubercle. Behind this tubercle is generally another, for the attachment of the external lateral ligament of the ankle.

The *internal* surface presents a deep concavity for the safe transmission of the plantar vessels and nerves. At its upper part is the process termed the "*sustentaculum tali*," which helps to support the head of the astragalus, and gives attachment to the elastic ligament of the sole of the foot. There is a groove along the under surface of this process for the tendons of the "flexor longus pollicis," and the "flexor communis digitorum."

The *inferior* or plantar surface presents at its back part two tubercles, of unequal size, the internal being the larger. They are the only parts of the os calcis which touch the ground. They serve for the origin of muscles, and for the attachment of the strong plantar fascia which protects the sole of the foot. There is also another tubercle in front for the attachment of the calcaneo-cuboid ligament. Thus, there are three exceedingly strong ligaments attached to the os calcis for the preservation of the arch of the foot—1, the plantar fascia (which acts as a ligament); 2, the calcaneo-scaphoid, or elastic ligament beneath the head of the astragalus; and 3, the calcaneo-cuboid.

OS SCAPHOIDES.

The scaphoid bone, so named from its boat-like form, is situated on the inner side of the tarsus. It presents posteriorly, a concave surface, which forms part of the socket for the head of the astragalus; anteriorly, it has three articular facettes for the three cuneiform bones; externally, it has a small facette which articulates with the cuboid bone; internally, it has a *tubercle* which projects on the inner side of the foot. This tubercle is the best guide to the joint behind it, in the performance of Chopart's operation; and its use is to give advantageous insertion to the tendon of the "tibialis posticus." The lower part of the scaphoid is very rough for the attachment of the calcaneo-scaphoid ligament.

If the bone be held in its natural position, that is, with the cup backwards, and convex surface upwards, the broader end of the cup will be on the side to which the bone belongs.

OS CUBOIDES.

The cuboid bone is situated on the outer side of the tarsus, and is wedged in between the os calcis and the fourth and fifth metatarsal bones. Observe, that the *base* of the wedge is turned towards the cuneiform bones, so that the pressure in the arch of the foot may be properly distributed. Suppose, for a moment, the base were turned the other way, would not the lateral thrust from the external cuneiform bone force the cuboid quite out of the arch, and the falling of the arch be the consequence?

Its *posterior* surface articulates with the os calcis. Observe that the plane of this joint is the same as that of the scaphoid and astragalus. Hence partial amputation of the foot (Chopart's operation) here is easy. But it cannot be done at one stroke of the knife, because the inner corner of the cuboid projects a little beneath the os calcis, to prevent it being dislocated upwards.

Its *anterior* surface has two smooth facettes for the support of the fourth and fifth metatarsal bones.

Its *internal* surface articulates with the third cuneiform, and generally with the scaphoid.

Its *inferior* surface is traversed by a deep groove for the tendon of the "peroneus longus." The prominent ridge behind the groove, and the rest of its under surface, give attachment to the calcaneo-cuboid ligament.

Hold the bone in its natural position, *i. e.* with the groove downwards, and the largest articular surface backwards: the groove will be on the side to which the bone belongs.

OSSA CUNEIFORMIA.

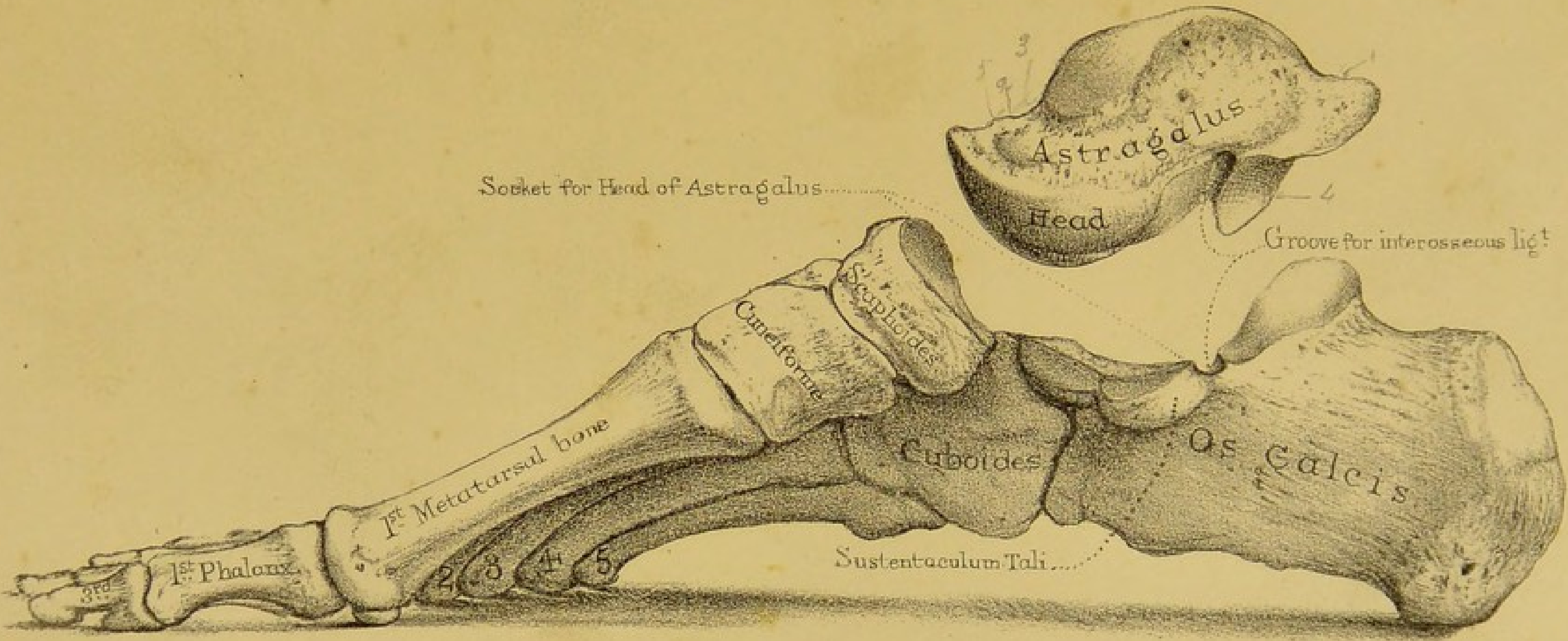
The cuneiform or wedge bones are placed at the front part of the tarsus, and are named the "inner," "middle," and "external;" or first, second, and third, according to their position. Behind they articulate with the scaphoid; in front with the three inner toes, respectively. The bases of the second and third are towards the dorsum of the foot, but the base of the first is turned towards the sole, in order to form one of the buttresses of the transverse arch of the foot.

First Cuneiform. The first or internal cuneiform is the largest, because it supports the great toe. Anteriorly, it articulates with the metatarsal bone of the great toe by a slightly convex, kidney-shaped surface, with the long diameter vertical. Inferiorly, the base projects into the sole considerably below the others, in order to give broad insertion to the tendons of the two muscles which turn the sole of the foot inwards, namely, the "tibialis anticus" and "posticus." Externally, it is slightly concave, and articulates with the second cuneiform bone and the second metatarsal bone: internally, it is convex, and has a little smooth surface, over which the tendon of the "tibialis anticus" plays.

Hold the bone with the base downwards, and the kidney-shaped surface forwards: the concave side will be turned towards the foot to which the bone belongs.

Second Cuneiform. The second or middle cuneiform bone is not only the smallest of the three, but does not reach so far forwards; consequently the second metatarsal bone, which it supports, is more deeply set in the tarsus than any of the others. This is a point to be remembered in the operation of removing the metatarsal bones (Hey's operation). It has on each side an articular surface for the other wedge bones. The articulation on the external side runs vertically along its posterior half; that on the internal side runs horizontally along its upper half. It is one of the peculiarities of these wedge bones of the foot that intervals

PLATE XXXVII



L. Holden ad natur del. Printed by J. Sawell T. Godart Lith.

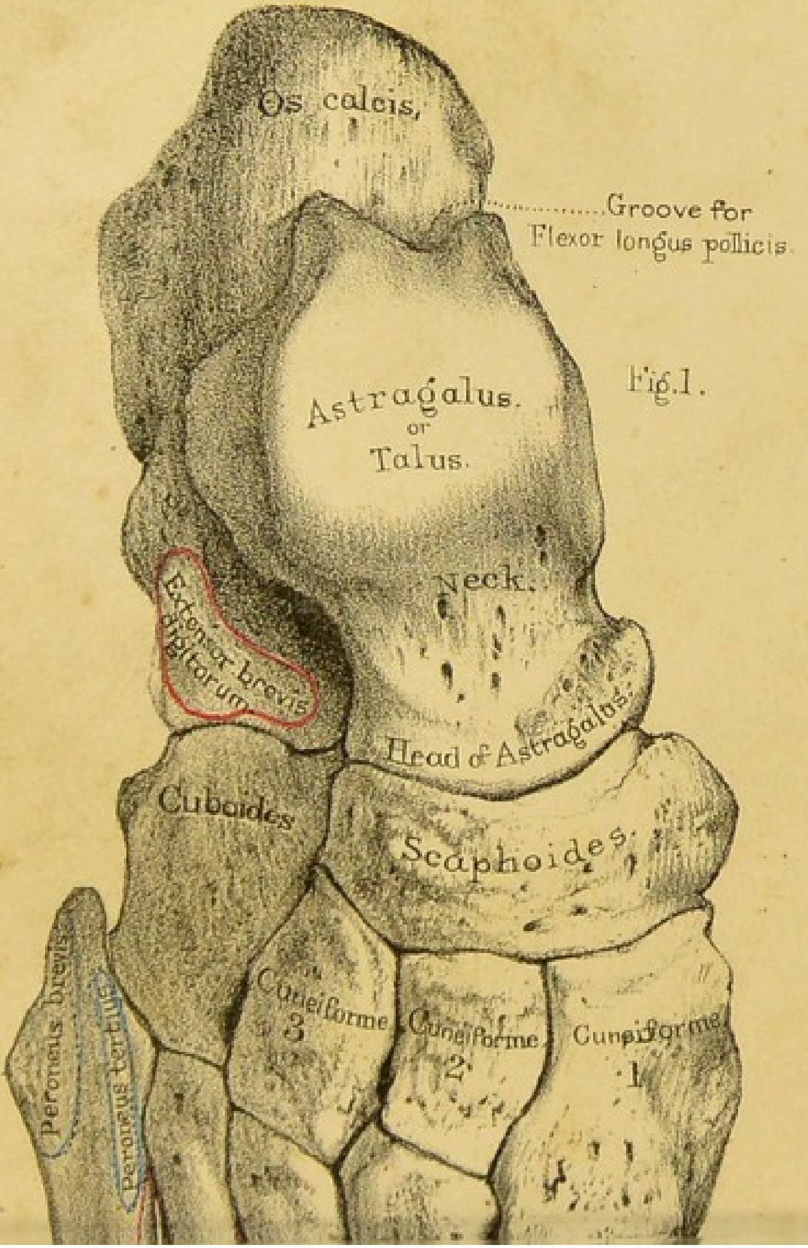

Os calcis,
Groove for Flexor longus pollicis.
Astragalus. or Talus.
Neck.
Extensor brevis digitorum
Head of Astragalus.
Cuboides
Scaphoides.
Peroneus brevis
Peroneus tertius
Cuneiforme 3
Cuneiforme 2
Cuneiforme 1

Fig. 1.

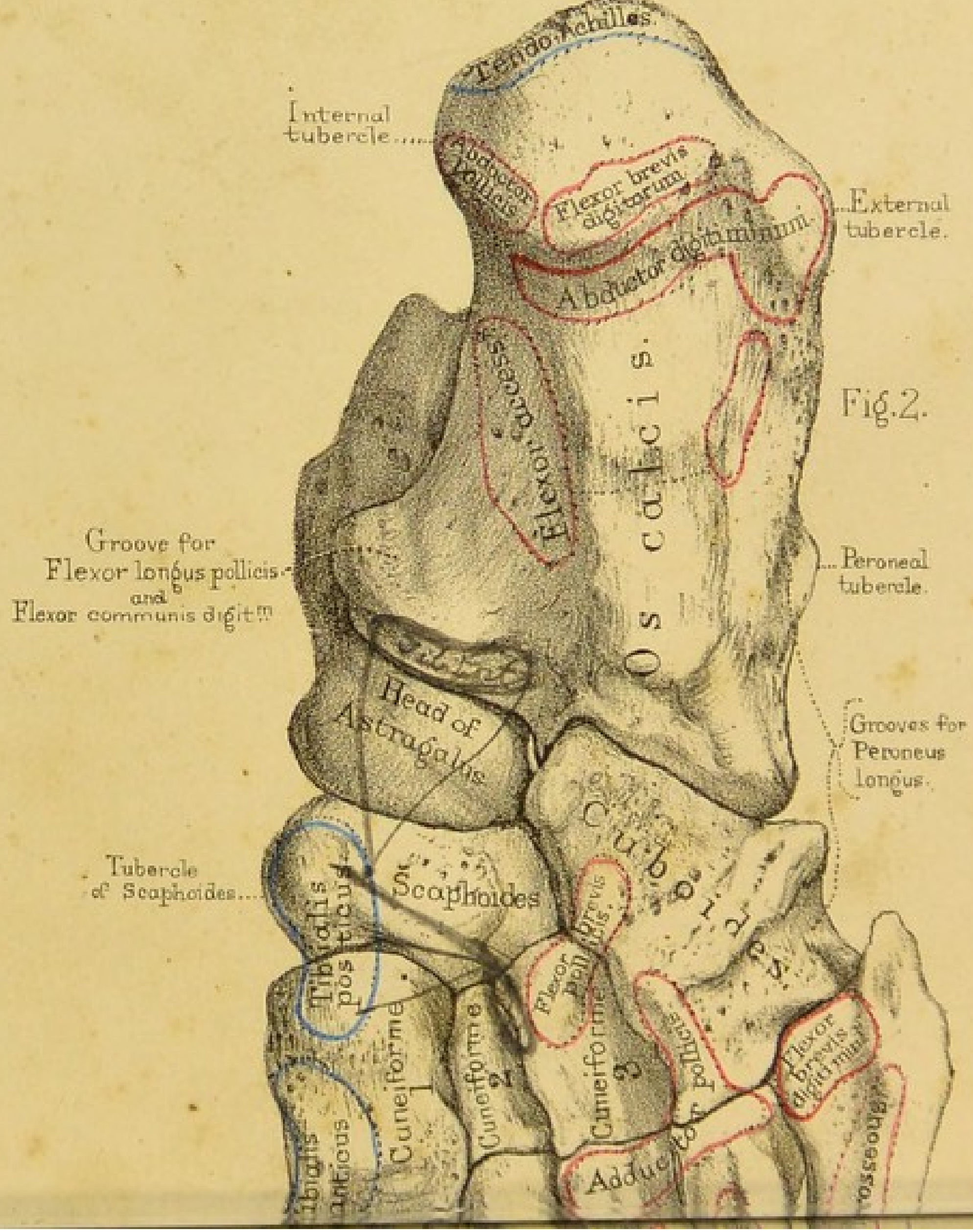
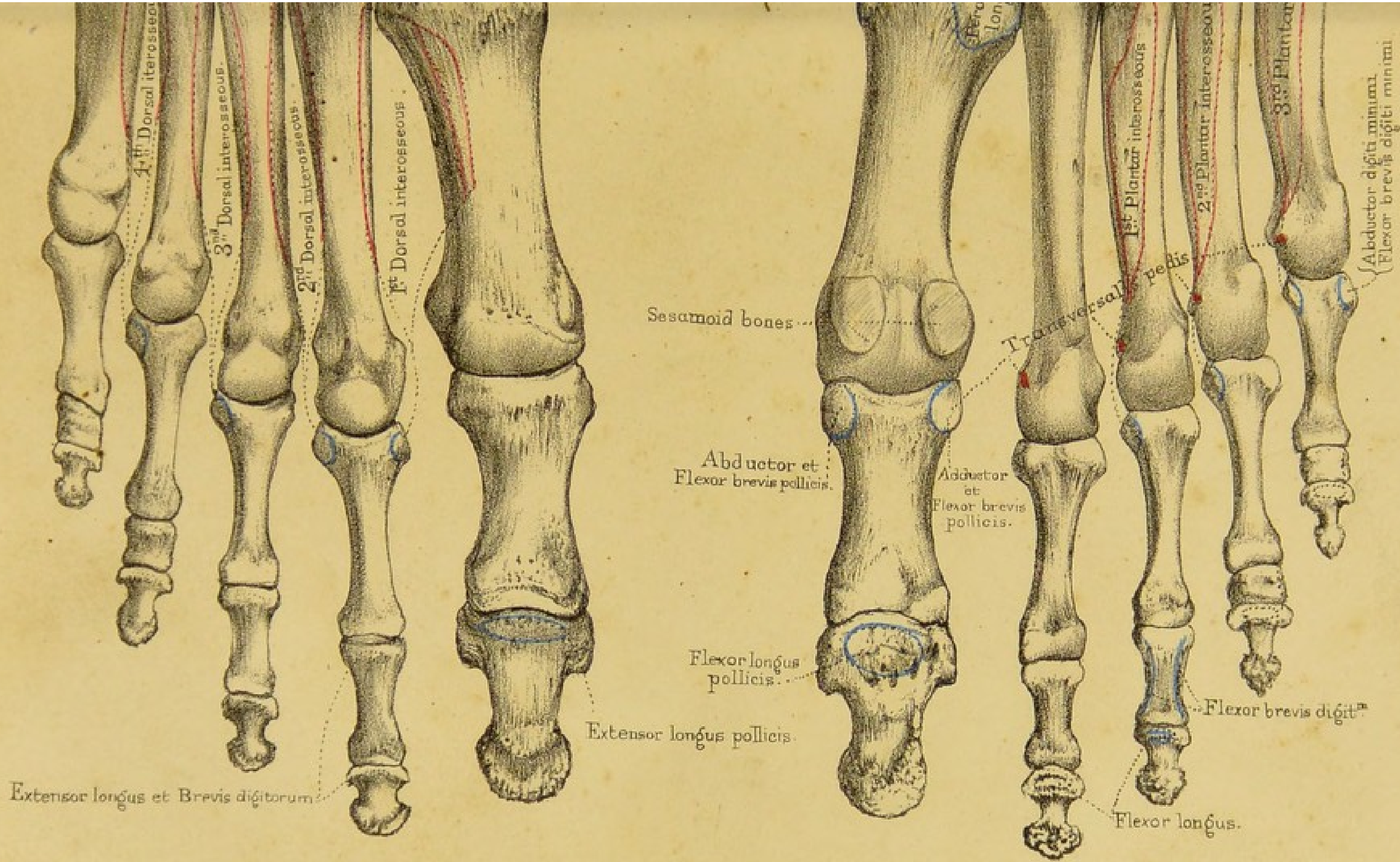

Tendo Achilles.
Internal tubercle
Abductor pollicis
Flexor brevis digitorum
External tubercle.
Abductor digiti minimi
Flexor accessorius
Os calcis.
Groove for Flexor longus pollicis and Flexor communis digit.m
Peroneal tubercle.
Head of Astragalus
Grooves for Peroneus longus.
Cuboides.
Tubercle of Scaphoides
Tibialis posticus
Scaphoides
Flexor brevis pollicis.
Flexor brevis digiti mini
Cuneiforme 1
Cuneiforme 2
Cuneiforme 3
Adductor pollicis
Tibialis anticus

Fig. 2.



L. Holden ad natur. delt.

T. Godart Lith.

are left between their sides for the interposition of the interosseous ligaments which rivet the bones together.

Hold the bone with the apex downwards, and the narrowest side of the base forwards: that side which has the vertical articular surface will look towards the foot to which it belongs.

Third Cuneiform.

The third or external cuneiform bone articulates, externally, with the cuboid; internally, with the second cuneiform and the second metatarsal; anteriorly, it supports the third metatarsal on a triangular surface.

Hold the bone with the apex downwards, and the triangular articular surface forwards: the rounded articular surface on one side will look towards the foot to which it belongs.

Ossification of the tarsal bones.

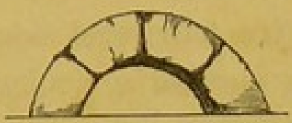
Each bone of the tarsus has only one centre of ossification, except the os calcis, which has two. The os calcis begins to ossify about the sixth month of fœtal life; the astragalus about the seventh month: the cuboid about birth; the external cuneiform about the first year after birth; the middle and internal cuneiform and scaphoid about the third or fourth year. The second centre of the os calcis is at the back part of it. It appears about the tenth year, and joins the rest of the bone about puberty.

General observations on the play of the arches of the foot.

In the description of the astragalus, you will remember it was stated, that when the foot sustains the weight of the body, the astragalus sinks into its socket and presses the os calcis backwards and the toes forwards. The ligament under the head of the astragalus (calcaneo-scaphoid) yields a little by virtue of its elasticity; the arch of the foot falls in proportion, and the foot becomes in consequence about half an inch longer; in some persons even more.

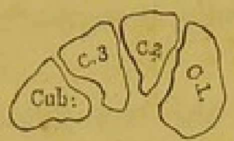
There is, however, another beautiful adaptation which we must admire in the structure of the foot. When we stand, not only does the *longitudinal* arch of the foot yield, but the *transverse* arch yields also. The wedge bones and the metatarsal bones are connected by interosseous ligaments, which, being elastic, give a little, and thereby increase the transverse breadth of the foot. If you make a transverse section across the instep, that is, through the wedge bones, you will find that they are shaped, not like the stones

Fig. 40.



of a bridge, as in fig. 40, but as represented in fig. 41. Their sides are not in apposition all the way down, but gaps are left between them: now these gaps are occupied by elastic ligaments, which permit a certain amount of separation between the bones when the arch is pressed upon.

Fig. 41.



Section to show the form of the cuneiform bones.

So the foot becomes not only longer but broader when we stand upon it; and thus we gain a more extensive base of support, combined with elasticity of tread and power of adaptation to the ground. Our shoes ought to be made so as to permit this natural play of the arches of the foot. It is easy, however, to see that the practice of wearing high heels alters the level of the piers of the arches. By raising one pier, *i.e.* the heel bone, we are always walking on an inclined plane; we alter the mutual bearings of all the other bones; we throw more pressure than nature intended on the toes; hence distorted feet, crooked toes, bunions, corns "et id genus omne."

METATARSUS.

The five metatarsal bones are named the first, second, third, &c., counting from the inner side. The first is the shortest and by far the strongest, since it supports the great toe. The second is the longest, and from this the others gradually decrease in length. All are slightly arched from before backwards; but, in addition to this, the three outer, in most cases, incline a little sideways towards the great toe. The spaces between them are termed the "interosseous spaces," and gradually decrease in size towards the outer side. As the metatarsal bones are "long" bones, we speak of their shafts and their articular ends; the upper end being termed the "base," and the lower, the head of the bone.

Like the corresponding bones in the hand, the shafts of the metatarsal bones are triangular, for the more convenient lodgment of the interosseous muscles, and they gradually taper from their upper ends.

Bases or upper ends.

Their *bases* articulate with the second row of the tarsus, and also, laterally, with each other; that of the first excepted. Observe that the line of the tarso-metatarsal articulations would be tolerably even but for the second metatarsal, which is jambed into a recess between the cuneiform bones.

Heads or lower ends.

Their *heads* are convex, to fit into the cups of the first phalanges, grooved above for the attachment of ligaments, and have lateral tubercles also for the attachment of ligaments.

First metatarsal.

The excessive strength and size of the first metatarsal bone is peculiar to man. It is the chief support upon which the body is raised by the great muscles of the calf. Its base presents a kidney-shaped surface, which articulates exclusively with the internal cuneiform bone; and there is an impression on its plantar surface indicating the insertion of the "peroneus longus." Its head is remarkably broad, to support the ball of the great toe, and has on its under surface two grooves (separated by a ridge) for the play of the two sesamoid bones.

Hold the bone in its natural position, with the base towards you: the concave side of the kidney-shaped surface will look towards the foot to which it belongs.

Second metatarsal.

The second metatarsal bone may be known by its triangular surface at the base for the second cuneiform bone, a small lateral facette for the first cuneiform, and four lateral facettes on its outer side; namely, two for the third cuneiform, and two for the third metatarsal bone.

Hold the bone with the base towards you, and in its natural position: the four lateral facettes will be on the side to which the bone belongs.

Third metatarsal.

The third metatarsal bone may be known by its having two articular facettes on the inner side of the base, and one on the outer side.

Hold the bone with the base towards you: the single lateral facette will be on the side to which the bone belongs.

Fourth metatarsal. The fourth metatarsal bone may be known by its square surface for the cuboid, and a single lateral facette on each side.

Hold the bone with the base towards you: the base will incline slightly to the foot it belongs to.

Fifth metatarsal. The fifth metatarsal bone cannot be mistaken, in consequence of the great projection on the outer side of its base. The use of this projection is to give attachment to muscles and ligaments.

Hold the bone with the base towards you: the projection from it will be on the side to which the bone belongs.

Each metatarsal bone has two centres of ossification; one for the shaft, the other for the head. The first metatarsal, however, has its terminal epiphysis *not* at the head, but at the base, which is precisely the case with the metacarpal bone of the thumb.

Phalanges of the toes. The phalanges of the toes resemble in number and plan the corresponding bones in the hand, which we have already described. Like the thumb, the first, or great toe has only two phalanges. That which is absent is the second phalanx. This is the case throughout the whole mammalian class, provided it supports a nail, a hoof, or a claw. In subservience to its function of supporting the body, the great toe is not only the largest but the longest of the toes. The third toe is the representative of the chief part of the hind foot of the horse. The last two phalanges of the little toe are generally anchylosed in adults, in consequence of being cramped by tight shoes: so different from that free spreading of the toes which nature intended!

MUSCLES ATTACHED TO THE SKELETON OF THE FOOT.

Let us examine these in the order in which they are met with on dissection.

MUSCLES ON THE FRONT OF THE LEG.

Tibialis anticus	O. Outer surface of tibia; interosseous membrane. I. Internal cuneiform bone.
Extensor communis digitorum	O. Head of tibia; inner surface of fibula; interosseous membrane. I. Second and third phalanges of the toes.

Extensor proprius pollicis......	O. Inner surface of fibula; interosseous membrane. I. Last phalanx of great toe.
Peroneus tertius	O. Inner surface of the fibula. I. Metatarsal bone of little toe.

ON THE DORSUM OF THE FOOT.

Extensor brevis digitorum......	O. Front part of os calcis. I. Into the tendons of the common extensor.

ON THE OUTER SIDE OF THE LEG.

Peroneus longus....................	O. Outer surface of the fibula. I. Metatarsal bone of the great toe.
Peroneus brevis	O. Outer surface of the fibula. I. Metatarsal bone of the little toe.

ON THE BACK OF THE LEG.

Gastro-cnemius	O. Back part of the condyles of femur. I. Back part of the os calcis (tendo Achillis).
Plantaris	O. Above the external condyle of femur. I. Joins the tendo Achillis.
Soleus	O. Oblique ridge and inner edge of tibia; posterior surface of fibula. I. Joins the tendo Achillis.
Flexor longus digitorum	O. Posterior surface of tibia. I. Base of third phalanges of the four outer toes.
Flexor longus pollicis............	O. Posterior surface of fibula. I. Base of last phalanx of great toe.
Tibialis posticus	O. Posterior surface of tibia; inner surface of fibula; interosseous membrane. I. Scaphoid bone.

SOLE OF THE FOOT.

Abductor pollicis	O. Internal tubercle of os calcis; internal annular ligament. I. Base of first phalanx of great toe.
Abductor minimi digiti	O. External tubercle, and under surface of os calcis. I. Base of first phalanx of little toe.
Flexor brevis digitorum.........	O. Under surface of os calcis. I. Sides of the second phalanges of the four outer toes.
Flexor accessorius	O. Inner, and also outer surface of os calcis. I. Into the tendon of the long flexor of the toes.
Flexor brevis pollicis............	O. Cuboid and third cuneiform bone. I. Both sides of base of first phalanx of great toe.
Adductor pollicis	O. Cuboid bone and bases of third and fourth metatarsal. I. Inner side of base of first phalanx of great toe.
Flexor brevis digiti minimi ...	O. Base of fifth metatarsal bone. I. Outer side of base of first phalanx of little toe.
Transversalis pedis................	O. Heads of the four outer metatarsal. I. Base of first phalanx of great toe.

INTEROSSEOUS MUSCLES.

These are divided into the four dorsal and the three plantar. Observe that the *dorsal* arise from the opposite sides of the metatarsal bones, and are inserted into the first phalanges of the second, third, and fourth toes, so that they draw the toes *from* a stationary line supposed to run down the centre of the *second* toe. The *plantar* belong to the three outer toes, arise each from one metatarsal bone, and are inserted into the phalanges of the three outer toes, so that they draw *to* the stationary line alluded to.

THE THORAX.

(Plate XXXIX.)

General description.

The thorax is the frame-work which contains the heart and lungs. The ribs with their cartilages describe a series of arcs, successively increasing in length as far as the seventh, so as to form, with the spine and sternum, a barrel of a somewhat conical shape, broader from side to side than from before backwards. The lower aperture or base of the cavity is open in the skeleton, but closed in the recent subject by a thin flat muscle, called the "diaphragm," which separates the chest from the abdomen, and has openings for the passage of the alimentary canal and the great blood-vessels. This muscular partition is not flat, but arched, so that it forms a vaulted floor for the chest: by its property of alternately contracting and dilating, it can increase and diminish the capacity of the chest. The spaces between the ribs are filled by the intercostal muscles. In each space there are two layers which cross like the letter X: the outer layer runs downwards and forwards: the inner, upwards and forwards. The upper opening of the chest gives passage to the trachæa, œsophagus, and the great blood-vessels and nerves at the root of the neck.

Such, in outline, is the frame-work of the chest. Its walls are made up of different structure,—bone, cartilage, and muscle, put together so as to answer two apparently incompatible purposes. By their solidity and elasticity they protect the important organs contained in the chest; and by their power of alternately dilating and contracting, they serve as the mechanical agents of respiration. They can enlarge the cavity of the chest in three directions: in *height*, by the descent of the diaphragm; in *width*, by the turning outwards of the ribs; and in *depth*, by the raising of the sternum.

THE STERNUM.

(Plate XXXIX.)

The sternum (στερνον, the breast) is a long flat bone, situated in front of the chest, for the support of the ribs and the clavicles. In the adult male, it is from six to seven inches long; rather less in the female. Observe that its direction is not perpendicular, but slanting forwards, so as to make more room for the heart and lungs: it is also much broader and thicker at the upper end (manubrium)*, because this has to support the clavicles.

We notice upon it four faintly-marked transverse lines, which are traces of the original division of the bone into five pieces. The most conspicuous of these lines corresponds with the insertion of the second costal cartilage; that is, at the junction of the manubrium with the second piece. The first bone of the sternum has a notch on the top, so as not to press on the trachæa. On either side of it is an oblong articular surface for the clavicle. In the dry bone, this surface looks flat; but in the recent state, the incrusting cartilage makes it somewhat saddle-shaped, that is, convex from before backwards, and concave from above downwards. This kind

* The sternum was compared by the ancients to a sword; the broad part was called "manubrium," the middle part "mucro," and the cartilage at the end the "xiphoid" or "ensiform" cartilage.

of joint permits the clavicle to rotate as freely as the thumb does on its carpal bone. Although the end of the clavicle is so much larger than the surface on which it rotates, yet dislocation of it is exceedingly rare, owing to the great strength of the ligaments. To break the clavicle is much easier than to dislocate it.

Each border of the sternum has seven notches in it for the reception of the seven true ribs. All of them, with the exception of the first, are situated at the places where the original pieces of the bone unite. In some instances there is a hole in the lower part of the sternum.

Ensiform cartilage.

The ensiform cartilage at the lower end of the sternum generally remains unossified even at a great age. Its length and shape vary much in different persons, Sometimes it is bent forwards, or, it may be, backwards, and this especially in the case of workmen who hold tools against the pit of their stomach. Occasionally one sees it forked at the end. It gives attachment to a narrow aponeurotic band, termed the "linea alba," which descends along the middle line of the abdomen to the symphysis pubis, and is the answerable part of the sternum.

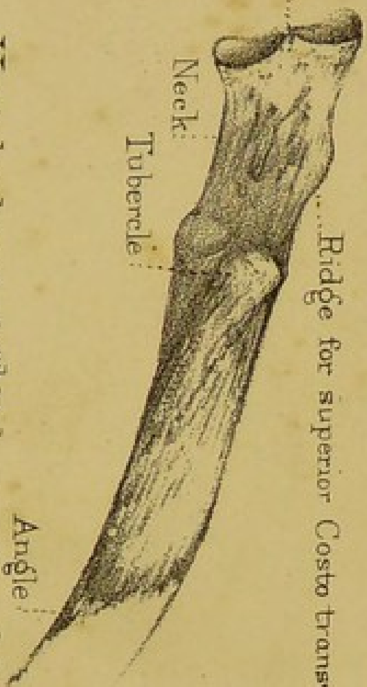
The front surface of the sternum gives origin to the "sterno-mastoid" and the "pectoralis major." The inner surface gives origin to the "sterno-hyoid" and "sterno-thyroid," and to the "triangularis sterni." The inner surface of the ensiform cartilage gives origin to the "diaphragm."

Ossification of the sternum.

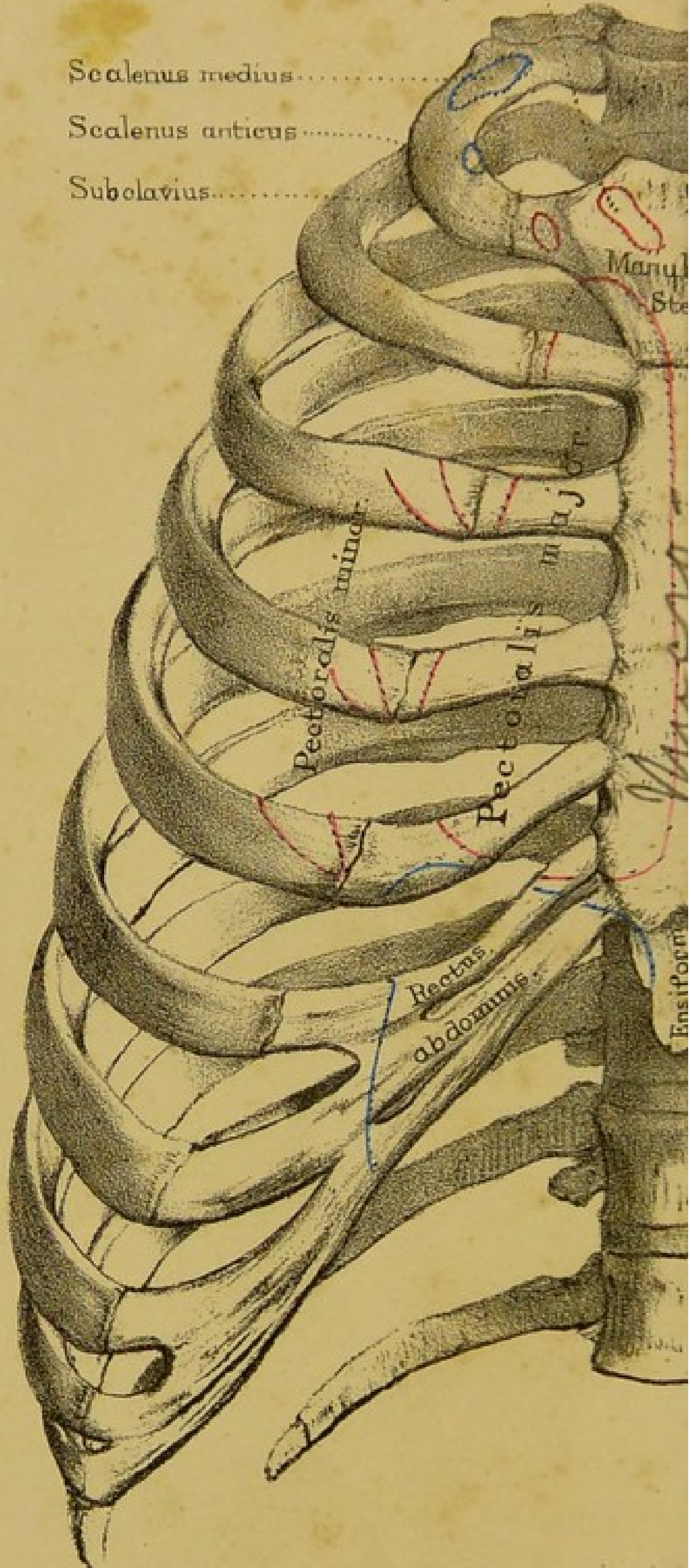
Until about the middle of fœtal life, the sternum is all cartilage. It is ossified from five centres*, not simultaneously, but successively from above downwards, opposite the intercostal spaces. The five bones, thus formed, ultimately coalesce, the lower first, and so on upwards,—the reverse of the order in which they were ossified. Thus the fifth unites to the

* Exceptions to this rule are frequent. There may be two, three, or more centres for the first bone; and, instead of a single centre, any of the other pieces may have two, placed side by side. However, the sternum is a good example of the uniformity of type in the construction of the vertebrate skeleton. Thus the typical form of the sternum seems to be that of a series of distinct bones, one placed between each pair of ribs in front, as the vertebræ are behind. This, in many animals, is its permanent form. In man, it conforms to the type, in so far as it is ossified from several centres; but, to suit his skeleton, these centres coalesce, and are ultimately reduced to three.

Fig.3.



Vertebral end of 5th Rib, seen from behind.



Tho

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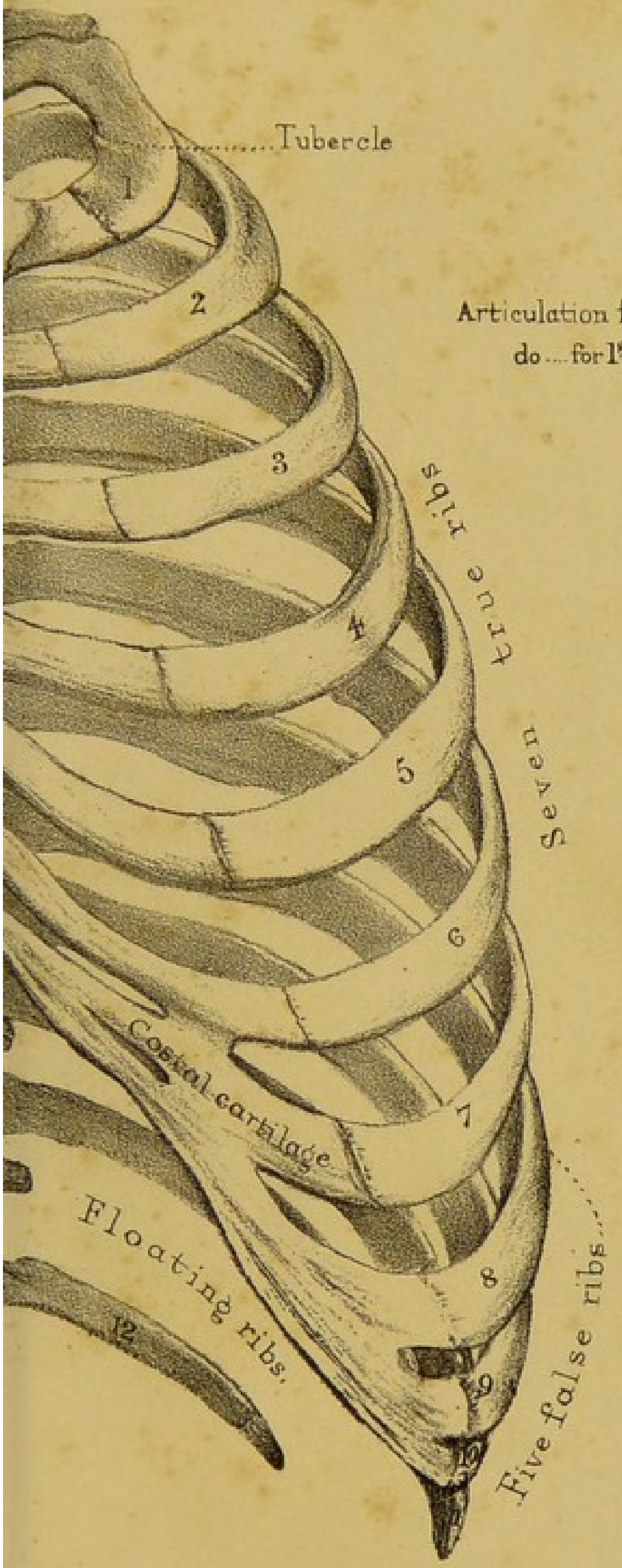
Fig. 1.



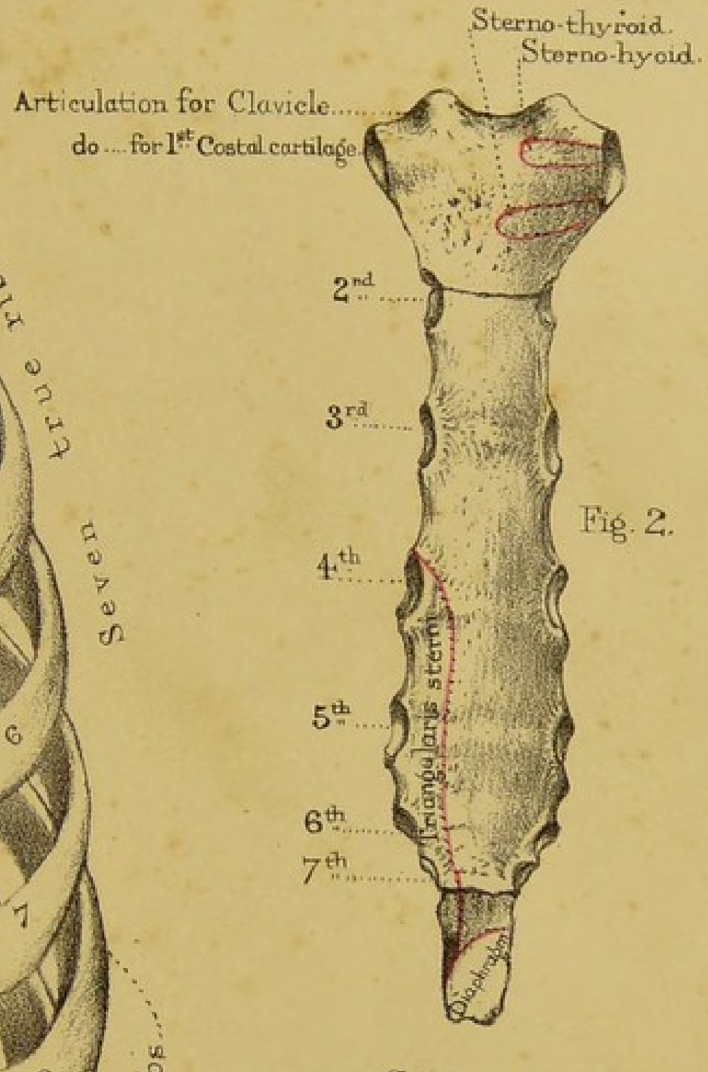


Fig. 2.

Sternum,
Inner surface.

T. Godart Lith.

fourth about puberty; the fourth to the third about the age of 20 or 25; the third to the second about 35 or 40: the second rarely unites to the first, or, if so, only in advanced age; and even then, there is only a thin layer of bone externally; the cartilage in the centre still remains. The reason why the union between the first and second bones of the sternum remains cartilaginous is to permit a certain amount of motion which facilitates respiration. In some subjects the line of junction is very perceptible through the skin, more especially in persons of a tubercular diathesis.

THE RIBS.

(Plate XXXIX.)

There are twelve ribs on each side; the upper seven increase in length from the first, and are called "true" ribs, because they are fixed to the sternum by their cartilages. The lower five decrease in length from above downwards, and are called "false," because their cartilages fall short of the sternum. The cartilages of the eighth, ninth, and tenth ribs are connected to that of the seventh; but the eleventh and twelfth are free, and are therefore called "floating" ribs. One sometimes, though rarely, meets with skeletons with thirteen ribs, the 13th being a lumbar rib. This is a degradation. The Chimpanzee has thirteen ribs, but the same number of vertebræ as man.

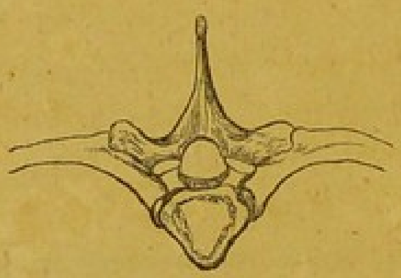
General characters of a rib.

As an example of the general characters of a rib, let us take the fifth or sixth. In the first place, observe that the curve is not uniform. It is much more curved towards the vertebral end than elsewhere. Besides which, if laid on a table, the vertebral end will rise. It is plain in the skeleton that the vertebral ends of the ribs are higher than their sternal ends. If both ends had been on the same level, the sternum could not have been raised *forwards* in inspiration.

The vertebral end or "head" (fig. 3) has two oblique surfaces (with an intervening ridge), which articulate with the sides of the bodies of two contiguous vertebræ. The lower of these two surfaces is always the larger. The head of the rib is the fulcrum upon which the rib moves, and it is wedged in, as it were, between two vertebræ, because it is less liable to be dislocated than if supported by a single one; and moreover it has the benefit of the elasticity of the intervening fibro-cartilage. This, as Paley observes, is the very contrivance employed in the famous iron bridge at Bishop's Wearmouth.

Next to the head comes the "neck" of the rib. This is smooth in front, where it is covered by pleura, but rough behind for the attachment of a ligament (middle costo-transverse), which connects it to the transverse process by which the rib is supported, as is seen in the adjoining cut: again, the neck has a little ridge along its upper surface for the attachment of a second ligament (superior costo-transverse), which connects it to the transverse process *above* it.

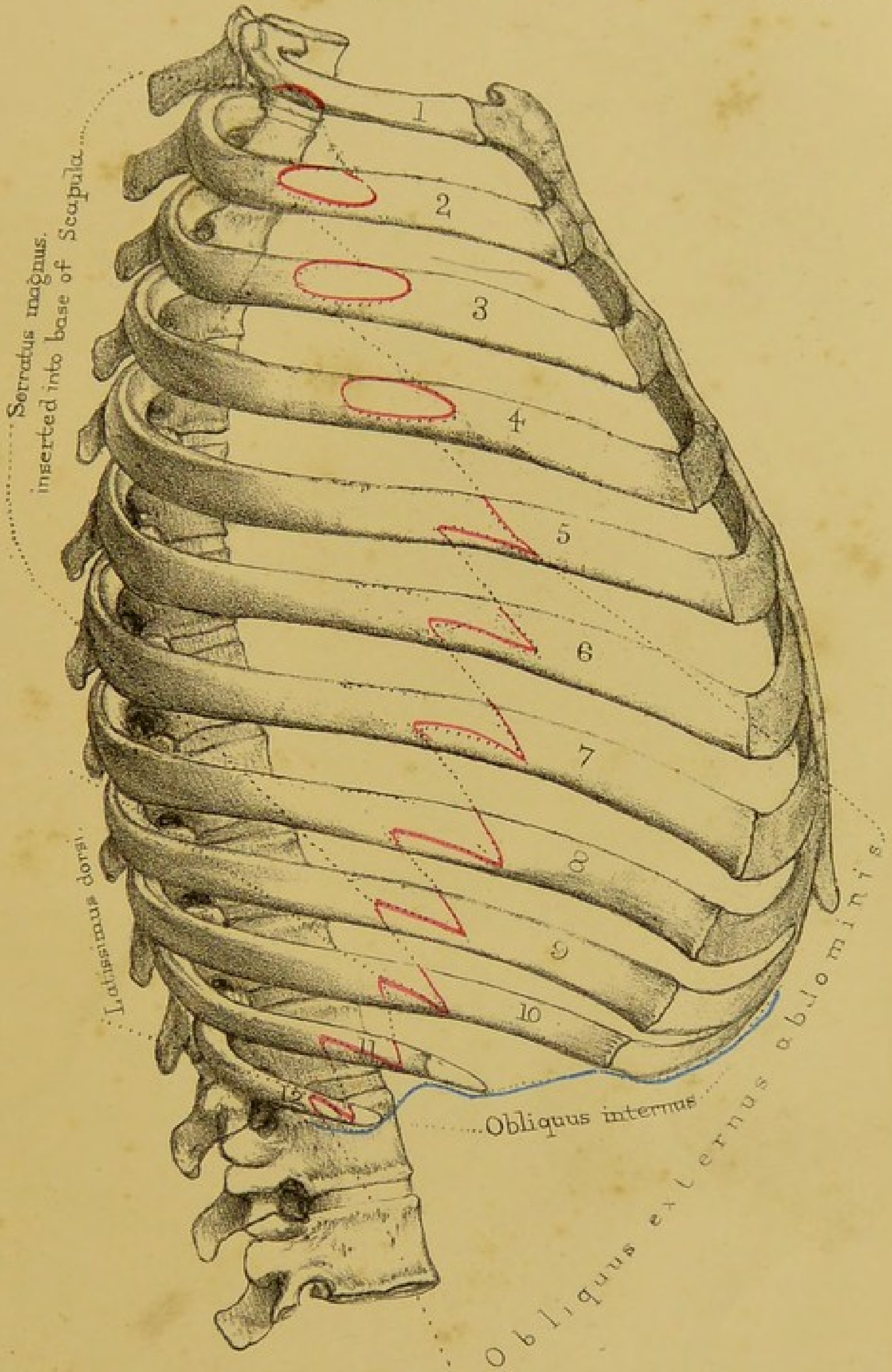
FIG. 42.



External to the neck is the "tubercle." It has a little facette which articulates with the transverse process supporting the rib; and above the facette is the rougher part of the tubercle which gives attachment to a third ligament connecting the rib to the transverse process (posterior costo-transverse).

External to the tubercle, the rib makes a sudden curve forwards, forming the "angle." Observe that the distance between the angle and the tubercle increases as we trace the ribs downwards, in order to make room for the great muscle of the spine (erector spinæ). The angle, for obvious reasons, is the strongest part of the rib. It is either at the angle or near it, that the rib breaks when the chest is compressed, for instance, in a crowd. In this kind of fracture—*i. e.* by *indirect* violence—the broken ends project outwards, and are therefore less liable to injure the pleura. I have seen 8 ribs broken, from the 2nd inclusive to the 9th, in consequence of a squeeze; all reunited by bone, without injury to the

PLATE XL.



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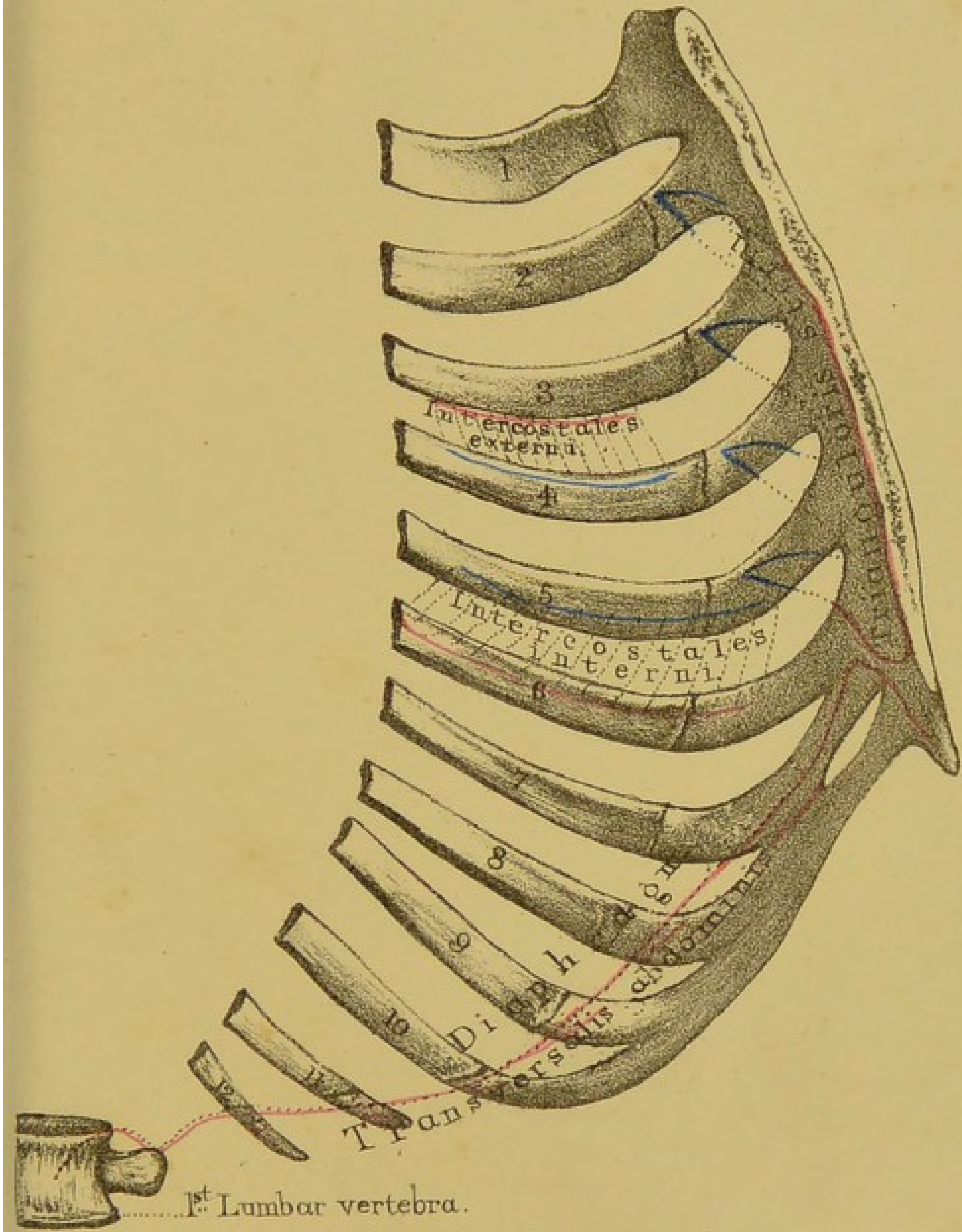


L. Holden Del.

T. Godart Lith.

pleura. But in *direct* violence—*e. g.* a kick by a horse—the rib breaks where it is struck, and the broken ends are driven inwards, and consequently are more liable to injure the pleura.

The rest of the rib arching forwards from the angle along the side of the chest is called the "body." It is flattened from above downwards, like a bow. On its inner surface, near the lower border, is a deep groove for the intercostal vessels and nerve. Observe, the groove does not extend all along the rib: it begins about the angle, and is gradually lost before we come to the anterior end. The vessels and nerve are safe where they lie in the groove, but between the angle of the rib and the spine, and again in front of the chest, they are liable to be injured through the intercostal spaces. In consequence of this groove, the lower end of the rib is much thinner than the upper, which is thick and rounded. In the groove itself you will notice the orifices of the numerous canals which transmit blood-vessels into the interior of the rib. The ribs are the most vascular bones in the body: hence the rapidity with which they unite after a fracture.

Respecting the anterior end we need only remark that it is rough, and a little excavated to receive the costal cartilage.

Peculiarities of the FIRST, ELEVENTH, and TWELFTH ribs.

The first, eleventh, and twelfth ribs have peculiarities requiring separate notice.

The *first* rib is the most horizontal, the shortest, the most curved, the flattest and broadest of all, for reasons which speak for themselves. Its head has a single articular surface which rests on the first dorsal vertebra. It has the largest tubercle, and this is well supported by the transverse process. There is scarcely a trace of angle. On its upper surface, we notice two slightly marked transverse grooves about the breadth of a finger, indicating where the rib is crossed by the subclavian vein and artery. Against this surface the subclavian artery may be effectually compressed. The grooves are separated on the inner border of the rib by a "tubercle" denoting the insertion of the "scalenus anticus." Behind this is the insertion of the scalenus medius. Lastly, there is no groove for the intercostal artery.

It is an interesting fact, that the compact tissue forming the *concave* margin of the first rib is very much thicker than that on the convex side. The first rib is the strongest of all: it has to support the manubrium sterni and the clavicles, and to protect all the important parts at the base of the neck. Fracture of the first rib is a very rare accident; but when it does happen, a most serious one, because it is the starting point of all the other ribs in respiration, and because there are so many important vessels and nerves in relation with it.

The *eleventh* and *twelfth* ribs being shorter and less perfectly developed, are chiefly distinguished by their negative characters. They articulate with only one vertebra, do not touch the transverse processes, have no tubercle or groove. Each is tipped with cartilage. On account of their looseness they are seldom broken.

Ossification begins very early in the ribs to protect the heart and lungs. There is one "primary" centre for the body, an epiphysis for the head, and another for the tubercle. These epiphyses appear from the 15th to the 18th year, and unite with the rest of the bone about the age of 25.

COSTAL CARTILAGES.

Respecting the costal cartilages, we observe that they increase in length from above, in order to allow the requisite play of the ribs in respiration. Their great elasticity answers a double purpose. They act as mechanical agents of expiration by depressing the ribs, and enable the chest to bear great blows with impunity. A blow on the sternum is distributed over fourteen elastic arches! One can understand, then, why the chest is able to bear such tremendous blows with impunity; and this more especially during a full inspiration. During expiration the bones are less able to resist injury, because the muscles are not acting. Notwithstanding these beautiful provisions, the sternum is sometimes broken, especially when the cartilages of the ribs are ossified. Dupuytren mentions the case of a fireman whose sternum was broken by the fall of a piece of timber. The man was carried away, supposed to be dead. Coming up accidentally, Dupuytren replaced the sternum, and the man recovered.

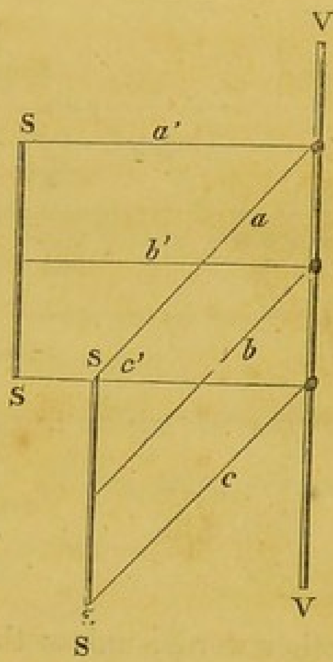
Mechanism by which the thorax is enlarged in inspiration.

We propose to demonstrate at present how the chest is enlarged in the transverse and in the antero-posterior direction by the elevation of the ribs.

The spine, of course, is fixed, and serves as a fulcrum for the ribs, which are the levers.

At the moment of inspiration, the ribs, which you must remember are oblique, are raised by the intercostal muscles. The centre of motion being at the spine, it is plain that the more nearly the ribs become horizontal, the greater will be the distance between the spine and the sternum. Thus let the line V V in fig. 43, represent the spine; the line S S the sternum; *a*, *b*, *c*, three ribs in their oblique position; and *a′*, *b′*, *c′*, the same ribs elevated. It is obvious that by raising the ribs we increase at the same time the antero-posterior diameter of the chest; or, in other words, we increase the distance between the spine V V and the sternum S S.

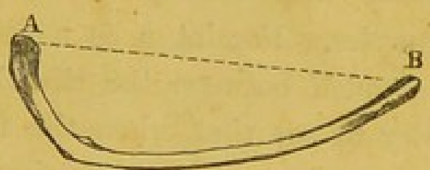
Fig. 43.



The same diagram proves, that when the ribs are raised, the intercostal spaces are widened; that is, a perpendicular let fall between two ribs is longer when the ribs are raised than when they are depressed.

Now when the ribs rise, they describe a kind of rotatory movement around an imaginary axis, as shown at A B, fig. 44, which unites their vertebral and sternal ends. In consequence of this rotation on its ends, the external surface of the rib which looks downwards and outwards when at rest, takes a direct outward aspect when it is elevated. In this way the *transverse* diameter of the chest is augmented.

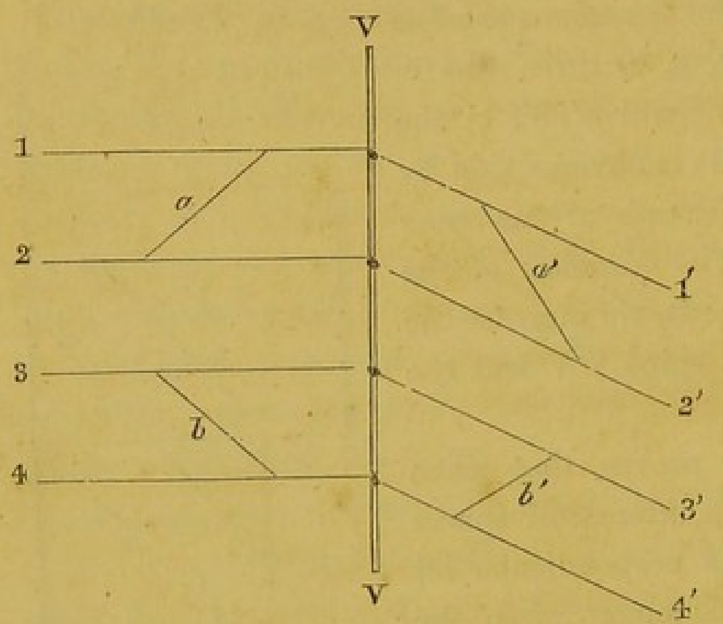
Fig. 44.



If the ribs were all of the same length, as in fig. 43, the projection of the sternum, caused by their elevation would be equal all the way down. But since the lower ribs are longer than the upper, it follows that the sternum will be projected more and more as we descend from its upper end.

Next come the questions, how are the ribs raised, and how are they depressed? They are *raised* by the external intercostal muscles (which run obliquely downwards and forwards); they are *depressed* by the internal intercostal muscles (which run obliquely upwards and forwards). These facts are proved by the following diagram:—

Fig. 45.



Let V V represent the spine, 1′ 2′ two ribs in a state of obliquity or rest, and *a*′ a fibre of an external intercostal muscle. Now when the fibre *a*′ contracts, it shortens itself: but this shortening cannot take place unless the ribs are at the same time brought more into the horizontal line, as shown at 1, 2; in other words, unless they are raised; therefore the external intercostal muscles are *inspiratory* muscles.

The same kind of demonstration proves that the internal intercostal muscles depress the ribs, and are therefore *expiratory* muscles. For let *b* be a fibre of an internal intercostal muscle extended between the ribs 3 and 4 in a state of elevation, it is easy to see that, when the fibre *b* contracts or shortens itself, it cannot do so without bringing the ribs into a more oblique position, as shown at 3′ and 4′. That the fibre *b*′ must be shorter than the fibre *b* may be proved by a pair of compasses.

MUSCLES ATTACHED TO THE CHEST.

TO THE FRONT OF THE CHEST (Plate XXXIX.)

Pectoralis major	O. Front surface of sternum; sternal half of clavicle; cartilages of all true ribs but first and last. I. Outer edge of bicipital groove of humerus.
Pectoralis minor	O. Third, fourth, and fifth ribs. I. Coracoid process of scapula.

TO THE SIDE OF THE CHEST (Plate XL.)

Serratus magnus	O. Eight or nine upper ribs by digitations. I. Posterior border of scapula.
Obliquus externus abdominis	O. Anterior half of crest of ilium. I. By digitations into eight or nine lower ribs; linea alba; spine of pubes.

TO THE UPPER PART OF THE CHEST.

Sterno-cleido-mastoid	O. Upper and front part of sternum; sternal third of clavicle. I. Mastoid process of temporal bone; superior curved line of occiput.
Sterno-hyoid	O. Behind first bone of sternum. I. Body of the os-hyoides.
Sterno-thyroid	O. Behind first bone of sternum. I. Along side of thyroid cartilage.
Sub-clavius	O. Cartilage of first rib. I. Under surface of clavicle.
Scalenus anticus	O. Transverse processes (anterior tubercles) of third, fourth, fifth, and sixth cervical vertebræ. I. Tubercle of first rib.
Scalenus medius and posticus	O. Transverse processes (posterior tubercles) of six lower cervical vertebræ. I. Hinder part of first and second ribs.

TO THE LOWER PART OF THE CHEST.

Rectus abdominis	O. Crest of the pubes. I. Fifth, sixth, and seventh costal cartilages.
Obliquus internus abdominis	O. Anterior ⅔ of crest of ilium; outer ½ of crural arch. I. Lower borders of the three or four lower ribs; linea alba; crest of pubes.
Transversalis abdominis	O. Outer ⅓ of crural arch; anterior ⅔ of crest of ilium; transverse processes of lumbar vertebræ; inner surface of the six or seven lower ribs. I. Linea alba; crest of pubes.

Diaphragm	O. Ensiform cartilage; six lower ribs; ligamenta arcuata*; bodies of three upper lumbar vertebræ. I. The central tendon.
Quadratus lumborum	O. Crest of ilium; ilio-lumbar ligament. I. Last rib; transverse processes of four lower lumbar vertebræ.

INTERCOSTAL MUSCLES.

These muscles occupy the intercostal spaces, and are attached to the margins of the ribs. There are two layers, crossing like the letter X. The external layer begins at the tubercles and stops at the cartilages: its direction is downwards and forwards. The internal layer begins at the angles and extends to the sternum: its direction is upwards and forwards.

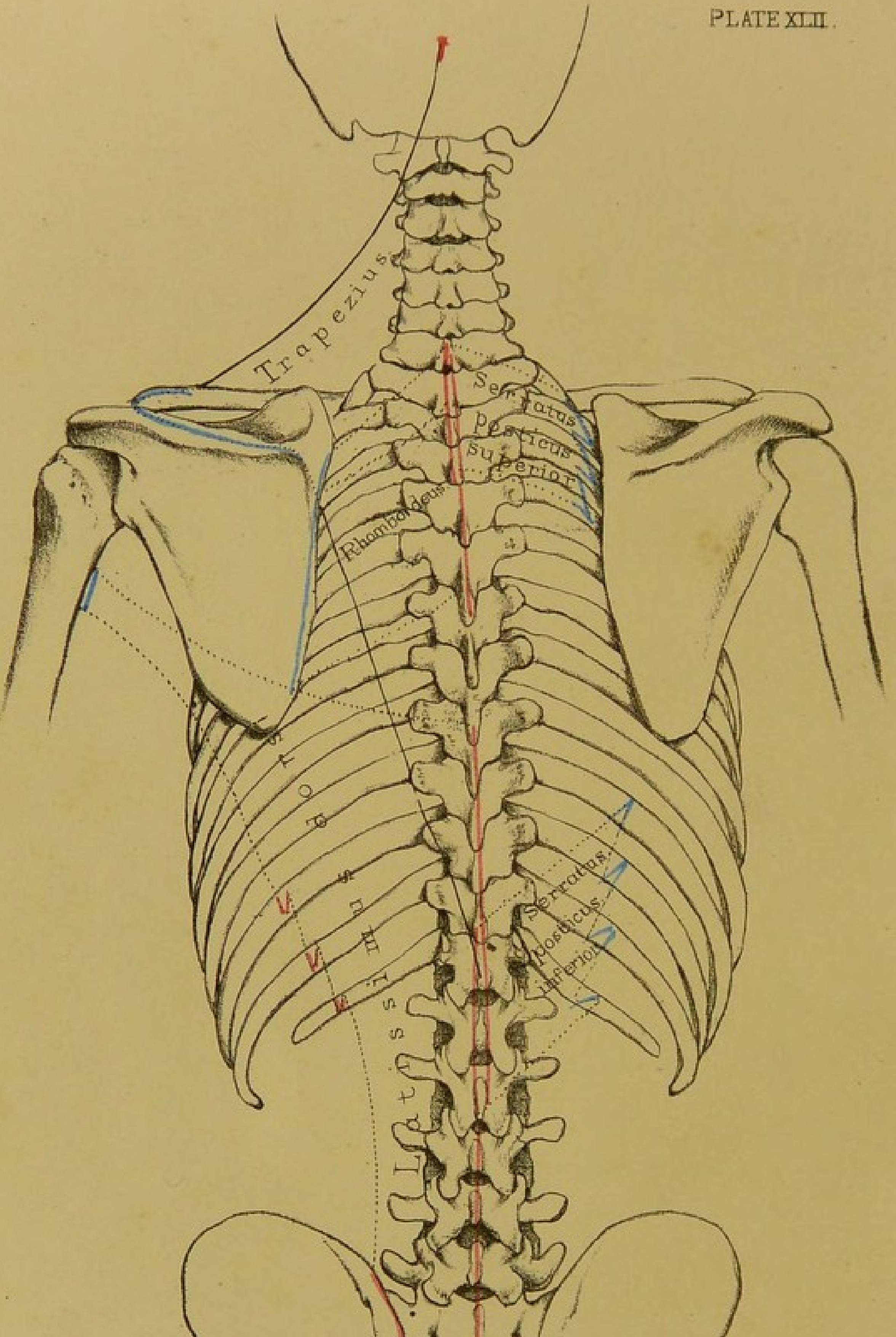
Triangularis sterni	O. Inner surface of sternum. I. Cartilages of second, third, fourth, and fifth ribs.

MUSCLES OF THE BACK.

(Plates XLII. to XLV.)

The plan we propose to adopt in the description of the muscles of the back is to take, first, the more superficial muscles connected with the arm. When these are removed, we bring into view the great muscles of the spine, which fill up the vertebral grooves, and keep the body erect. Lastly, we have the mass of muscles at the back of the neck which are attached to the occipital bone.

* The "ligamenta arcuata" are shown in Plate XLI. The inner of these two arched ligaments extends from the body of the first lumbar vertebra to its transverse process; the outer extends from the transverse process to the last rib.



L. Holden del.t

J. Sorrill, Imp.

T. Godart Lith.

THE SUPERFICIAL MUSCLES OF THE BACK.

These are shown in Plate XLII. The most superficial is the trapezius," a triangular muscle of which the limits are defined by the continuous dark line. The other wide-spreading superficial muscle is the "latissimus dorsi." Under the trapezius we have the "rhomboideus" and the "levator anguli scapulæ" (shown in Plate XLIV.).

Trapezius	O. Occiput: ligamentum nuchæ: spines of all the dorsal vertebræ. I. Spine of scapula: acromion, acromial third of clavicle.
Latissimus dorsi	O. Crest of the ilium. Spines of all the lumbar, and six lower dorsal vertebræ, and by digitations from the three lower ribs. I. Bottom of bicipital groove of humerus.
Rhomboideus (major and minor)	O. Spines of last cervical and five upper dorsal vertebræ. I. Posterior border of scapula.
Levator anguli scapulæ	O. Transverse processes of four upper cervical vertebræ. I. Upper angle of scapula.

When the preceding muscles are removed, we have still to take off the "serratus posticus superior" and "inferior." Understand these belong neither to the arm nor the spine, but to the ribs.

Serratus posticus superior	O. Spines of last cervical and three upper dorsal vertebræ. I. Second, third, and fourth ribs.
Serratus posticus inferior	O. Spines of two last dorsal and two upper lumbar vertebræ. I. Four lower ribs.

We come now to the great muscles of the spine concerned in keeping the body erect. These are considered to be complicated: the truth is, they are very simple, provided the plan of their arrangement be fairly attended to. An attempt has been made to bring out the plan in Plate XLIII.

The vertebral groove on each side of the spine is occupied by the "erector-spinæ" and its prolongations, and also by the "transverso-spinalis."

The "erector-spinæ" arises by strong tendons from the crest of the ilium, back of the sacrum, and the spines of the lumbar vertebræ; and subdivides into two masses of muscle. The outer, termed the "sacro-lumbalis," with its prolongations (musculus accessorius and cervicalis ascendens) is attached to the *angles* of the ribs. The inner, termed the longissimus dorsi, with its prolongations (transversalis colli and trachelo-mastoid) is attached to the *transverse processes* of the vertebræ. Subjoined, these muscles are arranged in a natural tabular form. They all run longitudinally.

DEEP-SEATED MUSCLES OF THE BACK.

Crest of ilium.
Back of sacrum.
Spines of lumbar vertebræ.

O. ERECTOR-SPINÆ

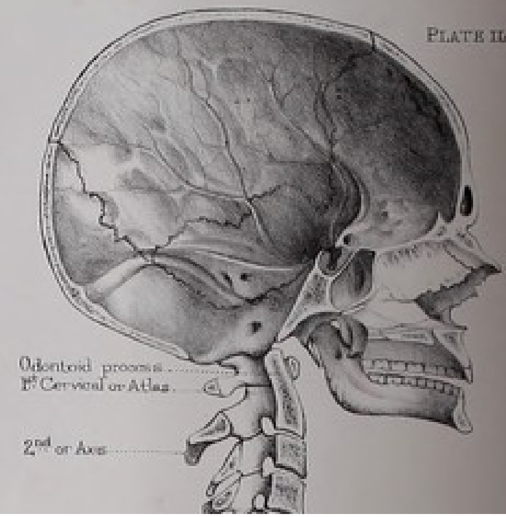
outer mass (Angles of ribs.)........ Sacro-lumbalis. I. 6 lower ribs. O. Musculus accessorius. I. 6 upper ribs. O. Cervicalis ascendens. I. 4 lower cervical vertebræ.

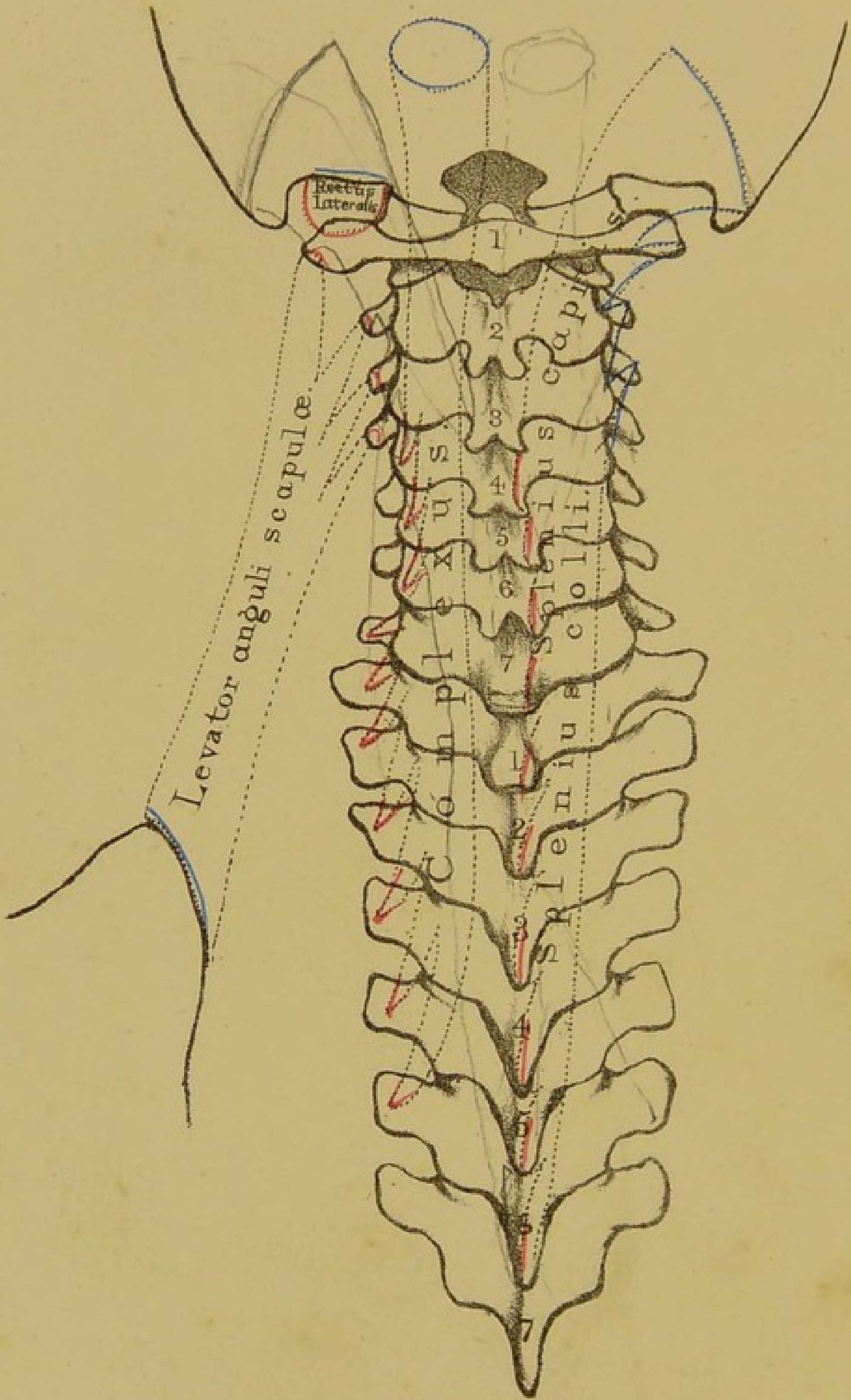
inner mass (Transverse processes of vertebræ.)........ Longissimus dorsi. I. all the lumbar and dorsal vertebræ. ....Transversalis colli. O. 5 or 6 upper dorsal vertebræ. I. 4 or 5 cervical vertebræ. ....Trachelo-mastoid. O. 4 or 5 cervical vertebræ. I. Mastoid process.

The "transverso-spinalis" is the mass which fills up the space between the transverse and spinous processes of the vertebræ. It *arises* from transverse, and is *inserted* into spinous processes. Therefore its direction is oblique. It is composed of several bundles. The more superficial pass over many vertebræ; the deeper, over one or two; the deepest run from vertebra to vertebra. The "transverso-spinalis" comprises the "semi-spinalis dorsi," "semi-spinalis colli," "multifidus spinæ," and "rotatores spinæ" of systematic authors.

The "levatores costarum" arise from the transverse processes, and are inserted into the ribs below them.

PLATE IIa.





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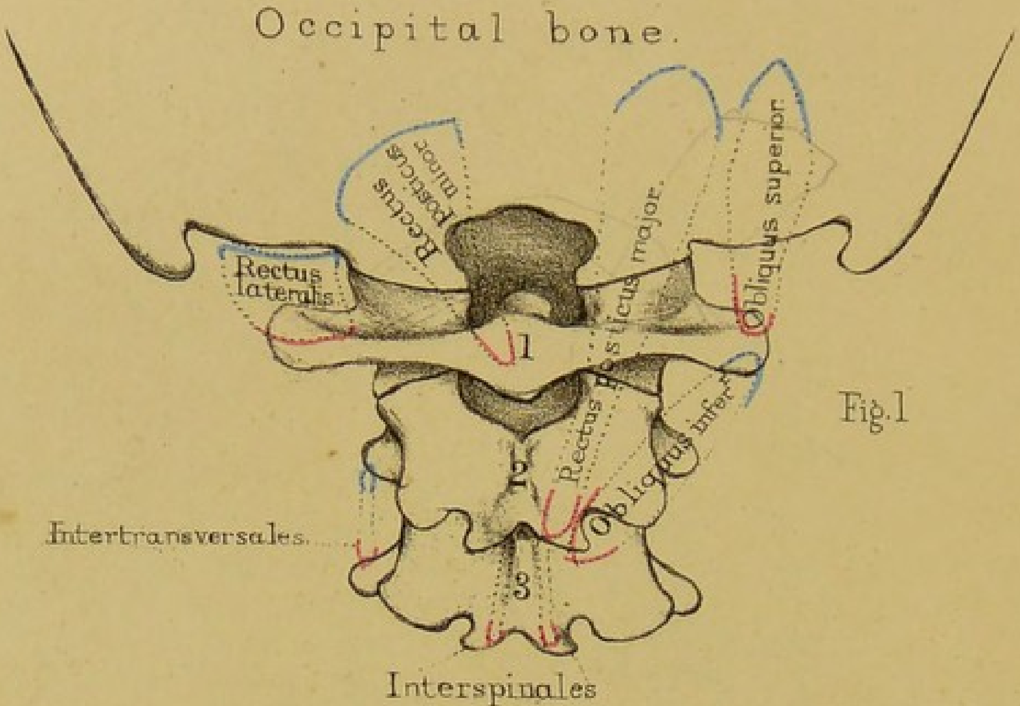

Fig. 1

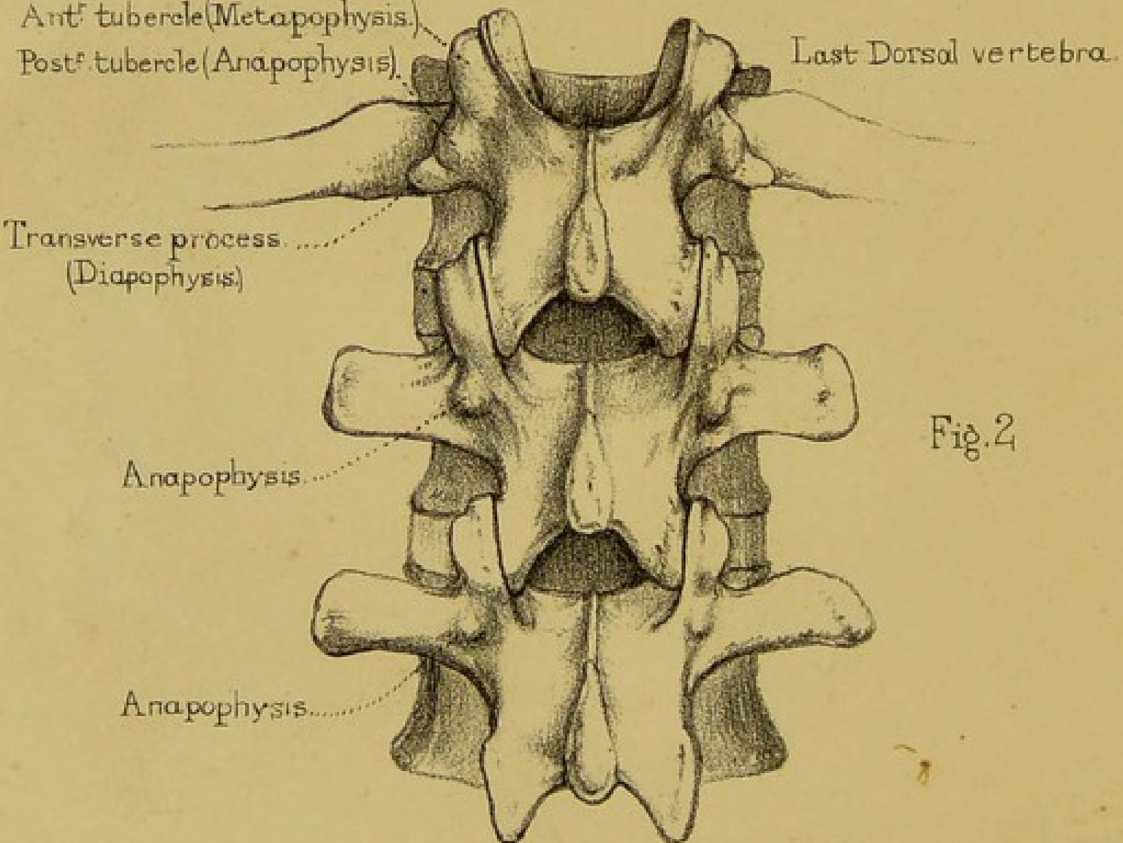

Fig. 2

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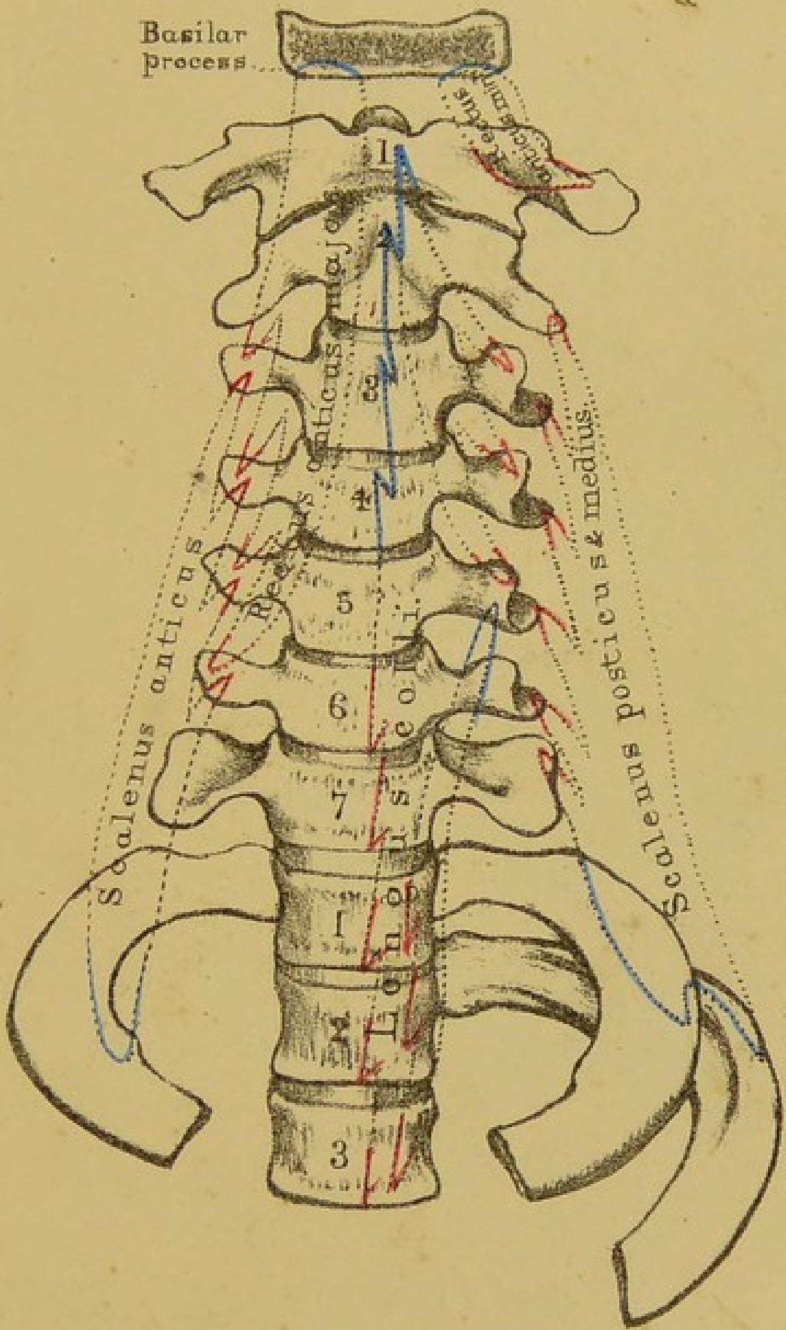
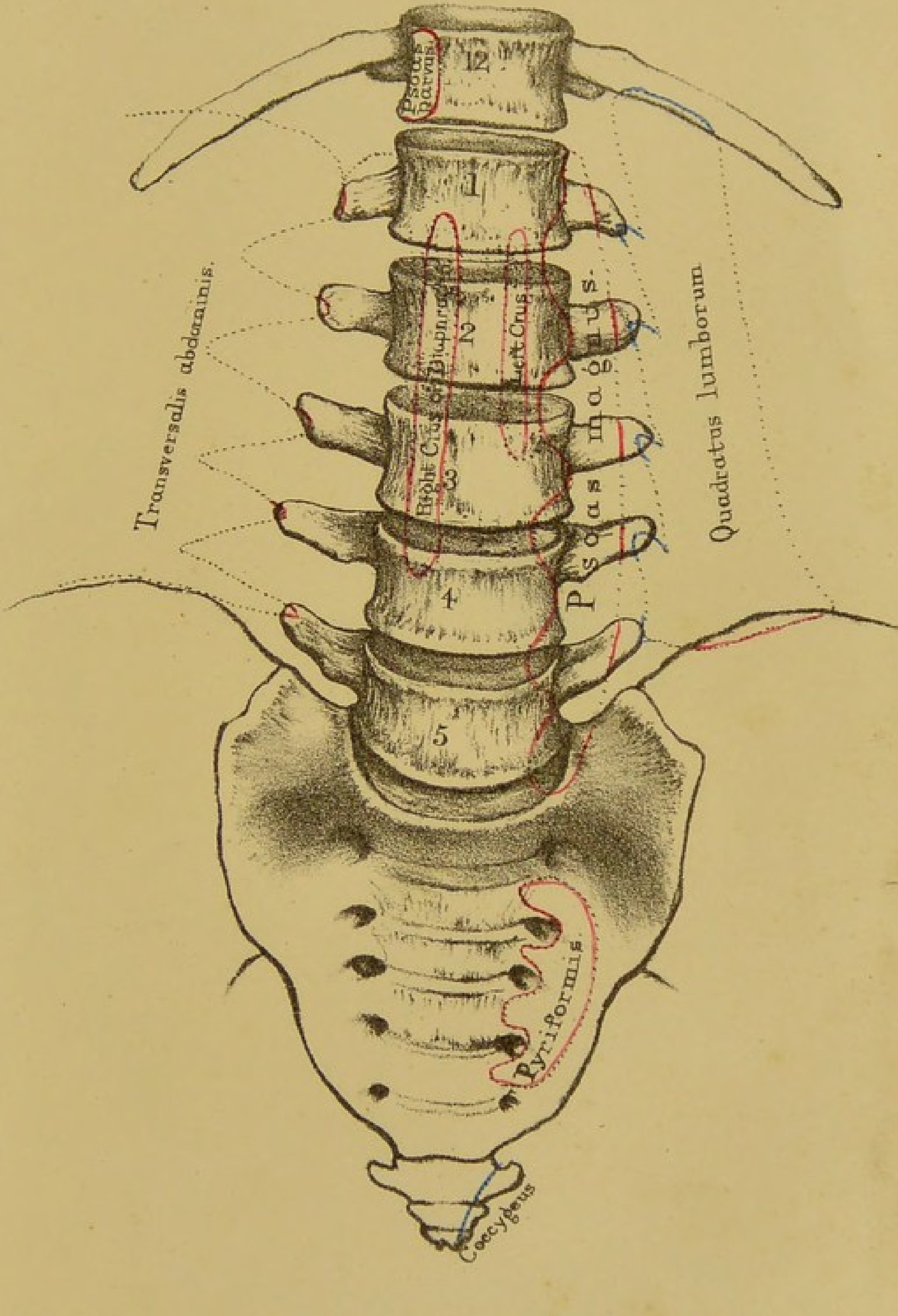


L. Holden Delt

T. Godart Lith.



Holden. Delt

T. Godart. Lith

Fig. 1.

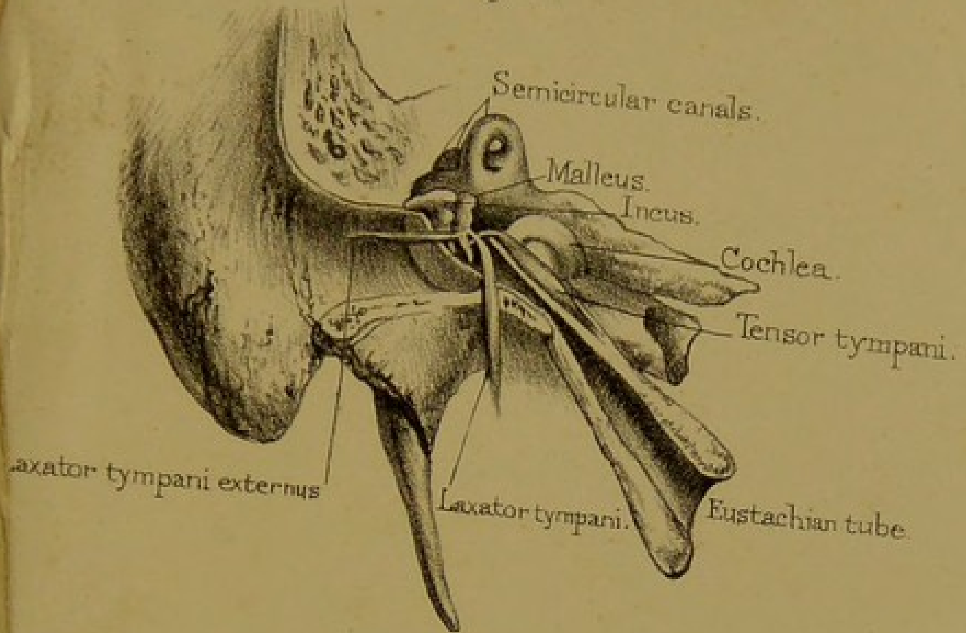


Fig. 2.

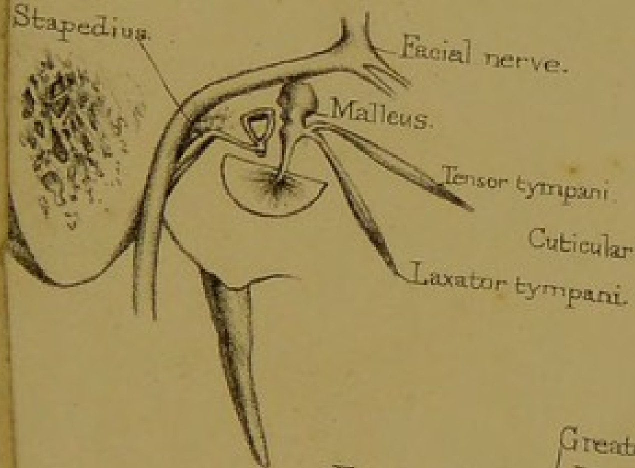


Fig. 3.

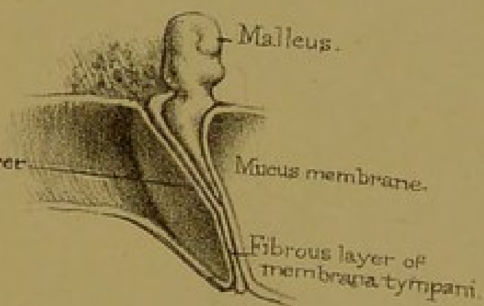
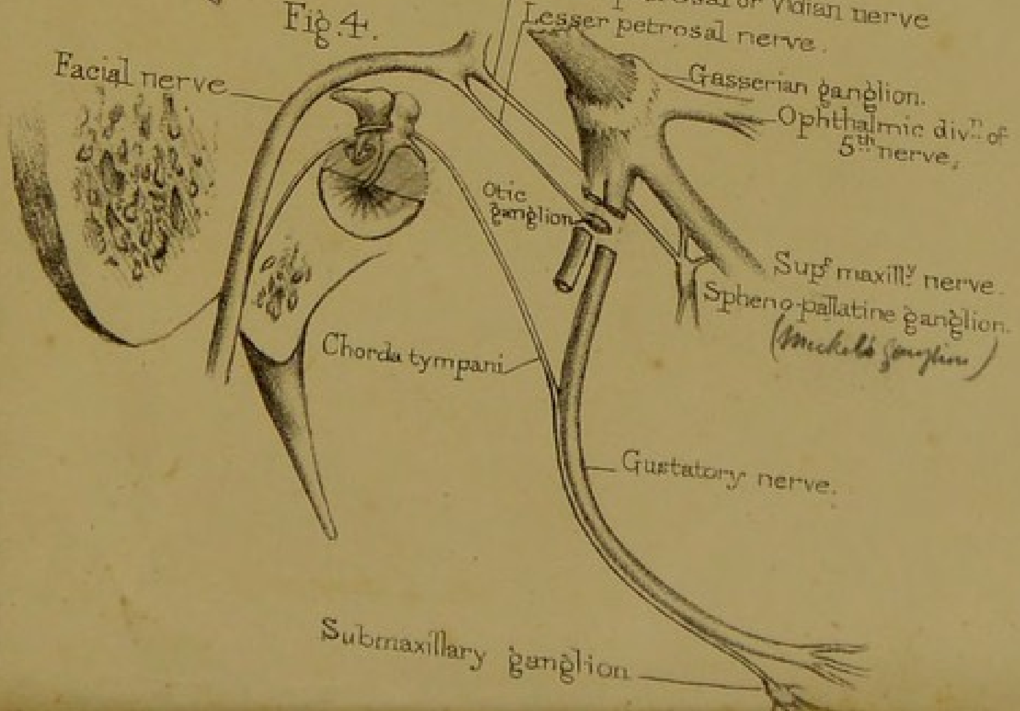


Fig. 4.



MUSCLES OF THE BACK OF THE NECK.

(Plate XLV.)

We make a separate group of these, because they are specially intended to maintain the head erect, and to move the first upon the second vertebra. The "trapezius" being reflected, we come to the "splenius," and beneath that to the "complexus."

Splenius capitis et colli	O. Spines of four cervical and six dorsal vertebræ. I. Mastoid process and occipital bone; transverse processes of three upper cervical vertebræ.
Complexus	O. Transverse processes of six dorsal and articular processes of four cervical vertebræ. I. Occipital bone.

The above muscles being reflected, we expose the muscles of the atlas and axis; namely, the "rectus capitis posticus major" and "minor," the "obliquus superior" and "inferior," and the "rectus lateralis."

Rectus capitis posticus major	O. Spine of the axis. I. Occipital bone.
Rectus capitis posticus minor	O. Spine of the atlas. I. Occipital bone.
Rectus capitis lateralis	O. Transverse process of atlas. I. Jugular eminence of occipital bone.
Obliquus superior	O. Transverse process of atlas. I. Occipital bone.
Obliquus inferior	O. Spine of the axis. I. Transverse process of atlas.

MUSCLES IN FRONT OF THE SPINE.

(Plates XLVI. and XLVII.)

There are only three pre-vertebral muscles in the cervical region; namely, the "rectus capitis anticus major" and "minor," and the "longus colli." In the lumbar region we have the right and left crura of the "diaphragm," the "psoas magnus," and occasionally a "psoas parvus."

Rectus capitis anticus major ...	O. Transverse processes of third, fourth, fifth, and sixth cervical vertebræ. I. Basilar process.
Rectus capitis anticus minor ...	O. Transverse process of atlas. I. Basilar process.

The "longus colli" consists of a longitudinal and an oblique portion. The *longitudinal* part *arises* from the bodies of the three upper dorsal and two lower cervical vertebræ, and is inserted into the bodies of the second, third, and fourth cervical vertebræ. The *oblique* part *arises* from the transverse processes of the third, fourth, and fifth cervical vertebræ, and is *inserted* into the tubercle of the atlas. Other oblique fibres arise from the bodies of the three upper dorsal vertebræ, and are inserted into the transverse process of the fifth cervical vertebra.

Diaphragm	O. Right crus from four lumbar vertebræ, left from three. I. Central tendon.
Psoas magnus	O. Bodies and transverse processes of all the lumbar vertebræ. I. Trochanter minor.
Psoas parvus	O. Body of last dorsal vertebra. I. Brim of pelvis.

OS HYOIDES.

(Plate XLVIII.)

The os hyoides, so called from its likeness to the Greek letter Upsilon, is situated between the larynx and the root of the tongue. When the neck is in its natural position, it can be plainly felt on a level with the lower jaw, and about one inch and a half behind it. It serves to keep open the top of the larynx, and for the attachment of the muscles which move the tongue.

It is divided into a "body" or front part, and into a "greater" and a "lesser cornu" on each side.

Os-hyoides.

Fig. 1.

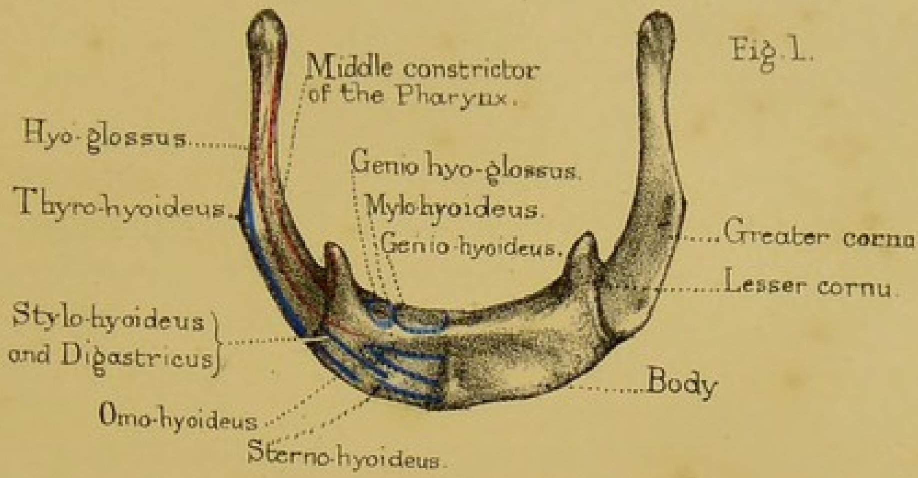


Fig. 2.

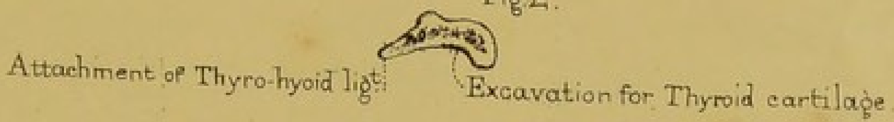
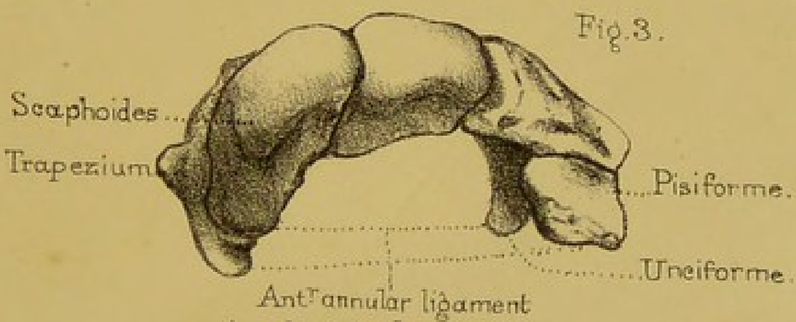
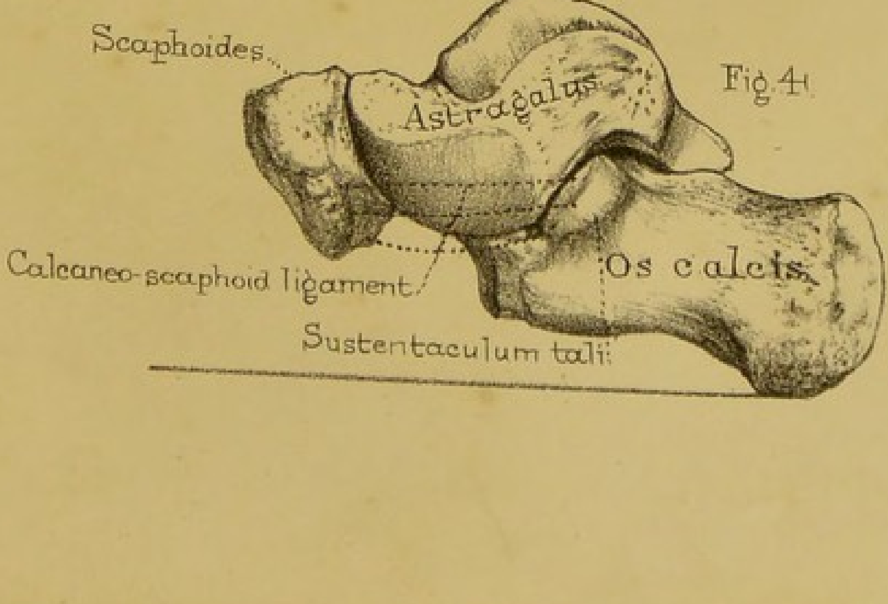


Fig. 3.



Arch of the Carpus.

Fig. 4.



The "body" is the thickest and strongest part. Its *upper* surface is marked by the impressions of the muscles attached to it. There is generally a transverse and a perpendicular ridge. Often there is a little projection from the middle, which is interesting as a rudiment of the process to which is attached the lingual bone of animals, which runs into the substance of the tongue. Its *under* surface is slightly excavated, as seen in fig. 2, which shows a transverse section through the centre of the body. Observe, this hollow is not for the attachment of muscles, but for the purpose of making room for the thyroid cartilage to rise behind the os hyoides in deglutition. It is a rudiment of the great cavity which forms the drum in the hyoid bone of the howling monkeys (mycetes). Observe, moreover, that the plane of the body is nearly horizontal, and that the thyro-hyoid ligament is attached to its *posterior* border.

The greater cornu projects backwards about one inch and a half, not quite horizontally, but with a slight inclination upwards, and terminates in a blunt end tipped with cartilage. Until the middle period of life, the great cornu is united to the body by cartilage; but this ossifies in the progress of age.

The lesser cornu is not much larger than a barleycorn, and projects backwards at an acute angle from the junction of the body and the greater cornu. It articulates with the body by a little joint, and is freely movable: the stylo-hyoid ligament is attached to the end of it.

The many muscles attached to the hyoid bone are shown in the plate.

The os hyoides is connected to the thyroid cartilage by three ligaments, which contain a large quantity of elastic tissue. These ligaments are: — 1. The *anterior thyro-hyoid* (Plate XLVIII. *a*, fig. 1), which proceeds from the pomum Adami to the upper part of the body of the os hyoides. 2. The two *posterior thyro-hyoid*, which extend, one on each side, from the end of the great cornu of the os hyoides to the superior cornu of the thyroid cartilage. The vacant space left in the dried preparation between the hyoid bone and the thyroid cartilage is closed in the recent state by the *thyro-hyoid membrane.*

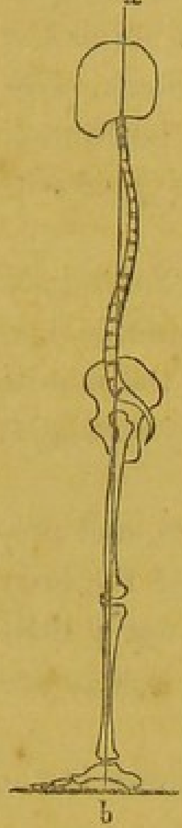
The bone is ossified from five centres—one for the body, and one for each of its four horns.

GENERAL SURVEY OF THE SKELETON.

Let us now take a general survey of the skeleton, and observe how admirably it is adapted to the erect attitude.

1. When a man stands erect, a transverse plane (*a b*) falling from the top of the head passes through the occipito-atlantoid, lumbo-sacral, sacro-iliac, hip, knee, and ankle-joints; in a word, through all the joints which transmit the weight to the ground. This explains why a man can carry a weight on the top of his head easier than in any other way.

Fig. 46.



2. The foramen magnum and the condyles of the occiput are nearly horizontal, and advanced almost to the middle of the base of the skull, so that the head may be nicely balanced on the cups of the atlas. True, there is a slight tendency in the head to drop forwards, but this is compensated by the great strength of the muscles which keep the head erect. Contrast the position of the condyles in the human skull with that of the ourang outan, in which the condyles are not only placed nearer to the *back* of the head, but obliquely, so as to make an angle of 40° with the horizon. The lower we go in the scale, the greater is the contrast. In the horse, for instance, the plane of the condyles and foramen magnum is vertical. In this, and all other herbivorous quadrupeds, the weight of the head is sustained, not by muscular power, but by an enormously strong and elastic ligament (ligamentum nuchæ, or *pack-wax*), which extends from the lofty spines (withers) of the dorsal vertebræ to the crest of the occiput.

3. The face is placed perpendicularly under the cranium, so that the plane of the face and forehead correspond, and this characteristic of the "human face divine" is the form best adapted for the erect attitude. If man went on all fours, he would habitually see and smell nothing but the ground. As it is, the di-

rection of the orbits is horizontal, and therefore gives the greatest range of vision; and the direction of the nose gives the greatest range of smell. We are all reminded here of the beautiful lines—

> "Pronaque dum spectant animalia cætera terram,
> Os homini sublime dedit, cœlumque tueri
> Jussit, et erectos ad sidera tollere vultus."

4. The thorax is much broader in the transverse than in the antero-posterior diameter, which is peculiar to man and the highest species of ape. This great breadth of the chest throws the arms farther apart, and gives them a more extensive range; besides which it diminishes the tendency there would otherwise be in the trunk to fall forwards. Contrast this with the chest of quadrupeds, compressed laterally, and deep from sternum to spine in order that the fore legs may come nearer together, and fall perpendicularly under the trunk.

5. The vertebral column gradually increases in size towards the base. It is curved, which makes it all the stronger, and better adapted to break and diffuse shocks; and these curves wave alternately, so as to distribute the weight advantageously with regard to the line of gravity. This line passes through all the curves, and falls exactly on the centre of the base. Observe, moreover, the length and size of the spinous processes in the lumbar region for the origin of the great "erector-spinæ."

6. The weight of the vertebral column is supported on a sacrum broader in proportion than in any other animal. The iliac bones are widely expanded and concave internally, to support the viscera and give powerful leverage to the muscles which balance the trunk. The whole pelvis is remarkably broad, so as to widen the base of support; and the plane of its arch inclines so as to transmit the weight from the sacrum (or crown of the arch), vertically on to the heads of the thigh bones: lastly, the deepest and strongest part of the socket for the thigh bone is in the line of weight: consequently, the joint is never more secure than in the erect position.

With the broad and capacious pelvis of man, contrast the long and narrow pelvis of animals, which, in place of forming an angle with the spine, is almost in the same line with it.

7. In proportion to the trunk, the lower limbs of man are longer than in any other animal, the kangaroo not excepted. Their great length prevents their being adapted for locomotion in any but the erect attitude. The femur has a long neck, set on to the shaft at a very open angle, so that the base of support is rendered still wider. The long shaft of the femur inclines inwards, so as to bring the weight well under the pelvis, which is obviously of great advantage in progression: and when the leg is extended, the femur can be brought into the same line with the tibia: thus the weight is transmitted vertically on to the horizontal plane of the knee-joint, and the articular surfaces of the bones are expanded to give adequate extent of support.

8. The foot of man is broader, stronger, and larger in proportion to the size of the body than in any other animal; so that he can stand on one leg, which no other mammal can do. Its strong component bones form a double arch of exceeding elasticity, which touches the ground at both ends, and receives the superincumbent weight vertically on its "crown." The great bulk and backward prolongation of the os calcis at right angles to the tibia support the arch behind, and form a powerful lever for the great muscles of the calf, which raise the body in progression, and the bones of the great toe are proportionably strong, in order to form the chief support upon which the body may be raised.

9. We see, then, that the whole fabric of the skeleton is adjusted so as to exempt the upper limbs from taking any part in its support. These are kept wide apart by the clavicles, and their component joints admit of the freest range of motion. The twenty-seven bones at the extremity of each constitute those instruments of consummate perfection, the "hands," of which, even if formal dissertations had not been written, one might well forbear to speak, since they have such eloquence of their own. "Nam cæteræ partes loquentem adjuvant, hæ, prope est ut dicam, ipsæ loquuntur: His poscimus, pollicemur, vocamus, dimittimus, minamur, supplicamus, abominamur, timemus; gaudium, tristitiam, dubitationem, confessionem, penitentiam, modum, copiam, numerum, tempus, ostendimus." *

* Quintilian.

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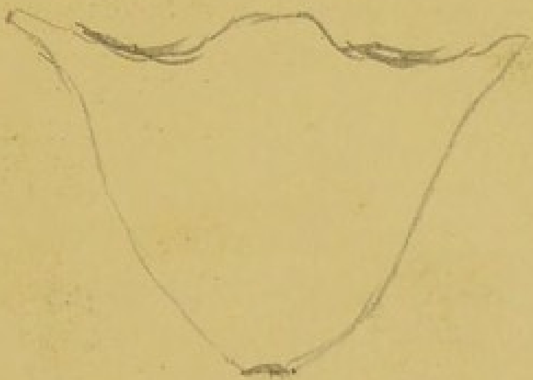


LARYNX.

Fig. 1.

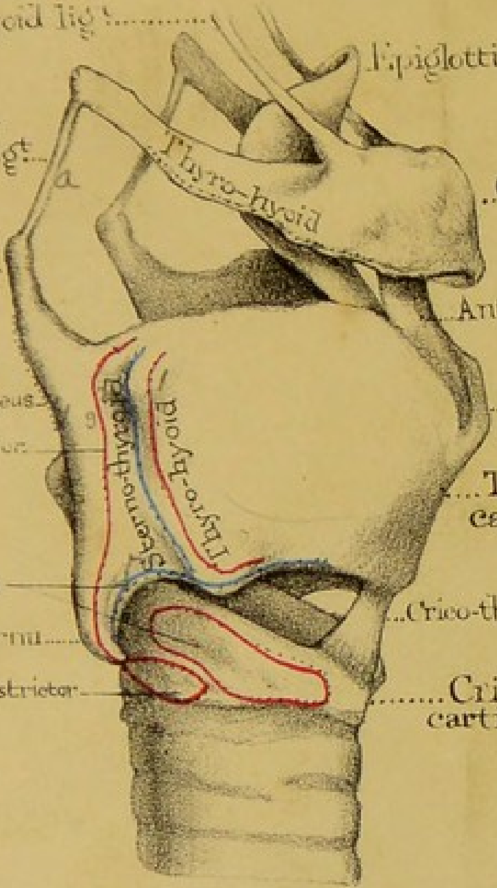


Fig. 2

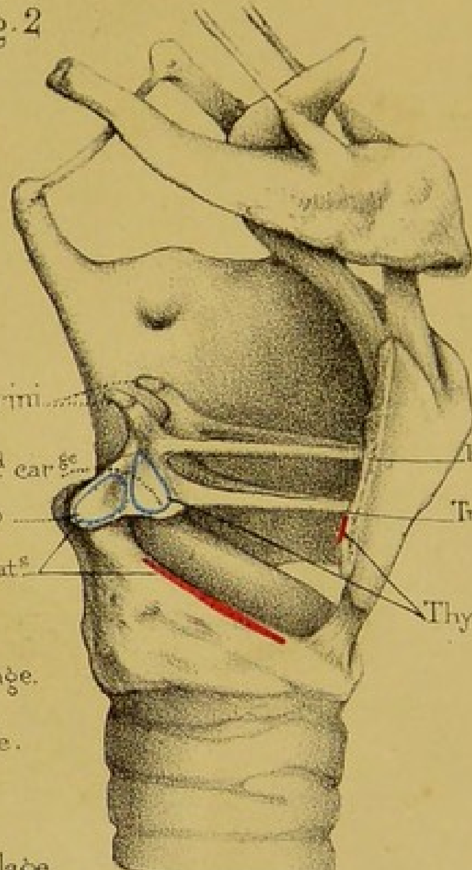
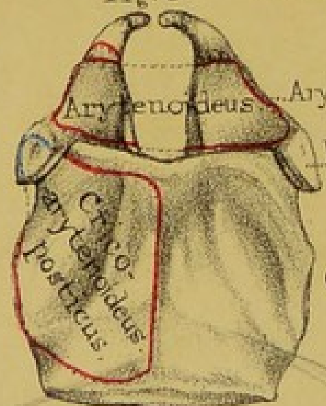


Fig. 3.



Post^r surface of Cricoid and Arytenoid cartilages.

On Stone by T. Godart.

THE LARYNX.

(Plate XLVIII. *a.*)

The larynx is situated at the top of the trachæa or windpipe. It answers a double purpose. It guards the opening through which the air passes into the lungs: it is the organ of the voice and of song. Its framework, which we now propose to examine, consists of five cartilages connected by joints and elastic ligaments in such a way that they can be moved upon each other by appropriate muscles; the object of this motion being to act upon two elastic ligaments termed the "vocal cords," upon which the voice essentially depends. The cartilages are named, respectively, the thyroid, the cricoid, the two arytenoid, and the epiglottis. 5(4.9)

THYROID CARTILAGE. The thyroid cartilage is so named because it shields the fine apparatus behind it.* It consists of two lateral symmetrical plates (alæ), united in front at an angle which forms the prominence termed "pomum Adami." This prominence, which is greater in the male than in the female, has a "notch" at the upper part, as if a portion of the angle had been sliced off: the object of this is to permit the cartilage to rise with greater facility behind the os hyoides in the act of deglutition. It will be remembered that the body of the os hyoides is excavated for this express purpose. More than this, there is a bursa of considerable size to prevent friction between the surfaces. The bursa is practically interesting, because it may enlarge and form a cyst in front of the neck. I have seen it large enough to hold a pigeon's egg.

Look at the outer surface of the ala of the thyroid cartilage (fig. 1). Observe that it has an oblique ridge, more or less marked, with tubercles at each end, indicative of the attachments of muscles. The ridge gives origin to the thyro-hyoid and insertion /

* θυρεός, a shield.

to the sterno-thyroid muscles. Behind the ridge is the origin of the inferior constrictor of the pharynx, which we trace down to the side of the cricoid cartilage. The *posterior* border of the ala is nearly vertical, and gives insertion to the stylo-pharyngeus. The *inferior* border of the ala has generally two curves, and gives insertion to the crico-thyroid muscle. This muscle, observe, arises from the side of the cricoid cartilage; consequently, when it acts, it draws the two cartilages together.

The posterior part of each ala has two projections, termed its "cornua" superior and inferior. The superior cornu gives attachment to the posterior thyro-hyoid ligament. The inferior cornu articulates with the cricoid cartilage. This is a perfect joint, provided with a synovial membrane and ligaments. It is important to remember that the form of the joint admits of only vertical movement of the thyroid cartilage; the axis of motion being a transverse line drawn through both joints. We shall presently see that upon this movement depends the tuning of the vocal cords.

So much for the outside of the thyroid cartilage. Now for the parts attached within the angle. To see them properly, one of the alæ should be removed, as we have done in fig. 2. You then observe that the following objects are attached to the angle beginning at the top: 1, the anterior thyro-hyoid ligament; 2, below this, the apex of the epiglottis; 3, lower down, the false vocal cords; 4, still lower, the true vocal cords; 5, below these, the origin of the thyro-arytenoideus; lastly, at the lower border of the angle, is the attachment of the crico-thyroid ligament.

Cricoid cartilage.

The cricoid cartilage (Plate XLVIII. *a*) forms a complete ring (whence its name) a little broader in the antero-posterior diameter than in the transverse. It is situated at the top of the trachæa immediately below the thyroid cartilage. The ring is not of the same depth all round. Observe that it is narrow in front, and that from this part the upper border of the ring gradually rises, so that, behind, the ring is a full inch in vertical depth, and occupies part of the interval between the alæ of the thyroid. This slope of the cricoid towards the front is obviously for the purpose of permitting the vertical play of the thyroid. The interval between the two cartilages can be plainly felt in the middle line of the neck; and in the adult it is about half an inch in depth. It is occupied by the crico-thyroid ligament, which connects the two cartilages. All that concerns this interval is practically interesting, because it is here that we perform laryngotomy. This operation consists in dividing the crico-thyroid ligament transversely close to the cricoid cartilage, in order that the incision may be as distant as possible from the vocal cords.

Passing from the front towards the side of the cricoid cartilage, we notice the origin of three muscles, namely—the crico-arytenoideus lateralis along the upper edge (fig. 2); the crico-thyroid in the middle (fig. 1); and, lower down, a portion of the inferior constrictor of the pharynx.

At the back part of the cricoid cartilage (fig. 3) we observe on either side a broad excavation for the origin of the crico-arytenoideus posticus. Generally these muscles are separated by a slight vertical crest. At the top of the cricoid are the two small oval articular surfaces, one on each side, for the arytenoid cartilages, which we shall examine presently.

The side of the cricoid articulates with the inferior cornu of the thyroid cartilage by means of a perfect joint, provided with a synovial membrane and ligaments. The structure of this joint permits the two cartilages to move upon each other, so that their opposite borders can be approximated by the crico-thyroid muscle, as before observed. It deserves especial attention, because the degree of this approximation regulates the tension of the vocal cords.

Lastly, the lower border of the cricoid is horizontal, and connected to the first ring of the trachæa by an elastic membrane.

ARYTENOID CARTILAGES. The arytenoid cartilages, so named from their resemblance to an ancient ewer (ἀρύταινα), are situated, one on each side, at the upper part of the cricoid (fig. 3). Each is somewhat pyramidal in form, with the apex above, looking towards its fellow, and slightly curved backwards. The apex of each is generally surrounded by one or two nodules of cartilage, termed the "cartilages of Santorini" or "cornicula laryngis." The base presents an oval concave surface, which forms a perfect joint, with a corresponding convex surface on the cricoid cartilage. This joint has a loose synovial membrane and ligaments, so that the arytenoid cartilages admit of being approximated or separated, a freedom of motion which is essential to the dilatation and contraction of the glottis or chink between the true vocal cords through which the air enters the trachæa.

At the base of each arytenoid cartilage observe the *anterior* tubercle to which the true vocal cord is attached, and the *posterior* tubercle, which gives insertion to two muscles, namely, the crico-arytenoideus lateralis and the crico-arytenoideus posticus: more especially, notice that these muscles are inserted, not into the same side, but into *opposite* sides of the tubercle; the effect of which is that they antagonise each other.

Each arytenoid cartilage has three surfaces — a posterior, an anterior or external, and an internal. The posterior surface is excavated for the attachment of the arytenoideus muscle (fig. 3), which crosses from one cartilage to the other, and fills up the gap between them. The anterior surface is also excavated, and completely occupied by the insertions of the crico-arytenoideus lateralis and the thyro-arytenoideus muscles. The internal surface is flat, looks towards its fellow of the opposite side, and contributes to form part of the margin of the glottis.

Vocal cords, true and false.

The vocal cords are four elastic ligaments, two on each side, extending horizontally backwards from the angle of the thyroid cartilage to the anterior part of the arytenoid. The two lower are by far the most important, and are termed the "true" vocal cords, because, by their vibration, they produce the voice: the two upper cords are called "false," because they have little or nothing to do with the voice. The precise attachments of these cords are best seen in the dried larynx, in which all the surrounding soft parts have been removed, as shown in Plate XLVIII. *a*, fig. 2. You observe that the true vocal cords are attached in front close together to the angle of the thyroid cartilage, about a quarter of an inch from its lower edge, and that they diverge as they pass backwards to be attached to the anterior tubercle of the base of the arytenoid. The false cords also proceed from the angle of the thyroid a little higher than the true, to about the middle of the front part of the arytenoid. We must not suppose that in the recent larynx these cords are free all round, like the strings of a violin; they are only free along the sides which face each other; everywhere else the true cords are in contact with muscle, and the false with fat and cellular tissue.

What is the length of the true vocal cords? During life, their length is continually varying, to a slight degree, with the pitch of the voice; but, in the dead subject, we may say that they are about five-eighths of an inch in the adult male. In the several male larynges which I have before me, the cords differ more or less from each other in point of length, though not more than one twelfth of an inch. These individual differences in the length of the cords make corresponding variations in the natural tone of the voice: *e. g.* tenor, barytone, or bass. A deep voice coincides with the longer cords, and a shrill voice with the shorter. In the female the cords are about one fourth shorter than in the male. In boys, too, they are much shorter than in the adult; hence the peculiar voice of boys. At the age of puberty the cords lengthen with the development of the larynx, and the voice is said to break.

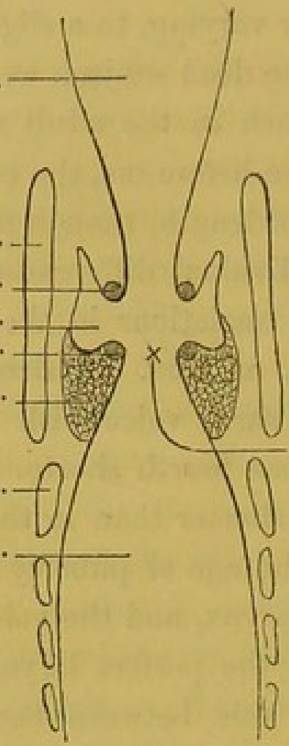
Ventricles of the larynx.

In the perfect larynx there is a little recess on each side between the true and the false vocal cords, like a little side pocket. These recesses are called the "ventricles" of the larynx, and are best examined by cutting open the larynx. Their shape, depth, and situation is represented in the outline, fig. 47, (on the other side of this leaf) taken from a transverse perpendicular section of the larynx. Their use appears to be, to allow free space for the vibration of the vocal cords, and probably to strengthen the voice. They are lined by the mucous membrane of the larynx, and the bottom of each is supported by the thyro-arytenoideus muscle. The length of the ventricles from before backwards corresponds with the length of the vocal cords. Their greatest vertical depth is towards the front, which is the part represented in the section.

The ventricles of the larynx are quite large enough to lodge a foreign body, such as a pea; and when an accident of this kind takes place, there is no rest for the patient until he dies, or the foreign substance is got rid of. A pill forced down a child's throat against its will has been known to catch in one of the ventricles, and occasion death, after a few struggles, from spasm of the glottis.

RIMA GLOTTIDIS. The term "rima glottidis" or "glottis" is applied to the interval or chink between the true vocal

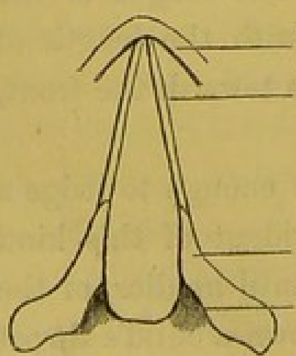
FIG. 47.



Section showing the ventricles of the larynx.

cords through which the air passes into and out of the trachæa. It is about one inch in length. Its boundaries (fig. 48) are formed by the vocal cords and by the arytenoid cartilages. The vocal cords form about the anterior two thirds, the cartilages about the posterior third of the opening. The glottis admits of being made wider, or narrower, or may even be hermetically closed by the action of muscles which we shall examine presently. In a state of rest, it is triangular in shape; the apex being in front at the thyroid cartilage, and the base at the cricoid between the arytenoid, as shown in fig. 48, where the ary-

FIG. 48.



Shape of the glottis when at rest.

tenoid are cut through on a level with the vocal cords. But when the glottis is dilated, which it is during every inspiration by the crico-arytenoidei postici, it then becomes spear-shaped as seen in fig. 50. During expiration the glottis gradually resumes its triangular shape or state of rest; and this return to a state of repose is effected not by muscle, observe, but by an elastic ligament shown in fig. 50, which draws the arytenoid cartilages towards the mesial line. We cannot but admire this beautiful provision. The glottis, like the chest, is dilated during inspiration by muscular tissue; like the chest, also, it is contracted during expiration by elastic tissue.

MUSCLES of the larynx.

There are nine muscles to act specially upon the rima glottidis—four on each side, and one in the middle. The four on each side are the crico-thyroidei, the crico-arytenoidei postici, the crico-arytenoidei laterales, and the thyro-arytenoidei. The single one in the middle is the arytenoideus. These we must now separately examine.

CRICO-THYROID muscles.

Each crico-thyroid is a short and strong muscle. It arises from the side of the cricoid cartilage, and is inserted into the lower border of the thyroid, including the lesser cornu. Its action is to stretch the vocal cords. It does this by depressing the thyroid cartilage. But the thyroid cannot be depressed without increasing the distance between the attachments of the vocal cords, as shown by the dotted line in the cut, fig. 49.

FIG. 49.

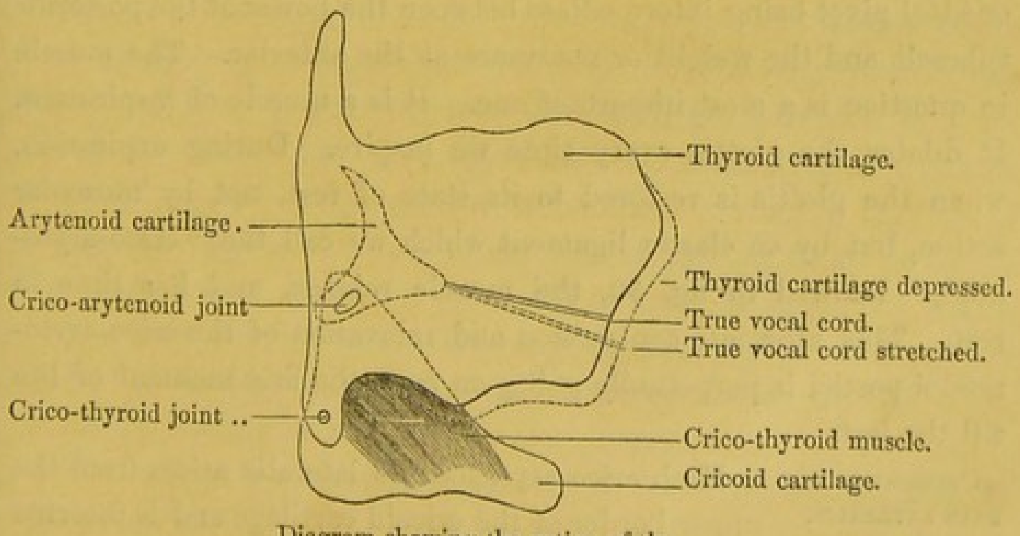
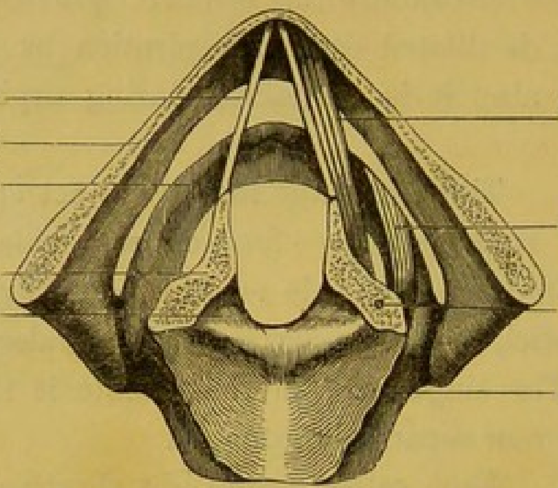


Diagram showing the action of the crico-thyroid muscle.

Consequently the crico-thyroid muscles, when in action must elongate the vocal cords..

CRICO-ARYTENOIDEI POSTICI. Each crico-arytenoideus posticus arises from the posterior part of the cricoid cartilage, and is inserted into the posterior tubercle of the arytenoid. The muscle is seen in action denoted by a wavy line in fig. 50. Its action is to dilate the

FIG. 50.

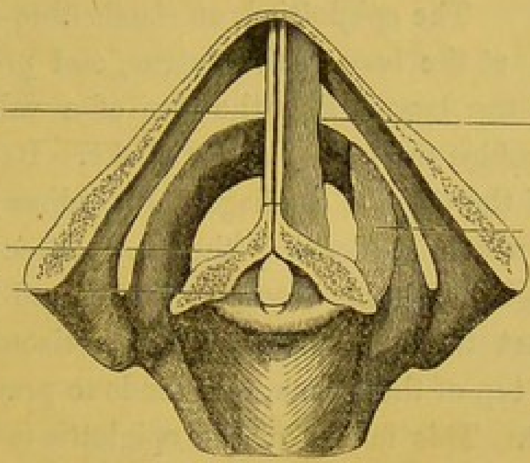


Glottis dilated. Muscles dilating it represented wavy.

glottis. It does this by drawing the *posterior* tubercle of the arytenoid *towards* the mesial line, and therefore the *anterior* tubercle *from* the mesial line. In this movement the arytenoid cartilage rotates upon the cricoid as it were upon a pivot. Moreover, the arytenoid cartilage is a lever of the first order; the fulcrum or ideal pivot being intermediate between the power at the posterior tubercle and the weight or resistance at the anterior. The muscle in question is a most important one. It is a muscle of inspiration. It dilates the glottis every time we inspire. During expiration, when the glottis is restored to its state of rest, not by muscular action, but by an elastic ligament which we call the "crico-arytenoid," marked in fig. 50, the muscle relaxes, and has time to rest. This alternate contraction and relaxation of the crico-arytenoidei postici is perpetually going on from the first moment of life till the last.

CRICO-ARYTENOIDEUS LATERALIS. Each crico-arytenoideus lateralis arises from the upper border of the cricoid cartilage and is inserted into the posterior tubercle of the arytenoid. Its action is to assist in closing the glottis as seen in the cut, fig. 51. It does this by

Fig. 51.



Glottis closed. Muscles closing it represented wavy.

rotating the arytenoid cartilage in a way directly the reverse of the muscle last examined.

Arytenoideus. The arytenoideus muscle arises from the back of one arytenoid cartilage, and is inserted into the back of the other. Plate XLVIII. fig. 3. Its action obviously is to clasp the two cartilages together, and therefore to assist very materially in closing the glottis.

Thyro-arytenoidei. Each of these muscles arises from the angle of the thyroid and is inserted into the front surface of the base of the arytenoid. Their action is to relax the vocal cords, since they tend to draw together the cartilages to which they are attached. More than this, they assist in narrowing the glottis. But their special action appears to be that of bringing the lips of the glottis parallel to each other; that of placing them in fact in the "vocalising" position. The glottis must be made not only a very narrow chink, but its lips must be brought parallel to each other, before they can be made to vibrate by the stream of the air, in such a manner as to produce voice or song.

We subjoin a tabular arrangement of the action of the muscles of the larynx.

Antagonists	Crico-thyroidei	stretch the vocal cords	govern the pitch of the notes.
	Thyro-arytenoidei	relax the vocal cords	
Antagonists	Crico-arytenoidei postici	open the glottis ...	govern the opening of the glottis.
	Crico-arytenoidei laterales Arytenoideus	close the glottis ...	

EPIGLOTTIS.

The epiglottis is an elastic fibro-cartilage situated at the base of the tongue, and projecting over the upper part of the larynx like the flap of a valve. In shape it somewhat resembles the leaf of an artichoke. Its apex is attached to the angle of the thyroid cartilage. Its ordinary position is perpendicular, or nearly so, leaving the glottis free for respiration; but during deglutition the larynx is raised, and the tongue is depressed, so that the epiglottis becomes horizontal, drops like a valve over the top of the larynx, and tends to prevent the entrance of food into it. This falling of the epiglottis is not produced by any special muscle; it is simply mechanical.

THE ANATOMY OF THE EAR.

In describing the anatomy of this intricate and delicate organ, we propose to give first a general outline of its structure, and afterwards to go into the details of its several parts.

General idea of the subject.

In order to communicate a general idea of the organ of hearing, we have made the diagram, fig. 1, Plate XLVIII. A. Referring to this diagram, we recognise the fibro-cartilage termed the "pinna" of the ear, which collects the sonorous undulations of the air, and transmits them down the passage called the "meatus auditorius externus." This passage, which is about one inch long, a little contracted in the middle, and slightly curved, with the concavity downwards, is closed at the bottom by a fibrous membrane (membrana tympani), fixed in a groove in the bone, placed obliquely, and stretched, in all respects, like the parchment of a drum, except that its outer surface is a little concave. On the other side of this membrane is a small chamber in the substance of the temporal bone, termed the "tympanum," or middle ear. This chamber is filled with air, which is admitted through a tube (Eustachian tube) about an inch and a half long, leading from the back part of the nostrils into the front part of the tympanum. Thus, there is an equilibrium of air on both sides the membrana tympani. The Eustachian tube probably performs the same office for the ear as the hole which is made in the side of a drum for the necessary purpose of opening a communication with the external air. Opposite to the Eustachian tube, that is, at the back part of the tympanum, are the irregular openings of the mastoid cells, which also contain air. All these air cavities are lined by a continuation of the same mucous membrane which lines the passages of the nose. This explains the degree of deafness which is often produced by a common cold, or other disease of the throat, the Eustachian tube being temporarily obstructed by the swelling of its lining membrane.

In the tympanum itself we find four little bones, called by names more descriptive of their shape than their office—" malleus," " incus," " os orbiculare," and " stapes." These bones are connected by perfect joints, so as to form a continuous chain, surrounded by atmospheric air, across the cavity of the tympanum, and the mucous membrane is reflected over them. The handle of the malleus at one end of the chain is attached to the membrana tympani, and the foot-plate of the stapes at the other end is attached to the membrane closing the " foramen ovale," an opening on the inner wall of the tympanum leading to the vestibule of the internal ear. Both ends of the bony chain, observe, are attached to membranes. Moreover, little muscles (laxator tympani, tensor tympani, and stapedius) are attached to the bones, in order to slacken or tighten the membranes. Besides the foramen ovale, there is another opening in the inner wall of the tympanum, called the " foramen rotundum." It leads into the cochlea, and is also closed by membrane. So much for the tympanum.

The internal ear, often called, on account of its intricacy, the " labyrinth," consists of the vestibule, the three semicircular canals, and the cochlea. All these parts are imbedded in the petrous portion of the temporal bone, like passages cut out of a solid rock. Hence the great difficulty of exploring them. Bear in mind their relative position. The vestibule is in the middle, the canals are behind, and the cochlea is in front. This little chamber is very properly called the vestibule, because it communicates with all the other parts. You notice that it communicates, behind, with the five openings of the semicircular canals, in front, with the cochlea, on the outer side with the tympanum through the foramen ovale (occupied by the stapes), and on the inner side with the meatus auditorius internus, through which the auditory nerve enters the ear.

The cochlea is an exceedingly curious structure, in its outward form very like a snail's shell. It is placed so that the base of the shell corresponds to the bottom of the meatus auditorius internus, while the apex points forwards and outwards towards the Eustachian tube. It is formed by the spiral convolutions of two gradually tapering tubes, or rather, by one tube separated into two compartments by a longitudinal septum (lamina spiralis), composed partly of thin bone, but chiefly of membrane (in the diagram the course of the septum is indicated by a dotted outline). This septum is the most important part of the cochlea, because the auditory nerve expands upon it. It runs all through the tube except at the apex, where it suddenly terminates in a curved hook, and leaves an aperture (helicotrema), so that the two portions of the tube may communicate. One portion of the tube (scala vestibuli) opens into the vestibule; the other portion (scala tympani) leads into the tympanum through the foramen rotundum. This foramen, observe, is open only in the dry bone; in the recent state it is closed by a membrane (membrana tympani secundaria), which therefore has the air of the tympanum on the one side and the water of the cochlea on the other. The central pillar of the cochlea, round which the tube makes about three turns, is called the "modiolus" or "axis."

The semi-circular canals are three in number, and called, from their position, superior, posterior, and external. They are placed, we know not why, in planes at right angles to each other like the faces of a cube. Each canal forms the greater part of a circle, and opens at each end into the vestibule. There should therefore be six openings; but there are only five, since two of the canals have an opening in common. Each canal has a dilatation at one end, termed the "ampulla," and the reason of this is to make room for a corresponding dilatation of the membranous canal within it upon which the auditory nerve expands. The ampulla, therefore, is the most important part of each canal.

Next comes the question, what is the purpose of all these curious and elaborate excavations in the petrous bone? The answer is, to form receptacles of water in which may float the delicate membrane destined to receive the terminal filaments of the auditory nerve. This membrane, as may be well conceived, is the very essence of the organ of hearing. It is to the ear what the retina is to the eye. Its arrangement is at once simple and interesting. In the vestibule and semi-circular canals it forms a continuous but closed sac, which copies pretty accurately the shape of these cavities, without being in contact with their bony walls. The sac, with its tubular prolongations into the canals, is termed the "membranous labyrinth." It is bathed within and without by fluid. The fluid within is called the "endo-lymph," that without, the "peri-lymph." In the cochlea there is also a membrane, but quite differently arranged. Here it forms the larger part of the "lamina spiralis," which divides the tube into its two compartments. Though not a closed sac, still this membrane in the cochlea answers a similar purpose to that in the vestibule; namely, it provides a stratum of membrane immersed in fluid for the reception of the auditory nerve.

The auditory nerve enters the ear through the meatus auditorius internus. At the bottom of this passage are a multitude of small pores, which transmit the minute subdivisions of the nerve to their respective destinations. Some are distributed upon the sac in the vestibule, some upon the dilatations (ampullæ) of the membranous semi-circular canals; others run down the axis of the cochlea and spread out upon the membranous part of its lamina spiralis.

Now for the explanation, usually received, of the function of these several parts. The waves of sound, collected by the cartilage of the ear, pass down the external auditory passage, strike upon the membrana tympani, and cause it to vibrate. These vibrations are carried by the little bones across the tympanum to the membrane which closes the foramen ovale, or opening into the vestibule. This membrane, thus thrown into vibration, communicates motion to the water in the labyrinth; the filaments of the auditory nerve receive the impression and transmit the sensation of sound to the brain. The vibrations of the membrana tympani no doubt excite corresponding vibrations in the air within the cavity of the tympanum, which again communicates them to the membrane closing the foramen rotundum, and through this they reach the cochlea. Here we have a ready explanation of the use of the foramen rotundum and the membrane closing it: that is, we have, interposed between air and water, a tense membrane, which is the very best medium for transmitting, with increased intensity, vibrations from one to the other.

Having thus given a comprehensive sketch of the anatomy of the ear, we proceed now to a more minute description of its component parts. It is, of course, taken for granted that the learner is already familiar with the anatomy of the temporal bone described at page 64.

MEATUS AUDITORIUS EXTERNUS. This passage leads to the membrana tympani. Its outer third is formed by a tubular continuation of the cartilage of the ear; its inner two thirds by the osseous canal in the temporal bone. The cartilaginous part is united by fibrous membrane to the rough margin of the processus auditorius. The cartilage, however, does not form a complete tube of itself; there is a slight deficiency at the upper part, completed by fibrous membrane. There are also one or two vertical fissures in the cartilage. The object of those breaks in the cartilage is to give greater freedom of motion; but they are interesting practically, as explaining why collections of matter in the neighbourhood of the ear sometimes make their way into the meatus auditorius.

The length of the meatus, measured from the middle of its external orifice to the middle of the membrana tympani, is about one inch and two or three lines. The anterior wall is about one fourth of an inch longer than the posterior, in consequence of the oblique direction of the membrana tympani.

The direction of the meatus is inwards and forwards. It de-

Fig. 1.

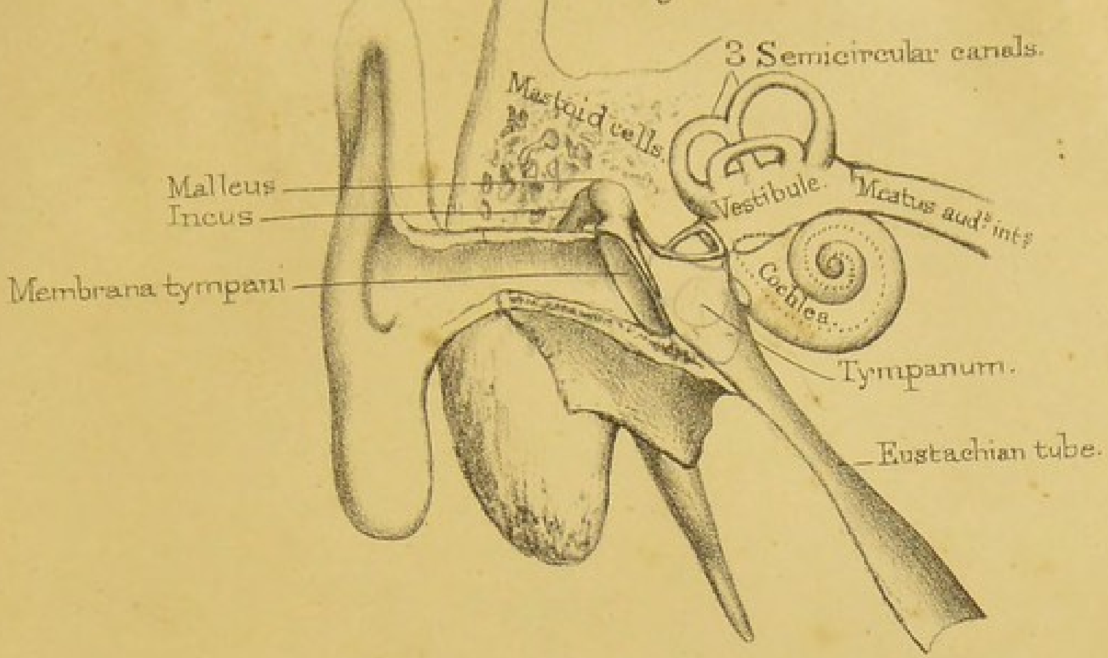
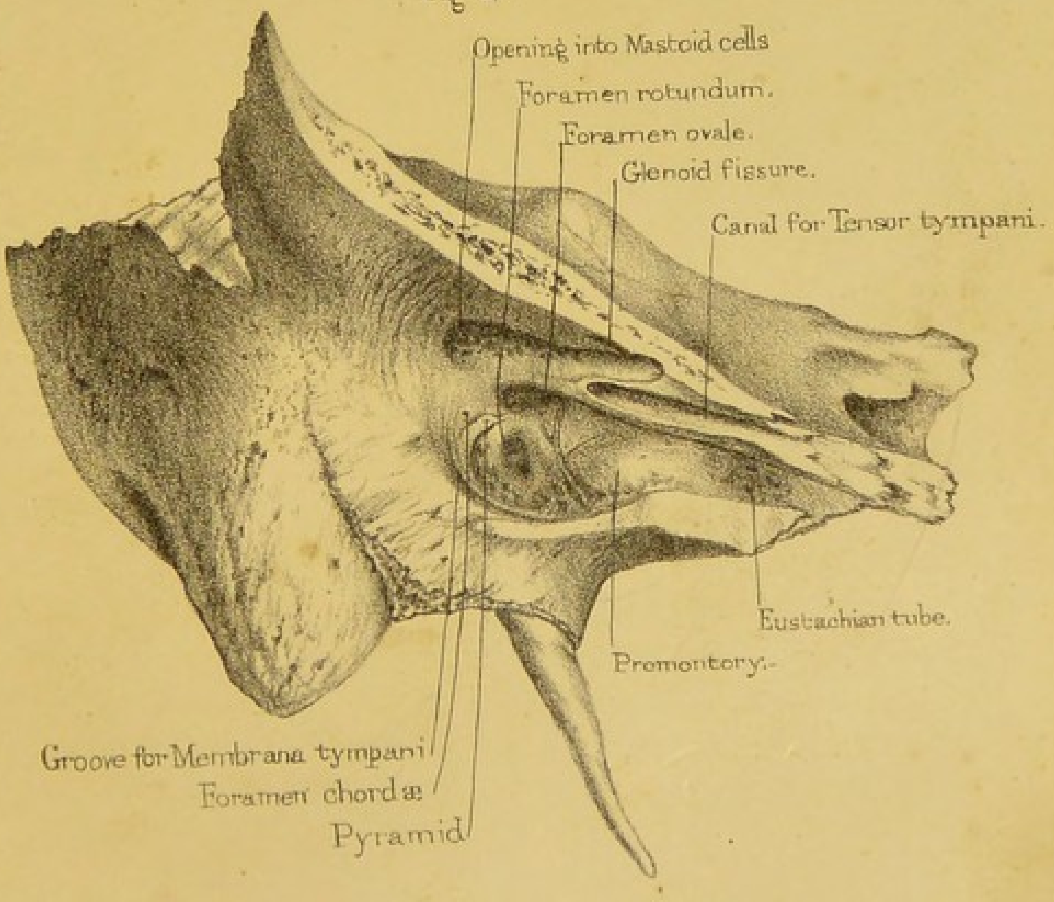


Diagram of the Ear.

Fig. 2.



L. Holden, ad nat. del.

Fig. 1.

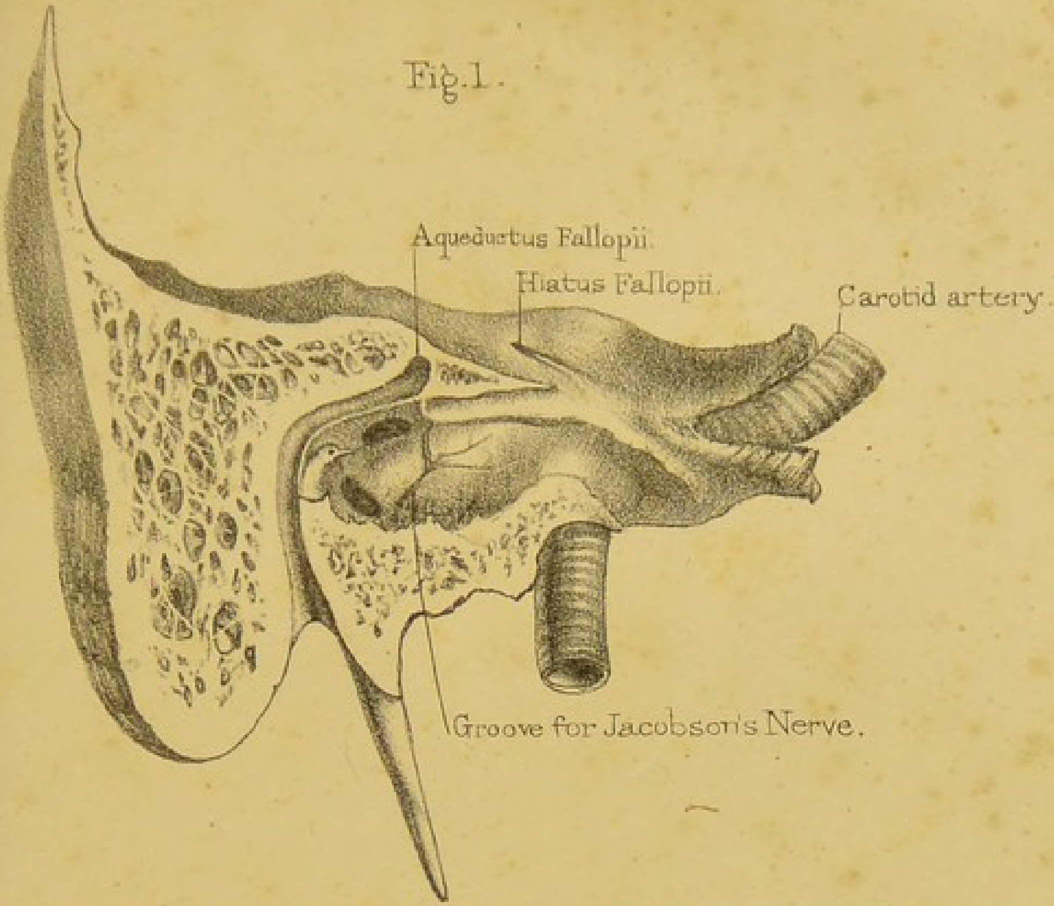
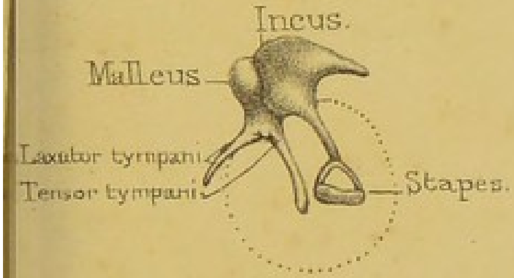
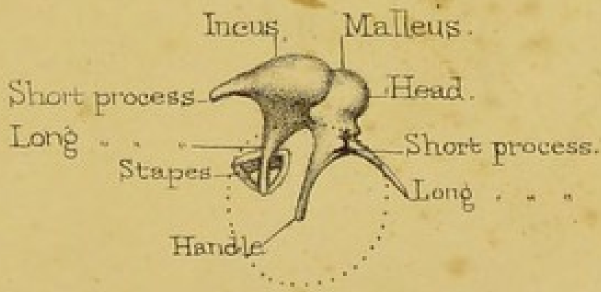


Fig. 2



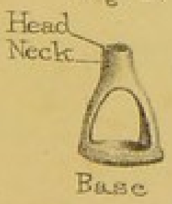
Inner view.

Fig. 3.



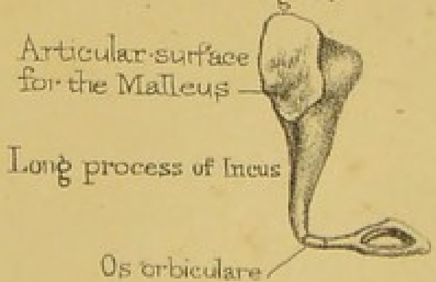
Outer view.

Fig. 4.



Stapes.

Fig. 5.



scribes a slight curve with the concavity downwards. Besides this general curve, the cartilaginous part is slightly curved with the concavity forwards, and the osseous part with the concavity backwards. Altogether, the meatus has such a curious shape that it cannot be well understood without looking at a cast of it. Of many which I have before me, no two are precisely similar in shape. Every surgeon knows how difficult it is to see the whole of the membrane of the tympanum at one view: one can seldom see more than a part of it, however much the ear be dilated and pulled so as to straighten the outer curve. The narrowest part of the meatus is about the middle. Beyond this point we ought not to introduce the speculum.

Insects sometimes find their way down the meatus and cause intense pain. I will adduce an instance related by Wilde*, if only to show how to dislodge them: "I remember being out shooting with a friend, who, suddenly exclaiming 'Oh, an earwig!' and throwing aside his gun, fell on the ground, making the most piteous groans, and rolling about in agony. Suspecting that some insect had got into his ear, I procured some water from a ditch, and poured it into the meatus. While watching the result, a little animal, well known among anglers as the hawthorn fly, crept out, and my friend was instantly relieved."

MEMBRANA TYMPANI. The membrana tympani is a thin, semi-transparent, fibrous membrane, of a greyish colour, placed very obliquely at the bottom of the meatus auditorius externus. Its direction is downwards, forwards, and inwards. The reason of this obliquity would seem to be to increase the extent of its surface; so that every wave of sound reflected down the meatus must fall upon it. Observation has shown that the perfection of the sense of hearing in mammals and birds bears a direct ratio to the obliquity and extent of this membrane. Its circumference, which is pretty nearly circular, is fixed into a groove in the bone so fine that it might have been traced with the point of a needle (Plate XLVIII. A, fig. 2). This groove, however, does not form a complete circle: it is deficient at the upper part, where the membrana tympani is, more obviously than elsewhere, continuous with

* Aural Surgery, p. 178.

the skin lining the meatus. Those who are familiar with the development of the temporal bone will remember that the bony ring for the tympanum (tympanic ring) is an independent element of the bone, produced from a separate point of ossification, and that it remains for some time distinct in the fœtus. From this ring the meatus auditorius grows externally, and a portion of the floor of the tympanum internally.

The membrana tympani is not quite flat like the parchment of a drum, but slightly conical with the apex towards the tympanum. This shape seems given to it by the handle of the malleus, which draws the membrane a little inwards. The handle of this bone can be seen through the membrane in the living subject, like a thin white streak, which is not quite vertical, but inclines slightly backwards.

I have many times found a hole in the membrane, and in cases where there has been, during life, no defect of hearing. This sufficiently explains why some persons can blow the smoke of tobacco through the ear as well as through the nose.

Thin as it is, the membrana tympani is very strong. It has three strata: an outer stratum, of cuticle; a middle, fibrous, upon which the strength of its texture chiefly depends; and an internal, mucous. The middle stratum is composed of fibres, radiating and circular, but no longer considered muscular. It is this coat which is fixed into the bony groove, and contains in its very substance the handle of the malleus. The dermal stratum is composed almost entirely of cuticle, continuous with that lining the meatus auditorius. The mucous lining is continuous with the lining of the tympanum. The membrane is well supplied with blood by arteries derived from the stylo-mastoid and the internal maxillary.

TYMPANUM or middle ear.

We need not repeat what has been said already about the tympanum, but pass on to examine what is to be seen on its several aspects. We describe, therefore, its external aspect, its internal, its anterior and posterior, its superior and its inferior.

External aspect.

On the outer aspect of the tympanum there is the bottom of the meatus auditorius, closed by the membrana tympani.

Internal aspect. On the inner aspect of the tympanum (Plate XLVIII. A, fig. 2) we see,—1. The "foramen ovale" leading to the vestibule: this is open in the dry bone, but closed in the recent state by a membrane to which is attached the base of the stapes. 2. The foramen rotundum: this in the recent state is also closed by membrane (membrana tympani secundaria), in the dry bone it leads to the tympanic scale of the cochlea.* 3. The promontory: this is nothing more than the bulging of the first turn of the cochlea; its surface is marked by grooves for the ramifications of Jacobson's nerve.

Anterior aspect. On the anterior aspect of the tympanum we have, 1. The bony canal for the tensor tympani† (in the drawing, this canal is cut open). 2. The Eustachian tube. 3. The orifice of the glenoid fissure which transmits the laxator tympani and the corda tympani nerve.‡

Posterior aspect. On the posterior aspect of the tympanum, we have,—1. The opening into the mastoid cells. 2. The pyramid—a small projection containing a minute canal, about the size of a bristle, for the lodgment of the stapedius muscle.§ The pyramid is always supported by a minute bony column, which extends like a flying buttress from its apex to the promontory. 3. The foramen cordæ. This minute foramen is a little below the level of the pyramid, and close to the groove for the attachment of the membrana tympani. Introduce a bristle into it, and you will find that it leads into the aqueductus Fallopii. It transmits the corda tympani nerve. Now this nerve is a branch of the facial (which, remember, is contained in the aqueductus Fallopii: see Plate XLVIII. C, fig. 4). It comes up through the foramen cordæ,

* Strictly speaking, the foramen rotundum, *in the dry bone*, leads into the vestibule as well as into the cochlea.

† Just before its termination in front of the foramen ovale, the bony canal of the tensor tympani makes a sudden curve outwards in order to form a little pulley for the tendon of the muscle within. In most bones, this part of the canal is broken, and has the appearance of a little spoon — unde nomen, "processus cochleariformis."

‡ In five times out of six the corda tympani runs through a little canal of its own, close to and a little above the glenoid fissure: but this canal is of no practical moment, and hardly deserves a new name.

§ At the base of the pyramid (but within it) are two minute canals which transmit, the one an artery, the other a nerve, to the stapedius.

runs, not across the tympanum, but across the membrana tympani, outside the mucous membrane, between the handle of the malleus, and the long process of the incus; it leaves the membrane through the glenoid fissure (or, rather, through a distinct canal of its own), and, joining the gustatory, eventually goes to the submaxillary ganglion.

Superior aspect. On the superior aspect of the tympanum is a thin plate of bone which separates the cavity of the tympanum from that of the cranium. This is an important relation. Ulceration commencing in the cavity sometimes destroys this thin plate of bone, and occasions death by involving the dura mater and the brain.

Inferior aspect. The inferior aspect, or floor of the tympanum, is formed by the jugular fossa, which lodges the jugular vein. A little in front of this fossa is the canal for the carotid artery, which is separated from the tympanum only by a thin scale of bone. The vicinity of these great vessels explains the sudden and profuse hemorrhage which sometimes (though, happily, rarely) occurs from the ear when diseased. Professor Porter saw blood gush from the ear with a rapidity such as he never witnessed in a surgical operation.* Ulceration had extended into the carotid artery.

In another case of sudden and profuse bleeding from the ear, Mr. Syme tied the carotid artery.† The patient died. Dissection discovered that the blood came from the lateral sinus, near the jugular fossa, the thin bony septum between which and the tympanum had been destroyed by ulceration. Looking at the proximity of these large vessels, we cannot wonder that bleeding from the ear, after injury to the head, makes one suspect the existence of a fracture through the tympanum.

In the floor of the tympanum there are a number of minute holes, among which we specially note *one* as the upper opening of the canal for Jacobson's nerve. The lower opening of the canal is, you remember, at the base of the skull on the little crest of bone

* Graves's Clinical Medicine, Vol. I.

† Edinburgh Monthly Journal, No. III. A case is recorded in the Edinb. Med. and Surg. Journal, No. CXV. p. 319, in which Mr. Syme tied the carotid for hemorrhage from the ear. The patient recovered.

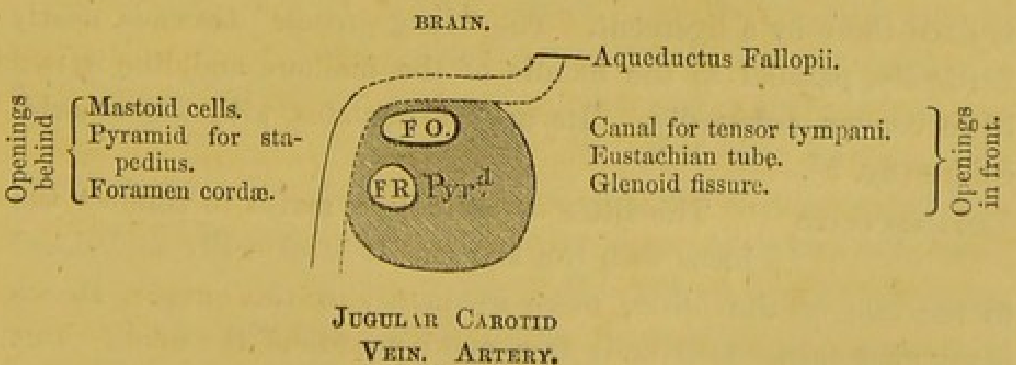
which separates the jugular fossa from the carotid canal. The nerve in question is a branch of the glosso-pharyngeal. It enters the tympanum, and ramifies upon the promontory, forming what is called the tympanic plexus. It supplies the mucous membrane of the tympanum. Its principal branches (which I need not mention here) are generally indicated by grooves made for their passage on the promontory. In a preparation where there appeared to be neither groove nor nerve, I subsequently found the nerve lodged in a complete bony canal within the promontory.

Aqueductus Fallopii.

We must not leave the tympanum without noticing the aqueductus Fallopii, or canal for the facial nerve which supplies all the muscles of expression. (Plate XLVIII. B, fig. 1.) Commencing at the bottom of the meatus auditorius internus, it runs for a short distance outwards, then turns horizontally backwards along the inner wall of the tympanum, just above the foramen ovale, and lastly, descending behind the tympanum, emerges at the stylo-mastoid foramen. Its course suggests how liable the nerve is to be injured in fracture through the temporal bone, or in disease of the ear. While in this canal the nerve sends off three important branches, all to ganglia. These I have endeavoured to show in Plate XLVIII. C, fig. 4. The first branch, the vidian, runs down the hiatus Fallopii to the spheno-palatine ganglion; the second, or lesser petrosal, goes to the otic ganglion; the third, or corda tympani, runs with the gustatory nerve to the submaxillary ganglion.

To assist the memory, I have arranged the objects seen on the inner wall of the tympanum in the following tabular form:—

FIG. 52.



Little bones in the Tympanum. The four little bones in the tympanum are drawn, larger than natural, but in their proper relative position, in Plate XLVIII. B, figs. 2, 3, 4, and 5. In fig. 3, you are supposed to be looking at them from the meatus auditorius; in fig. 2, from the inside of the tympanum. The dotted line in each figure is intended to represent the outline of the membrana tympani.

Malleus. The malleus, or hammer, presents a head, neck, and handle. The "head" is the large round part above the membrana tympani. It articulates posteriorly with the incus, by means of a concavo-convex joint, crusted with cartilage, and provided with synovial membrane. The "neck" is the narrow part which supports the head. From the front of the neck springs the "long process" (processus gracilis) which runs down the glenoid fissure, and gives insertion to the "laxator tympani." It is generally broken in removing the bones: sometimes it is only ligamentous. The handle descends nearly perpendicularly from the neck, making with it an obtuse angle, which projects externally, and presses against the upper part of the membrana tympani. This angle is generally described as the "short process." Below it, the handle descends obliquely backwards, and ends in a slightly curved extremity (with convexity outwards), a little below the centre of the membrane. On the inner side of the handle, and below the processus gracilis, is inserted the tensor tympani.

Incus. The incus, or anvil, lies behind the malleus. It has a body, a short, and a long process. The body is convex, placed above the membrana tympani, and has a concavo-convex surface, which articulates with the head of the malleus. The "short process" extends horizontally backwards into the mastoid cells, and is fixed there by a ligament. The "long process" descends nearly vertically, parallel to the handle of the malleus, and, like it, is a little convex outwardly. Its apex articulates with the os orbiculare (fig. 5).

Os Orbiculare. The little os orbiculare serves to connect the incus with the stapes. It is generally anchylosed to the one or the other, more frequently to the incus. Hence many anatomists describe it as a mere process of the incus. But to this opinion it may be objected, that in the fœtus there are two distinct little joints, each provided with a separate synovial membrane, one for the incus, the other for the stapes.

STAPES. The stapes, or stirrup, is placed horizontally, with the base in the foramen ovale. It has a head, neck, two branches, and a base or foot plate. The head articulates by a concave surface with the orbicular bone. The neck gives attachment behind to the stapedius (Plate XLVIII. C, fig. 2). The anterior branch is generally shorter and less curved than the posterior; both are grooved, probably for lightness' sake, on their concave sides, and the interval is closed by mucous membrane. The "base" is attached to the membrane closing the foramen ovale, and is similar in form. It is moreover firmly attached to the margin of the foramen by an elastic annular ligament, which allows the base to have a little motion.

Of the four bones, the stapes is the most essential to hearing. Disease may destroy the others, and still the patient may hear; but when the stapes falls out, the fluid in the vestibule escapes, and inevitable deafness results.

All the bones in the tympanum are ossified at birth. More than this, they are well developed at birth. I have before me the tympanic bones of an infant at birth, and those of a man who was seven feet high, and there is not much difference between them in point of size.

Little muscles moving the bones in the tympanum. There are certainly three muscles to move the bones in the tympanum, namely, the tensor tympani, laxator tympani, and stapedius. (Plate XLVIII. C, Figs. 1, 2.) The laxator tympani externus is doubtful.

Tensor tympani. The "tensor tympani" is a well marked muscle. It arises from the apex of the petrous bone, and from the cartilage of the Eustachian tube, and is inserted into the handle of the malleus, just below the processus gracilis. The muscle is lodged in the bony canal running above and parallel with the Eustachian tube; and when its tendon reaches the end of the canal, which forms a kind of elbow, it is reflected at a right angle to reach its insertion. From origin to insertion the muscle is enclosed in a strong fibrous sheath. The tendon slides within the

Laxator tympani.

sheath, and has a synovial membrane. The "laxator tympani" arises from the spine of the sphenoid bone, runs up the glenoid fissure and is inserted into the processus gracilis of the malleus. Like the last it is surrounded by a sheath. I have sometimes failed in finding this muscle. The

Stapedius.

"stapedius" arises in the canal of the pyramid. Its little tendon coming out of the canal at the apex, is reflected outwards and inserted into the posterior part of the neck of the stapes. Anatomists are not agreed about the precise use of the stapedius. One of its actions would appear to be, to tilt the stapes backwards, and thus diminish the pressure upon the fluid in the vestibule.

So much for the tympanum and it contents. Let us now pass on to the internal ear or labyrinth, comprising the vestibule, semicircular canals, and cochlea. And first of the vestibule, which we enter through the foramen ovale.

VESTIBULE.

The vestibule is of an oval form with the larger end upwards, and the long diameter nearly vertical. In a well formed adult temporal bone which I have before me, it measures about $\frac{4}{16}$ of an inch in the long diameter, and $\frac{3}{16}$ in the short. Posteriorly, it receives the five openings of the semicircular canals and the opening of the aqueductus vestibuli; anteriorly, and at its lower part, is the opening into the vestibular scale of the cochlea; on its external wall is the foramen ovale. In all, then, there are eight openings into the vestibule. The internal wall of the vestibule corresponds with a part of the bottom of the meatus auditorius internus. Looking attentively at this inner wall, as shown in Plate XLVIII. D, fig. 3, we observe two slight depressions separated by a bony ridge: the upper of the two, is for the utricle, the lower is for the saccule. Utricle and saccule, as we shall presently explain, are distinct parts of the membranous labyrinth. These depressions (fossæ), as well as the intervening ridge, are riddled with minute foramina, only visible with a lens, through which the filaments of the auditory nerve enter the vestibule. We have attempted to represent the vestibule and its eight openings in the annexed diagram, fig. 53.

SEMICIRCULAR CANALS.

The three semicircular canals are distinguished according to their position, into the superior ver

Fig. 1.

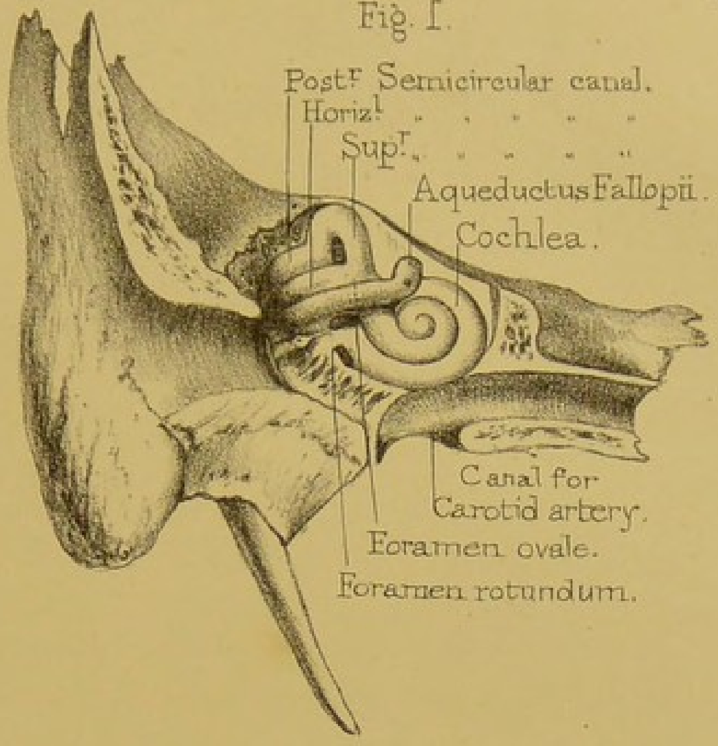
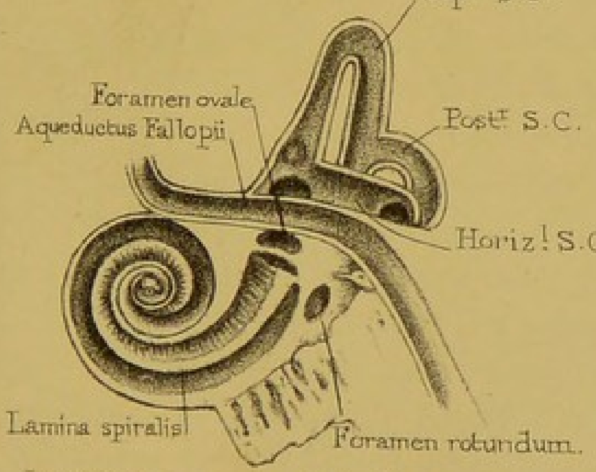
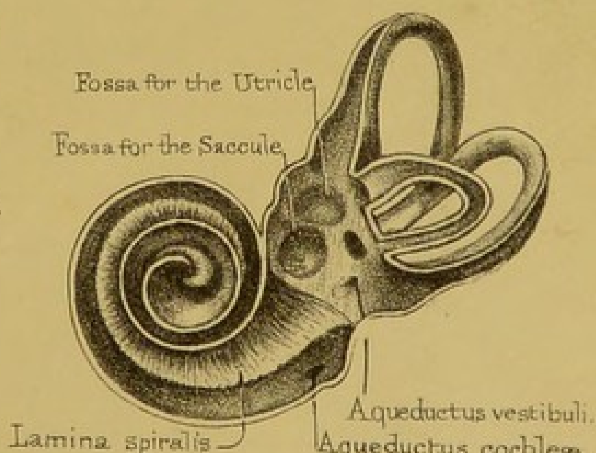


Fig. 2.



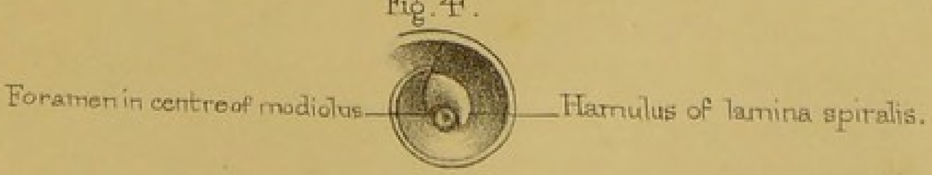
Semicircular canals and Cochlea cut open.

Fig. 3.



Vestibule opened to show its inner wall.

Fig. 4.



Apex of Cochlea.

T. Godart lith.

tical, posterior vertical, and external or horizontal. The superior vertical canal crosses the petrous bone at right angles, and stands

Fig. 53.

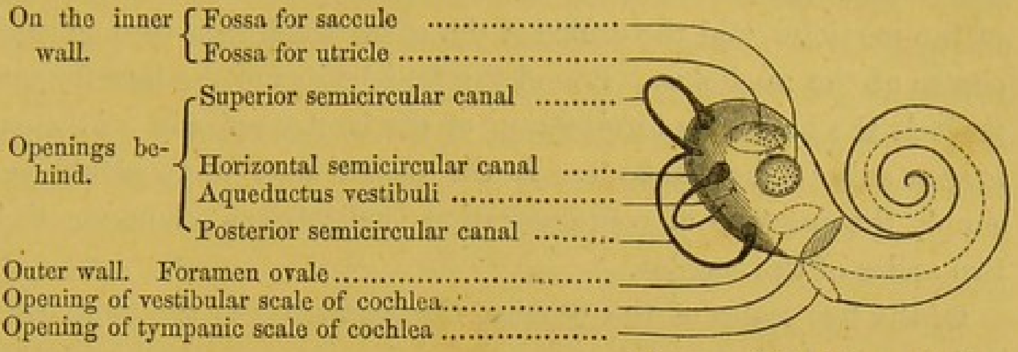


Diagram of the right vestibule, and the openings into it.

out in relief on its anterior surface. Its ampulla is at the outer orifice. The posterior vertical canal is the longest of the three. It runs parallel with the posterior surface of the petrous bone, and makes a little relief just above the aqueductus vestibuli. Its ampulla is at the lower orifice: its upper orifice joins the narrow end of the superior canal. The horizontal canal is the smallest of the three; its ampulla is at the outer orifice.

Cochlea. The cochlea is placed so that its base is at the bottom of the meatus auditorius internus, ready to receive the auditory nerve. Its apex is directed forwards and outwards close to the canal for the tensor tympani. It makes three coils which run from left to right in the right ear, and from right to left in the left.* Its first turn bulging into the tympanum makes the "promontory" there. The outer wall of the coil is composed of a lamella of very hard bone (lamina externa), like the semicircular canals: the inner wall is formed by a layer of thin and fragile bone, (lamina modioli) in contact with the axis. Now the axis and the inner wall of the coil do not extend beyond the second turn; the consequence of this is, that the third turn is formed entirely by the external wall. The third turn therefore presents peculiarities; and the best way to examine them is to remove the

* Most authors describe only two turns and a half; but a more careful examination proves that there are three turns.

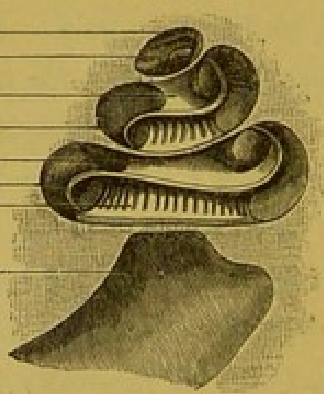
apex (cupola) of the cochlea, as we have done in Plate XLVIII. D, fig. 4.

In this drawing, you observe that the last turn forms a kind of half funnel, (infundibulum). At the apex of the funnel is the end of the modiolus, and the orifice of the canal which runs through the centre of the modiolus. Round the free border of the half funnel projects the hook-like termination of the lamina spiralis. All this is seen only in the dry bone. In the recent state there would be simply the aperture of communication (helicotrema), between the two scales of the cochlea.

Of the two scales of the cochlea the vestibular is the more anterior. At the lower part of the tympanic scale, near the beginning of it, is the minute termination of the "aqueductus cochleæ." (Plate XLVIII. D, fig. 3.)

The lamina spiralis, or partition between the two scales, is the most essential part of the cochlea. It is composed of bone, fibro-cartilage, and membrane, arranged in successive spiral zones round the axis. As each of these is very elaborate in its structure, we must speak of them separately. Let us first point attention to the bony part of the lamina, which is all that we can see in the dry bone fig. 54. It commences at the lower part of the vestibule,

Fig. 54.



Lamina spiralis and the two scales of the cochlea.

immediately above the foramen rotundum (Plate XLVIII. D, fig. 3). From this, which is its broadest part, it gradually diminishes in breadth as it winds round the axis into the apex of the cochlea, and finally terminates like a little hook in the funnel of the last coil. On the concave side of this hook is situated (in the recent state) the aperture of communication (helicotrema) between the two scales. Now, if you examine the lamina spiralis with a lens, you will find that both its surfaces are furrowed by canals which give passage to the nerves before they reach the cartilaginous part of the septum. You will also observe, that it is composed of two very delicate and brittle plates which separate from each other at the axis. On these plates we notice the orifices of the canals just alluded to. In the tympanic scale, these orifices are separated by little columns of bone, which give rise to a fluted appearance, shown in fig. 54. These columns themselves are made up of bundles of little tubes, enclosing the filaments of the auditory nerve.

The fibro-cartilaginous zone of the lamina spiralis comes next to the bony. It is thin and transparent. On its convex or outer edge the cartilage appears to divide into two layers, leaving a little furrow between them, visible only from the vestibular scale. Of these layers, one is directly continuous with the membranous zone. The other projects like a little crest in the vestibular scale, and when examined under the microscope, appears to be armed with a multitude of little points, like so many teeth placed side by side. Hence the cartilaginous layer has been called by some anatomists, "zona dentata." M. Corti *, the last writer on the subject, describes a second row of teeth which run parallel with the first. Their design is still doubtful.

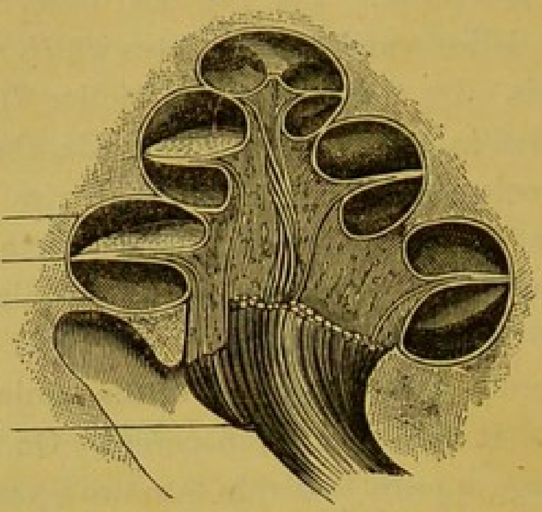
But I will not pursue this part of the subject, because I have not investigated it sufficiently to enable me to judge for myself. As regards, therefore, the membranous part of the lamina spiralis, and the controversy, not yet settled, concerning the ultimate terminations of the auditory nerve, I must refer the reader to Kölliker's "Microscopical Anatomy."

The axis (modiolus) of the cochlea is conical. The base, which we shall examine presently, is at the bottom of the meatus auditorius internus; the apex does not extend beyond the second turn of the cochlea, and joins the funnel formed by the last coil. The

* Recherches sur l'Organe de l'Ouie des Mammifères.

axis is composed of brittle and porous bone, and its interior is traversed by numerous canals which transmit the cochlear nerves to the lamina spiralis. One canal, larger than the rest, runs through the centre of the axis, and opens on its summit, that is, at

FIG. 55.



Section through the axis of the cochlea, to show the filaments of the cochlear nerve.

the apex of the funnel. It transmits a nerve to the last turn of the lamina spiralis.

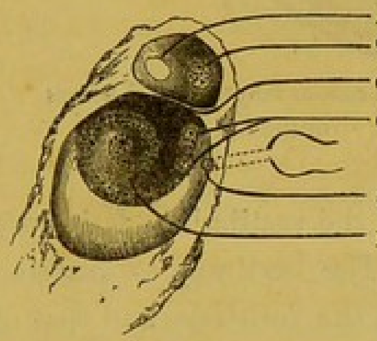
Foramina at the bottom of the meatus auditorius internus.

The meatus auditorius internus is situated on the posterior surface of the petrous bone. Its direction is nearly horizontally outwards; its length, about three-eighths of an inch. Its diameter varies a little in different bones, but is always larger than that of the nerves which it transmits.

The interval between the nerves and their bony canal is occupied by the cerebro-spinal fluid. In fractures through the base of the skull, involving the meatus, this fluid sometimes oozes out through the external ear. Whenever you observe this after an injury to the head, be on your guard. In thirteen cases of injury to the head admitted into St. Bartholomew's Hospital, blood or watery fluid flowed from the ear. Of these thirteen, six died, and in all six the corresponding petrous bone was found fractured. In the seven cases that recovered, five had bleeding from the ear, and two only had a discharge of fluid. So that although a watery discharge be a very unfavourable symptom, it is not necessarily a fatal one.

By cutting away the greater part of the meatus, as we have done in fig. 56., you will find that the bottom of it is divided by a crest of bone into two compartments of unequal size, an upper and a lower. In the upper and smaller one there are two openings, of which the anterior is the aqueductus Fallopii (transmitting the facial nerve); the posterior, when examined with a lens, presents a number of minute foramina which transmit the divisions of the superior vestibular nerve—the nerve, namely, which supplies the utricle, the superior and the external semicircular canals.

FIG. 56.



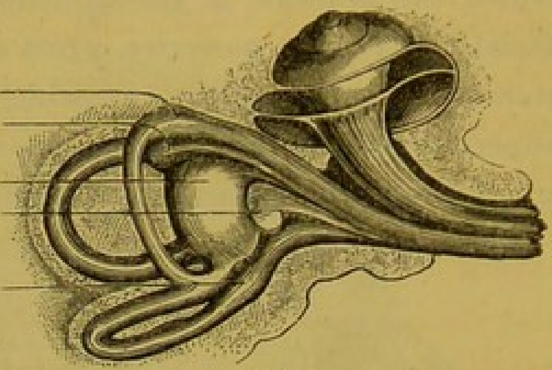
Foramina at the bottom of the right meatus auditorius internus.

In the lower and larger depression, we observe the base of the axis of the cochlea, termed "lamina cribrosa," because it has a double row of foramina arranged spirally, as shown in the cut. Now take any one of these foramina, which appear scarcely larger than the point of a pin, magnify it with a lens, and you will find that it becomes a fossa pierced by holes varying in number from three to seven. So fine are the canals which transmit the filaments of the cochlear nerve! In the centre of the lamina is the orifice of the central canal of the axis, which is the largest of all. Behind the lamina are two (sometimes three) openings leading to minute perforations which transmit the inferior vestibular nerve, or nerve to the saccule. Lastly, on the posterior wall of the meatus is the orifice of a very constant canal (represented by the dotted outline) which gives passage to the nerve of the posterior semicircular canal.

MEMBRANOUS LABYRINTH.

The membranous labyrinth comprises the two little bladders, termed the utricle and the saccule, in the vestibule, and the membranous semicircular canals. It floats in the perilymph, and contains the endolymph. It is represented in fig. 57.

FIG. 57.



Membranous labyrinth and nerves of the left ear.

The utricle occupies the upper half of the vestibule. It is very difficult to make a good display of it. The best way to examine it, is to remove very carefully the roof of the vestibule and that of the superior semicircular canal, and then to put the preparation in water. All the semicircular membranous canals open into it. It floats free in the perilymph everywhere except at the fossa (fossa for the utricle), where it is retained against the sieve-like plate of bone through which the utricular nerves enter.

The saccule is smaller than the utricle and situated below it, close to its appropriate fossa in the vestibule to which it is attached by the saccular nerve in a way similar to the utricle. Whether the utricle and saccule communicate with each other is a point not yet absolutely settled by anatomists. From the few observations which I have had the opportunity of making, my impression is that they do communicate.

The membranous semicircular canals only fill about half the space of the bony canals; the remainder is occupied by the perilymph. The nerve destined to each membranous ampulla spreads out only upon that surface of the ampulla which is nearest to the tympanum. The nerve does not advance beyond the ampulla, but ramifies upon a crescent-shaped septum which projects into the interior. The mode in which the ultimate nerve fibres terminate, whether in loops or in free ends, is undetermined.

Otoconia or ear powder.

On the inner wall of the utricle and the saccule, just at the spot where the nerves spread out upon them, and nowhere else, is a minute quantity of white powder, termed "otoconia" by Breschet. Each particle of this powder, when viewed through a microscope, is a little prismatic crystal; and appears to be in some way connected with the termination of a nerve filament. The powder in the human ear is but a rudiment of the ear stones (otolithes) in certain osseous fishes.

ON THE UNITY OF TYPE IN THE VERTEBRATE SKELETON.

We propose to give a simple and comprehensive sketch of this subject, enough to excite the attention of the young anatomist, and induce him to pursue it further in the masterly monographs of Professor Owen.*

Importance of the subject both to human and comparative anatomy.

Let no one turn from the subject in the idea that it is abstruse. There is no mystery in it. It is clear and simple, because drawn from nature. To say nothing of its extreme importance in the study of comparative osteology, it is absolutely essential to a right insight into the human skeleton. Of this a student may rest assured,—that however minutely he may have scrutinised the bones, he cannot understand them unless he knows something of the "Vertebrate Archetype." Without this knowledge, he is like one who speaks a language fluently, but is ignorant of its grammar. The "Archetype" may be said to be the grammar of *all* osteology.

It is incontrovertible that the skeleton in every animal is perfect as regards the final purpose to be served. More than this, it is now an admitted truth, fairly proved by a long-continued and

* On the Archetype and Homologies of the Vertebrate Skeleton, 8vo. 1848; On the Nature of Limbs, 8vo. 1849.

elaborate investigation of the facts of nature, that the skeleton in all vertebrate animals is constructed upon *one common plan* or pattern. However much modified to suit particular requirements, yet this plan or "Archetype" is never lost sight of, and may be traced at the bottom of all the modifications. Here is another instance of design, pointing to the ONE great cause of all organisation.

GENERAL IDEA of the subject.

Divesting the subject of technicalities as much as possible, it comes to this:—In all vertebrate animals the back-bone is made up of a series of segments termed "vertebræ." Each vertebra consists of certain "elements" which tally one with another throughout the whole length of the animal. One element, the "centrum," forms the axis for the support of the whole; from this other "elements," termed "processes" or "apophyses," ascend and unite to form an upper arch (neural arch) for the protection of the brain and spinal cord: other "elements" descend and unite to form a lower arch (hæmal arch) for the protection of the great blood-vessels and other vital organs. Thus there result an upper and a lower (in man, a hind and fore) series of arches. The upper series form a continuous canal for the lodgment of the nervous system from the top of the nose to the end of the tail. The lower series do not form a continuous canal; it is complete in some parts of the body, but in others there are wide breaks in it for particular purposes. For instance, the lower arches are complete in the back, where the ribs are prolonged, and unite with the sternal bones to make a protecting cage for the heart and lungs: in the pelvis, too, what have we but an enormous development of an inferior arch to form a fulcrum for the fixation of the lower limbs? But in the neck and loins the lower arches are absent, or, at all events, merely rudimentary,—and for the obvious reason, that they would impede the functions of these parts.

Skull composed of FOUR VERTEBRÆ.

Passing on to the cranium, we find that the skull itself is but a continuation of the back-bone, and that it consists of four vertebræ, or segments, which correspond to the four consecutive enlargements of the nervous system which we call the "brain." The upper arches of these four segments are enormously expanded, and unite to form the skull-cap for the protection of the brain: while the lower arches are extremely modified so as to form the upper jaw, the lower jaw, the hyoidean arch, and, strange as it may seem, the scapular arch; that is, the arch formed by the scapulæ and clavicles.

Merit of this discovery: to whom due.

The merit of discovering that the cranial bones are composed of "elements" answerable to the "elements" of vertebræ, is due to Lorenz Oken, a great comparative anatomist. It is a discovery which, according to Professor Owen, would alone have conferred immortality upon his name. "In August, 1806," says Oken, "I was travelling in the Hartz mountains. Walking through a forest, look! there lay at my feet a most beautiful blanched skull of a deer. I picked it up, gazed intently at it, turned it round, and the idea flashed through my mind, It is part of a vertebral column!"*

Now if any two vertebræ be taken from no matter what part of the body, and compared, it will be found that their component "elements," however individually modified in form and size, are nevertheless strictly "homologous;" in other words, they are answerable elements, and may be described by common names. Thus, in the study of comparative osteology there is no necessity for retaining the individual name of this or that bone, since we have the immense advantage of a natural nomenclature which comprehends the bones of all animals.

Typical Vertebra and Archetype Skeleton.

After years of inductive research and comparison, Professor Owen has eliminated the "pattern" or "perfect typical vertebra." He has gone farther still. By comparing the bones of one animal with those of another throughout the entire series, and guided by the light of reason, he has constructed the "Archetype Skeleton," the creature of reason, which may be referred to as the common pattern for the skeleton of every vertebrate animal.

Professor Owen† defines a vertebra to be one of those "segments" or natural groups of bones which constitute the axis of the body, and the protecting canals of the nervous and vascular trunks. Such a segment may also support *diverging appendages*. Ex-

* Isis, 1818, p. 511.

† On the Archetype of the Vertebrate Skeleton, 8vo. 1848.

clusive of these, it consists, in its typical completeness, of the following elements and parts shown in Plate XLIX.

A CENTRUM.

Two NEURAPOPHYSES, so called because they form the sides of the *neural** arch for the protection of the trunk nerve.

A NEURAL SPINE (sometimes bifid), which completes the neural arch.

Two HÆMAPOPHYSES, so called because they form the sides of the *hœmal*† arch for the protection of the principal blood-vessels.

A HÆMAL SPINE (sometimes bifid), which completes the hæmal arch.

Two PLEURAPOPHYSES‡, or ribs, one on each side of the centrum.

Four ZYGAPOPHYSES§, or articular processes, attached two to the neural and two to the hæmal arch.

Two DIAPOPHYSES‖, or upper transverse processes.

Two PARAPOPHYSES‖, or lower transverse processes.

Of these elements, the zygapophyses, the dia- and parapophyses, are termed "exogenous," because they are, strictly speaking, outstanding processes: all the others elements are termed "autogenous," because they are usually developed from distinct and independent centres of ossification.

Thus a typical or perfect vertebra, with all its elements, presents four canals or perforations about a common centre: namely, an upper, for the protection of a segment of the nervous system; a lower, for the protection of the vascular system; and one on each side for a blood-vessel, and often a nerve. Such a vertebra is found in the thorax of most of the higher class of vertebrata, and in the neck of many birds,—for instance, the pelican. The bones termed

* Derived from νεῦρον, a nerve.

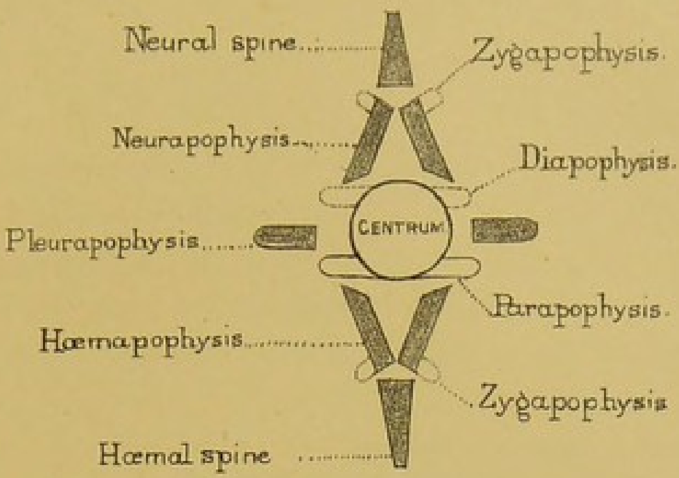
† Derived from αἷμα, blood.

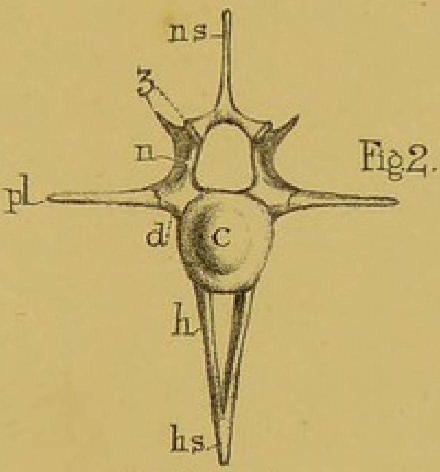
‡ Derived from πλευρὰ, a rib.

§ Derived from ζυγὸν, a yoke.

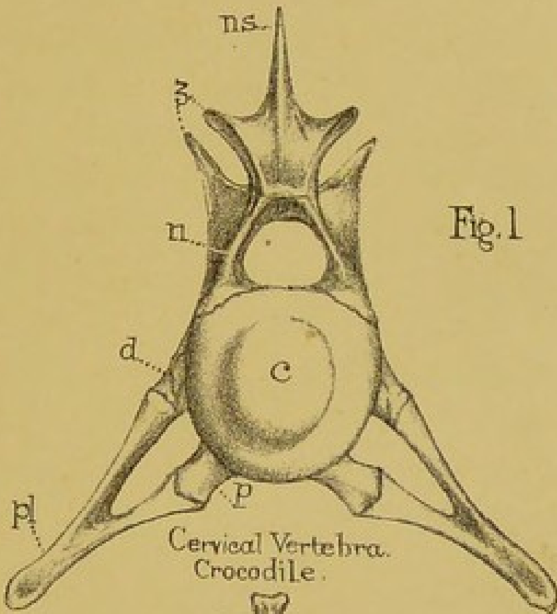
‖ The Greek prepositions διὰ and παρὰ imply that these processes are merely outgrowths of bone.

Ideal typical Vertebra
'OWEN'

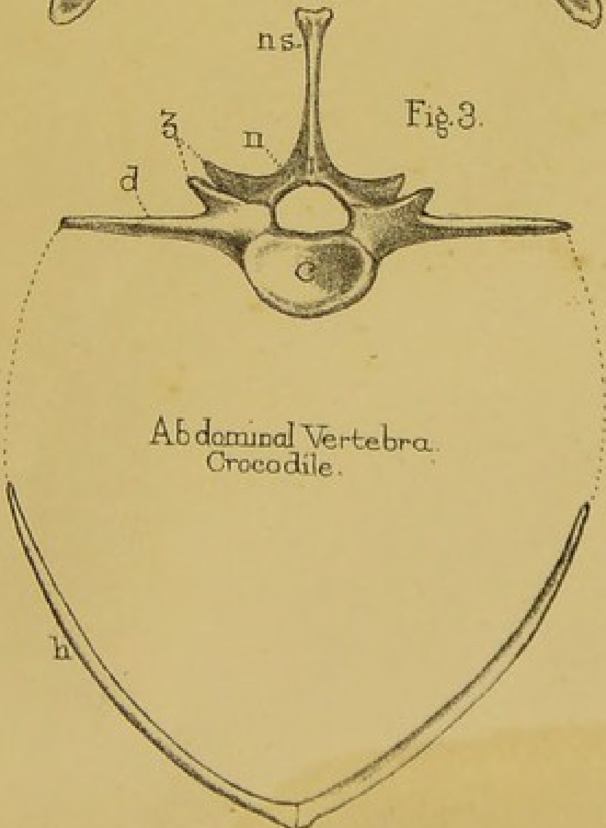




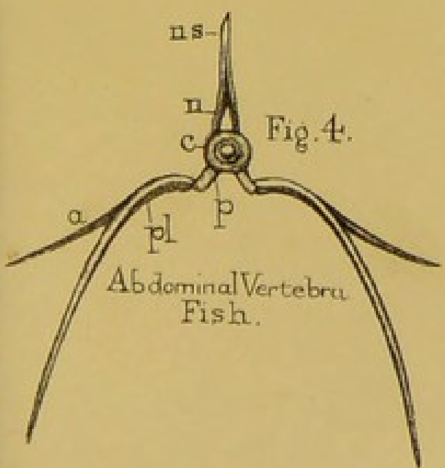
Caudal vertebra.
Crocodile.



Cervical Vertebra.
Crocodile.



Abdominal Vertebra.
Crocodile.



Abdominal Vertebra
Fish.

"diverging appendages" are added to some vertebræ for special purposes: for instance, the thoracic vertebræ of birds support diverging appendages, which serve to lock the ribs together, and strengthen the framework of the chest. Here they serve simply for purposes of fixation. Similar appendages, however, attached to certain vertebræ, serve the purposes of locomotion, and variously modified and developed, become fins, wings, legs, or arms, as the case may be.

Vertebræ subject to many modifications.

Since, then, a series of vertebræ, in the recent more extended sense of that good old word, constitute, as it were, the materials out of which the *entire* skeleton in every form of vertebrate animals is constructed, we must expect to find that vertebræ are subject to many and great modifications, as to the number of the "elements" retained in their composition, as to the form and proportion of these "elements," and even as to their relative position.

The most constant and the simplest element is the "centrum." Other elements are added in the different segments, according to the structure to be raised. Let anyone begin at the end of the tail of an animal. There he will see a "centrum" alone; but it is not on that account the less a segment or vertebra of the tail. Let him run his eye along the successive vertebræ of the tail, and he will see other elements gradually rising into notice, — elements which he cannot doubt are successively answerable parts. When he comes to the chest, he will not trace so readily the homologous elements of the vertebral chain; and for this reason: the lower arches must of necessity be greatly expanded, to make room for the lodgment of the heart and lungs. But nature does not accomplish this by a simple expansion and lengthening of those elements only which formed the hæmal arch of the tail. No: she shifts the hæmapophyses from the typical position which they held in the tail, and joins them to the ends of the pleurapophyses, or ribs, which are adequately elongated and bent down. In the neck, again, he meets with no difficulty. When he reaches the head, he is entirely at fault; and no wonder. In this complex region of the skeleton, the elemental parts of its constituent vertebræ are modified, not only by change of shape and proportion, by division and subdivision, but even by dislocation from their proper segment; the upper arches must needs be so widely expanded and interlocked, to protect the brain; the lower arches so enormously developed, to form the jaws; the diverging appendages of the upper jaw so massive, to form bulwarks for its fixation and the origin of the powerful muscles of mastication. Still the elements are there.

Such is a brief but very imperfect outline of this great subject. It may be said, it is pretty and plausible, but, after all, a mere "transcendental dream." These glimpses, indeed, of a great truth have, by some persons, been ill received. Even in 1845, the learned editor of Baron Cuvier's last course of lectures, M. de Saint Agy, commenting upon the osteological essays of Spix and Oken, remarks—"Pour moi, une mâchoire supérieure est une mâchoire supérieure, et un bras est un bras. Il ne faut pas chercher à faire sortir l'ostéologie d'un système de métaphysique." To this observation Owen very logically replies—"But a jaw is not the less a jaw because it is a 'hæmapophysis,' nor is an arm the less an arm because it is a 'diverging appendage.'" In the same spirit a critic might write—"Newton calls this earth a 'planet,' and the moon a 'satellite;' for me the earth is an earth, and the moon is a moon." One must not strive to make an ouranology out of a system of metaphysics.

Manner in which the subject is proved.

But if this be a great truth, how is it proved? To bring the matter home, the human anatomist may ask, how is it proved that a given bone in the human skull is an element of a particular vertebra? The proof is founded upon a series of comparisons extended over all the vertebrate kingdom. The comparative anatomist, led on by Owen, will point to the same bone throughout the descending scale of animals, tracing it step by step through its various modifications in mammals, birds, reptiles, and fishes, till he comes to its simplest "archetypal" form. He will never let him lose sight of the bone; he will show him that the bone is in each and every instance the answerable element of the same vertebra; and lead him on withal by such gentle transitions, that he cannot doubt the unbroken chain of evidence any more than he can doubt a series of mathematical propositions.

We will now take a few examples of the simpler forms of vertebræ from different animals, for the sake of explaining their modifications with the help of the "ideal type."

Caudal vertebra of a crocodile.

Fig. 2 (Plate XLIX.) represents a vertebra from the tail of a crocodile. Its elements are marked by the initials of their names. We recognise at once the "centrum" (c). Its posterior surface is convex, so as to form a ball-and-socket joint with the anterior surface of the centrum of the succeeding vertebra.* We see the "neural arch" formed by the "neurapophyses" (n); the "neural spine" (n s); the "zygapophyses" (z), or articular processes for interlocking with the next vertebræ. There is a short "diapophysis" (d), and to the end of this is articulated by suture a short "pleurapophysis" (pl), or stunted rib. The "hæmal arch" required for the protection of the great blood-vessels of the tail is formed by "hæmapophyses" (h), which articulate with the under surface of the centrum, and coalesce with each other and the "hæmal spine" (h s). Compared with the typical vertebra, we find that the "parapophyses" and lower zygapophyses are suppressed.

Lumbar vertebra of a crocodile.

Fig. 3 represents an abdominal or lumbar vertebra of a crocodile. It has the following modifications: — There are long "diapophyses" (d) for muscular attachments; the "pleurapophyses" are suppressed; the "hæmapophyses" (h) are removed from the centrum to the lower part of the abdominal wall. These "so-called" abdominal ribs, more or less ossified, and generally subdivided, form a half-arch for the support of the abdominal viscera, — a modification required in these amphibious reptiles, which, when on land, rest the whole weight of the abdomen on the ground.

Thoracic vertebra of a crocodile.

Fig. 1 (Plate L.) represents a thoracic vertebra of a crocodile. Here the "pleurapophyses" (pl) are connected to the "diapophyses" (d), and then elongated and turned down so as to form a large hæmal arch: this arch is

* This type of vertebra is termed by Owen "procœlian" (προς; κοιλος, hollow). It characterises all the existing genera and species of the order *Crocodilia.*

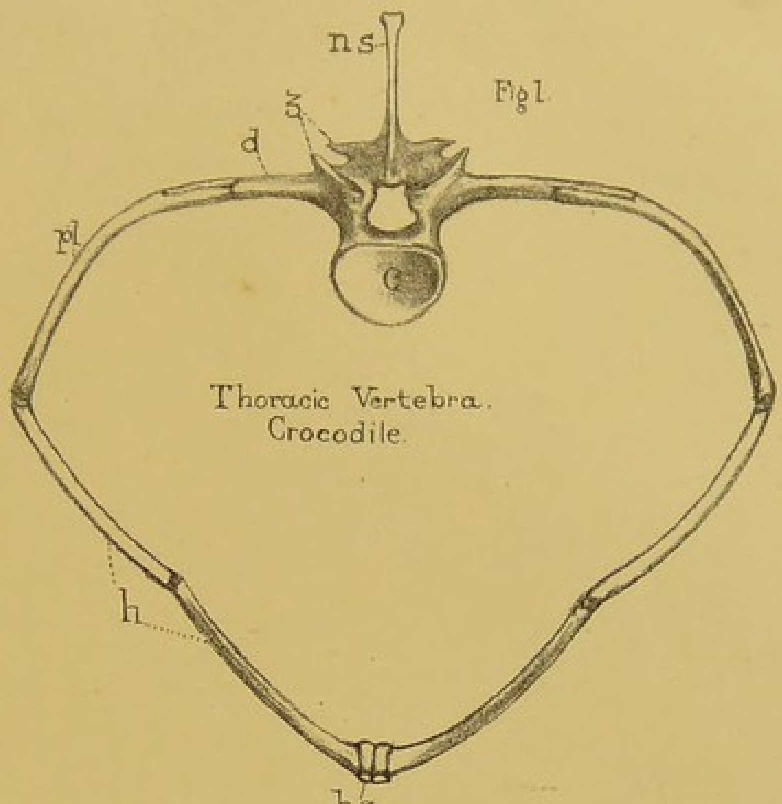
completed below by the "hæmapophyses" (h), which are removed from the centrum (c) and attached to the ends of the lengthened "pleurapophyses" (pl). There is also a bifid "hæmal spine" (h s).

Cervical vertebra of a crocodile. Fig. 3 (Plate XLIX.) represents a cervical vertebra of a crocodile. The chief modification here is the formation of the lateral canals. The "dia-" and "parapophyses" (d and p) articulate by suture with the prongs of a short and forked "pleurapophysis" (pl), and thus are formed the foramina on each side for the transmission of the vertebral arteries.

Caudal vertebra of a fish. A vertebra from the tail of a fish is a good example of a simple form. There is a small "neural arch" with "zygapophyses" and a long "neural spine." The "diapophyses" are suppressed. There is also a "hæmal arch;" but this is formed, not by "hæmapophyses," as is generally the case in other animals, but by "parapophyses," which bend down, meet, and are prolonged so as to form a hæmal spine. Each has a "zygapophysis" at its base.

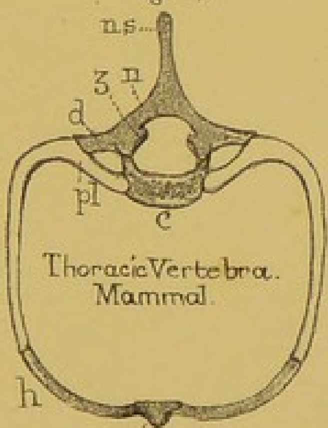
Abdominal vertebra of a fish. Fig. 4 (Plate XLIX.) represents an abdominal vertebra of a fish. Here the "diapophyses" are suppressed. The "parapophyses" (p) stand out for a short distance, and have the "pleurapophyses" (pl) appended to their ends. Each pleurapophysis supports a short "diverging appendage" (a) for the attachment of muscles. The "pleurapophyses" in fishes correspond with the floating ribs in human anatomy; and the abdomen is closed below by hæmal arches of aponeurotic tissue, like the "lineæ transversæ" of the abdominal wall in man.

Thoracic vertebra of a bird. Fig. 3 (Plate L.) represents the thoracic vertebra of a bird (vulture). Here the long "pleurapophyses" (pl) are firmly articulated to both "dia-" and "parapophyses" (d and p), so as to make two lateral canals: the "hæmapophyses" (h) are short and attached to the ends of the "pleurapophyses" (pl). But the principal modification is the great expansion of the "hæmal spine" (h s) and its prolongation in the form of a bony crest, in order to give additional surface for the origin of the great pectoral muscles concerned in flight. This crest is always developed in proportion to the powers of flight. Each "pleurapophysis" (pl) has a "diverging appendage" (a), Fig 1.



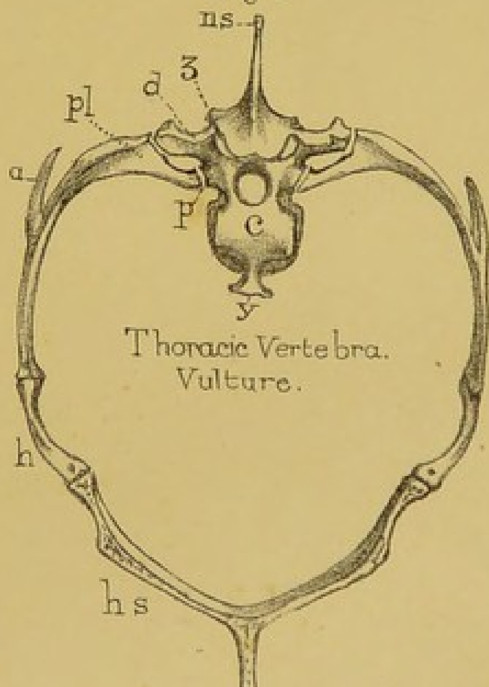
Thoracic Vertebra.
Crocodile.

Fig. 2.



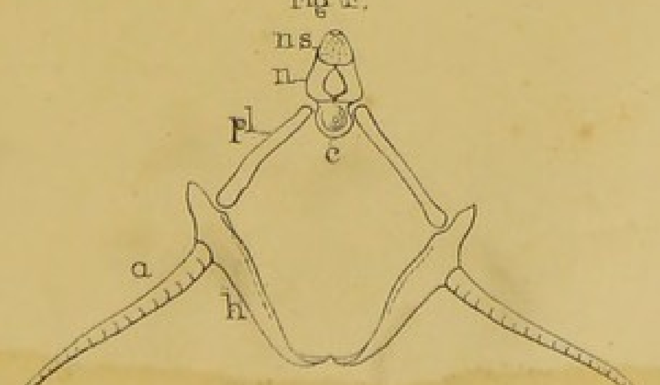
Thoracic Vertebra.
Mammal.

Fig. 3.



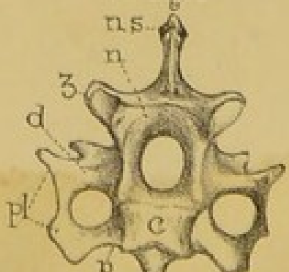
Thoracic Vertebra.
Vulture.

Fig. 4.



Occipital Vertebra.
Lepidosiren.

Fig. 5.



Cervical Vertebra.
Vulture.

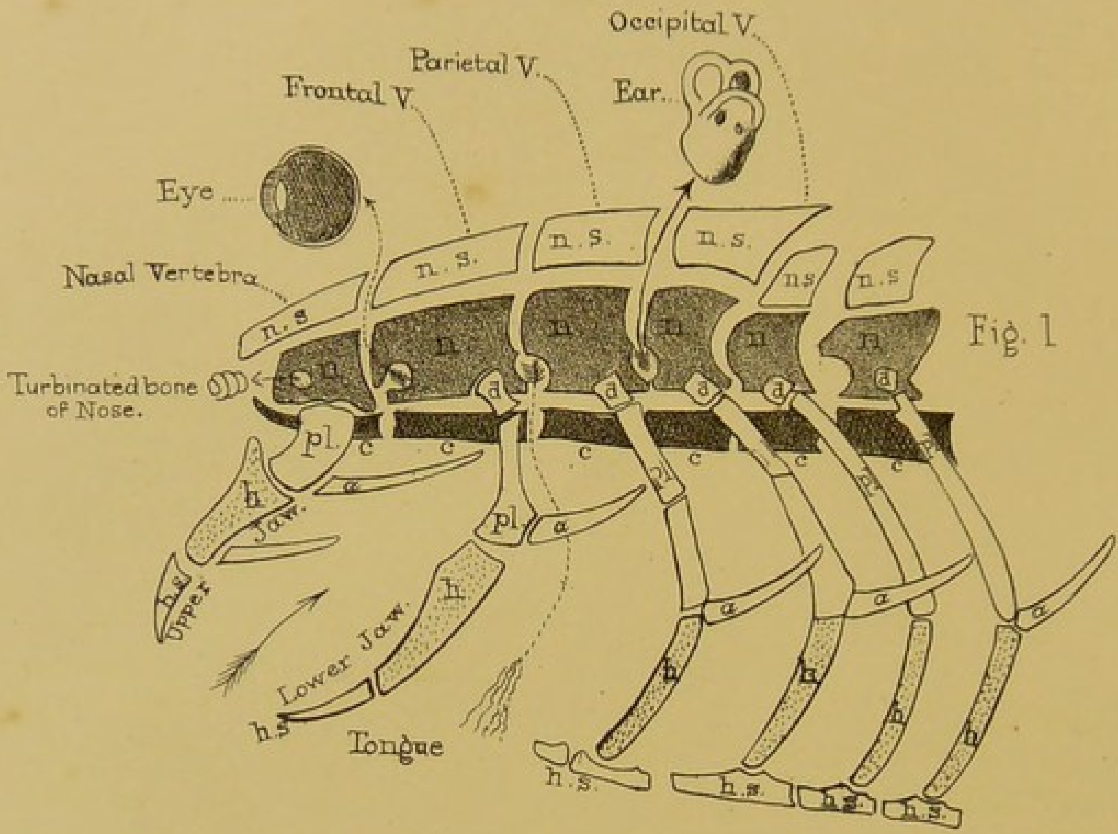
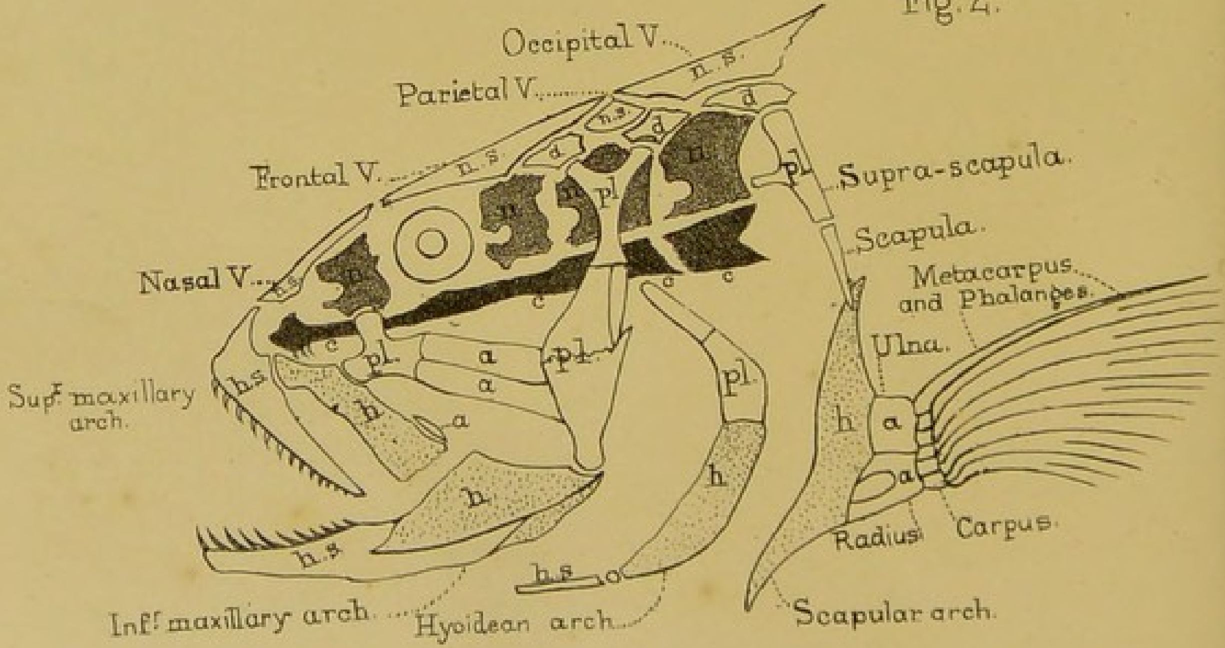


Fig. 1

Skull of the 'Archetype' skeleton.

"OWEN."

Fig. 2.



Skull of a Fish.

which serves to fix one rib to another, and associate the two in action, and give firmness and security to the whole thoracic cage. From the under part of the centrum, a secondary process, termed the "hypapophysis" (y), projects in order to give attachment to the muscles which bend the neck forwards, and enable the bird to give a powerful blow with its beak. This is especially developed in birds of prey.

Fig. 5 represents a cervical vertebra of a bird. The extremely stunted "pleurapophyses" (pl) coalesce with the "dia-" and "parapophyses" to form lateral foramina for the vertebral arteries. This is just like the cervical vertebræ in man.

Thoracic vertebra of a mammal.

Fig. 2 represents a thoracic vertebra from a mammal. The hæmal arch is complete for the protection of the heart and lungs. The long "pleurapophyses" (pl) come at once from the "centrum" (c), and are also supported by short "diapophyses" (d). The lower part of the arch is completed by the "hæmapophyses" (h), or costal cartilages, and the sternum or "hæmal spine" (h s).

Skull of the ARCHETYPE skeleton.

We pass on in the next place to show how vertebræ are modified to form a skull—taking that of a fish as the example, because it deviates least from the "archetype." And first, a few words explanatory of the skull of the "archetype," or primal pattern eliminated by Professor Owen (Plate LI. fig. 1).

The first four vertebræ of the skeleton are modified to form the skull. They are termed the *Nasal*, *Frontal*, *Parietal*, and *Occipital* vertebræ. The neural arches of these vertebræ correspond with the four segments or primary divisions of the nervous system which are manifested in the embryonic condition of the brain; namely, the *Rhinencephalon*, the *Prosencephalon*, the *Mesencephalon*, and *Epencephalon*. These several segments respectively give origin to the nerves of special sense; namely, smell, sight, taste, and hearing. The "neurapophyses" of the four vertebræ are perforated to allow the nerves of special sense to pass.

The organ of smell is situated in advance of its proper vertebra, which is modified to close and protect it.

The eye is lodged in a cavity, or "orbit," between the frontal and the nasal vertebræ.

The nerve of taste perforates the "neurapophysis" (n) of its own vertebra, the "parietal," to spread out in the tongue.

The organ of hearing is always lodged in the interspace between the "neurapophyses" (n) of the parietal and occipital vertebræ; and the surrounding vertebral elements are modified to form the cavity for its reception, called "otocrane."

The hæmal arches of the first two vertebræ form the upper and lower jaw.

Skull of a Fish.

From the skull of the "archetype" to that of a fish the transition is comparatively easy. Although some of the elements in the skull of a fish are modified into a scale-like form, the better to overlap and mutually support each other, yet the four vertebræ composing it, as well as the constituent elements of each vertebra, can be separated, with the exception of the centra (c), which are confluent, all but the first and second, in order to give greater strength to the head. We recognise the four neurapophyses (n) which form the neural arches for the primary divisions of the brain, and each is perforated or notched for the passage of its proper nerve.

The four neural spines (n s) protect each their own division of the brain and organ of special sense, and rise into a lofty and continuous crest for the insertion of the powerful muscles of the back.

The diapophyses (d) of the three posterior vertebræ (the first has none) stand out from the neurapophyses (n), like buttresses, and support the bones which form two of the hæmal arches; namely, the inferior maxillary and the scapular arch.

Under the first neural spine (n s) is the ossified part of the capsule (turbinal bone) of the organ of smell.

The interval between the first and second vertebra is the orbit for the eye.

The partly gristly partly bony case (petrosal bone) which contains the organ of hearing, is wedged in between the third and fourth neural arches.

The hæmal arch of the nasal vertebra is modified to form the upper jaw. It consists of the pleurapophysis (pl), hæmapophysis (h), and hæmal spine (h s). These bones correspond respectively to the palate bone, the superior maxillary, and the pre-maxillary of human anatomy; and all three are drawn forwards so that the apex of the arch may be fixed to the centrum (c) and the neural spine (n s), and thus close the neural canal in front. We observe that the hæmal spine supports the teeth, and that both it and the hæmapophysis are prolonged backwards, in relation to the protractile and retractile movements of the jaws in fishes necessary to respiration and seizing their food. Moreover, in order that the jaws may act together, an appendage (a a) proceeds from the pleurapophysis of the first arch to that of the second: this corresponds to the internal pterygoid plate of human anatomy.

The hæmal arch of the second or frontal vertebra is modified to form the lower jaw. It consists of a pleurapophysis (tympanic bone) and a hæmapophysis, connected by a moveable joint, and a hæmal spine which supports the teeth. The pleurapophysis abuts on and articulates with the diapophysis, not only of its own, but also of the succeeding vertebra: the reason for this modification is to give a firmer basis of support to the lower jaw. The pleurapophysis of the lower jaw in fishes has to support not only the weight and working of its own appendages (the gill covers), but also that of the succeeding hæmal arch, with all its appendages; namely, the respiratory (branchial) apparatus.* Another modification of the pleurapophysis of the lower jaw in fishes is its being subdivided into four overlapping pieces: this provision adds greatly to its strength, and diminishes its liability to fracture, like the overlapping plates in the springs of a carriage.

The hæmal arch of the third or parietal vertebra is the "hyoidean" arch. It consists of a pleurapophysis, a hæmapophysis, and a hæmal spine, answering to the styloid process, stylo-hyoid ligament, and os hyoides of human anatomy. This arch forms the bony support of the breathing machinery; namely, of the branchial arches, which are diverging appendages from it. Its pleurapophysis

* These several appendages have been left out in the diagram for the sake of perspicuity.

is displaced from the diapophysis of its own vertebra, in order to be attached to the pleurapophysis of the lower jaw, so that these two hæmal arches may move consentaneously in respiration. Thus the mechanical functions of the thorax in air-breathing animals are performed in fishes by one of the arches of the skull: hence the large size of the head, to make additional room for the heart and lungs.

The hæmal arch of the fourth or occipital vertebra is comparatively the most interesting of all the arches in the head, because the diverging appendage which it supports is the pectoral fin, an organ of locomotion. This appendage, variously modified and removed to a distance from its own arch, becomes, as we ascend in the animal scale, a foreleg, a wing, or an arm and hand. Its pleurapophysis or scapula is forked at the top. Its two prongs abut, like the head and tubercle of a rib in the human chest, on the dia- and neurapophysis of its own vertebra. The hæmapophysis or coracoid bone completes the hæmal or scapular arch which protects the heart and lungs in fishes. The pectoral fin or appendage consists of a short radius and ulna (the humerus is suppressed), a row of bones forming the carpus, and fin rays answering to the metacarpus and phalanges of the fingers.

Analysis of the HUMAN Skull.

From the skull of the fish—the simplest modification of the archetype—we pass on to the analysis of the human skull,—the extreme modification of the archetype. Plate LII. represents the individual elements of the four cranial vertebræ of the human fœtus separated from each other and seen from behind. In Plate LIII. they are shown in profile and in relative position, both from the inside and the outside of the skull.

OCCIPITAL VERTEBRA.

The occipital vertebra is comprised in the occipital bone. The basilar process is the centrum (c); the lateral pieces on each side the foramen magnum or neural arch are the neurapophyses (n); the arch is completed by the occipital plate or neural spine (n s) broadly expanded to protect its own segment of the brain, the cerebellum. The condyles are zygapophyses modified in adaptation to man's erect attitude.

The hæmal arch is displaced from its own vertebra, and planted free on the sides of the chest, to form the upper extremity. The scapula is the highly modified pleurapophysis (pl); the little coracoid process is the stunted hæmapophysis (h). The arch is completed by the clavicles, which are the displaced hæmapophyses (h) of the atlas, and they abut against the first bone (manubrium) of the sternum, which is the hæmal spine of the first thoracic vertebra. The arms are diverging appendages from this arch. It seems strange, to say that all the bones of the upper extremity (except the clavicle) are *essentially* bones of the skull; but in the fish we see the homologous bones in their primitive position actually attached to the occipital vertebra: they are well seen, too, in the lepidosiren, Plate L. fig. 4, where the hæmal arch of the occipital vertebra is complete, and the single ray-like appendage (a) is the homologue of the arm. Those who desire to trace the successive facts and reasoning upon which this unexpected conclusion is founded, are referred to Professor Owen's most interesting and philosophical work, "On the Nature of Limbs."

PARIETAL VERTEBRA. The parietal vertebra consists chiefly of its neural arch, which is formed by the posterior or basi-sphenoid*, the alisphenoids, and the parietal bones. The body of the sphenoid is the centrum (c): its greater wings, or alisphenoids, are the neurapophyses (n), and these, as usual, are perforated (by the foramen ovale) for the passage of the third or gustatory division of the fifth nerve. The two parietals form the bifid neural spine (n s) enormously expanded into a dome-like roof for the protection of the cerebral lobes. The mastoid processes are the diapophyses (d).

The hæmal arch is formed by the styloid processes, which are stunted pleurapophyses (pl), and continued by means of the stylo-hyoid ligaments to the lesser cornua of the os hyoides, which represent stunted hæmapophyses (h). The body of the os hyoides is the hæmal spine (h s). The greater cornua are diverging appendages (a).

* In the early fœtus there are two distinct sphenoid bones, each belonging to separate vertebræ; a posterior or "basi-sphenoid," an anterior or "pre-sphenoid." The bodies of both soon coalesce to form what appears afterwards the single sphenoid.

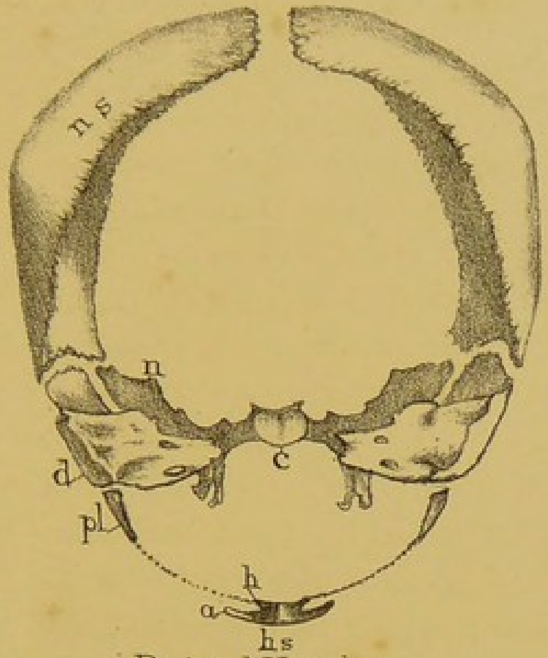
Obscured by the temporal bone.

The analysis of this cranial vertebra is rendered more difficult by the interposition of the very complex "temporal" bone. This bone consists of five elements, distinct in the fœtus; namely, the petrosal, the mastoid, the styloid, the tympanic, and the squamous. Of these, two, the mastoid and the styloid, belong to the parietal vertebra. The petrosal is not an element of a vertebra, but the *bony* capsule of the sense of hearing, as the sclerotic coat of the eye is the *fibrous* capsule of the sense of sight. It is interposed, as usual, between the occipital and parietal vertebræ, coalesces early with the mastoid, and assists in blocking up the base of the skull. The tympanic element is the stunted pleurapophysis (pl) of the next vertebra in advance of the frontal, and reduced in the fœtus to a mere ring of bone for the support of the membrana tympani: in the process of growth it forms the meatus auditorius externus. The squamous element is one of the diverging appendages of the hæmal arch of the nasal vertebra or upper jaw. It is interesting to trace the various purposes served by this appendage, and its successive modifications from its simple proportions in the lower animals up to its important development in man. In all animals above fishes, its office is, in some way or other, to assist in connecting the first hæmal arch or upper jaw with the second or lower jaw. In crocodiles, for instance, it forms an additional buttress to fix the upper jaw; in birds it makes the jaws move together; but in mammals we find it gradually introduced into the formation of the cranial wall, and in man it undergoes its extreme modification, and is expanded into a scale-like bone, which forms the greater part of the temporal wall of the skull between the third and fourth neural arches. Notwithstanding its singular modification in subservience to the great development of the human brain, observe that this squamous element still retains its natural connection with its own vertebra, and assists in forming the zygomatic arch.

Frontal Vertebra.

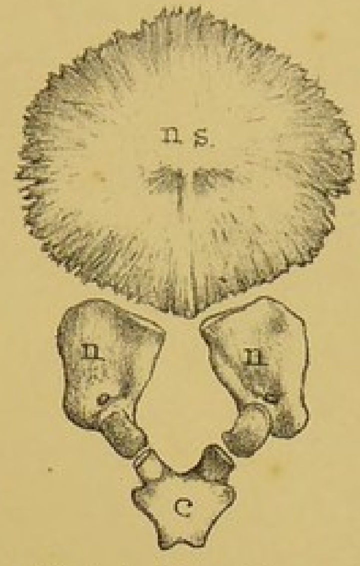
The body of the anterior or pre-sphenoid forms the centrum (c) of the frontal vertebra. The lesser or orbital wings form the neurapophyses (n): these are perforated, as usual, by the optic nerves. The frontal bone, enormously expanded for the protection of the anterior cerebral lobes, forms

Fig. 2.



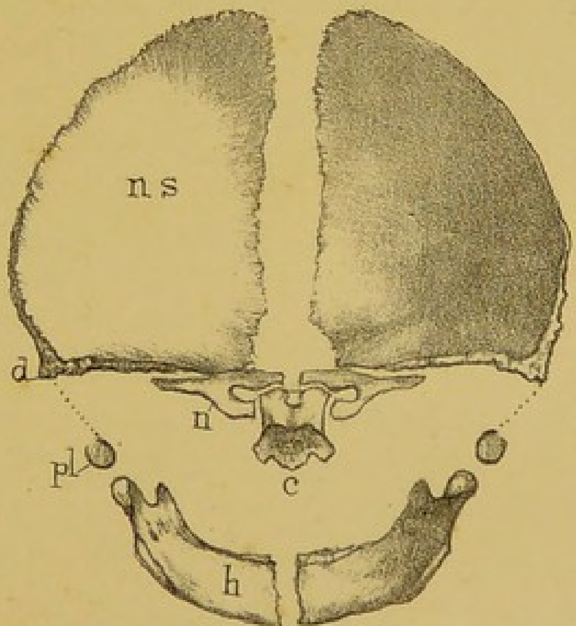
Parietal Vertebra.

Fig. 1.



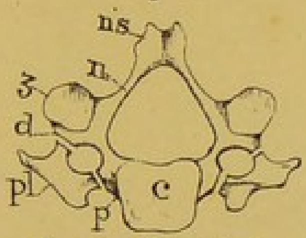
Occipital Vertebra.

Fig. 3.



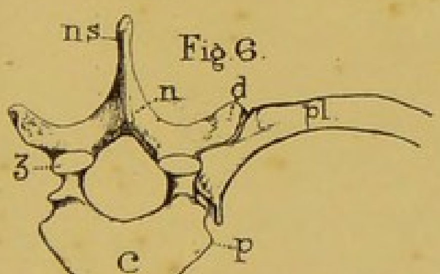
Frontal Vertebra.

Fig. 5.



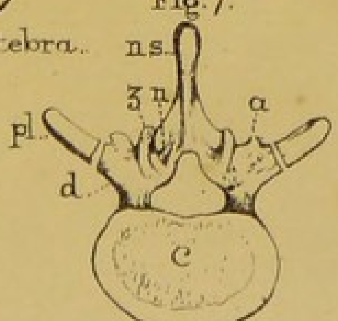
Cervical Vertebra.

Fig. 6.



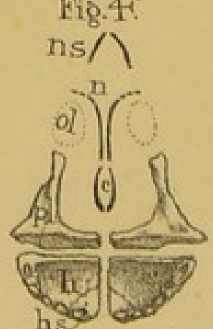
Dorsal Vertebra.

Fig. 7.



Lumbar Vertebra.

Fig. 4.



Nasal Vertebra.

Holden ad natur del. T. Godart Lith.

PLATE LIII

Fig. 1.

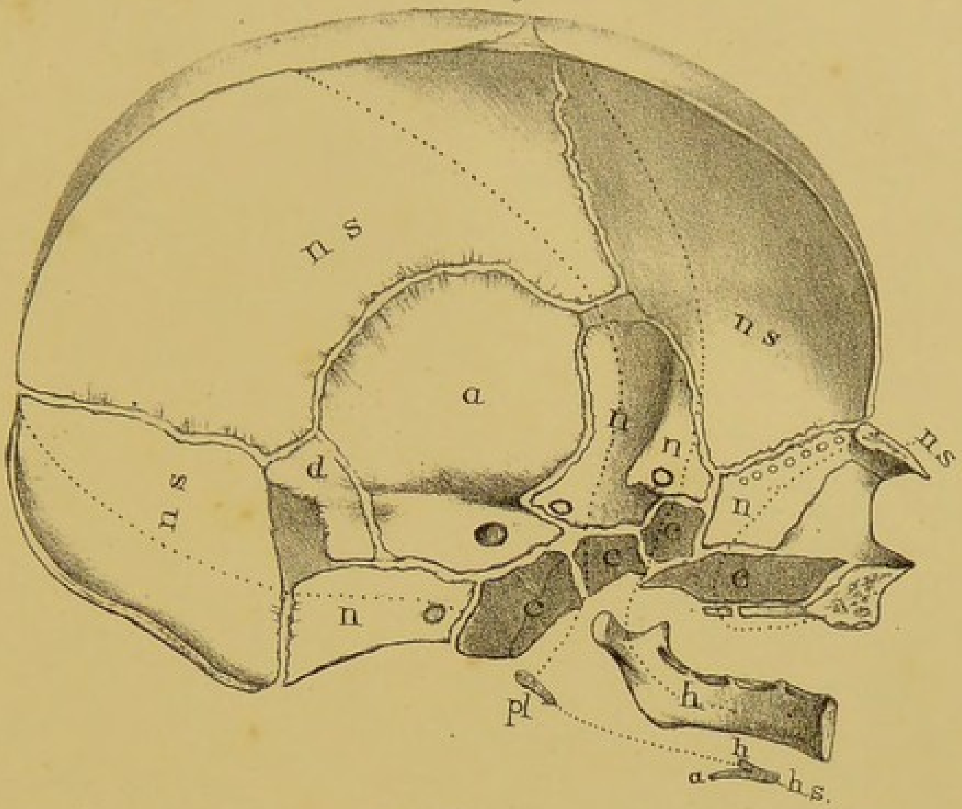
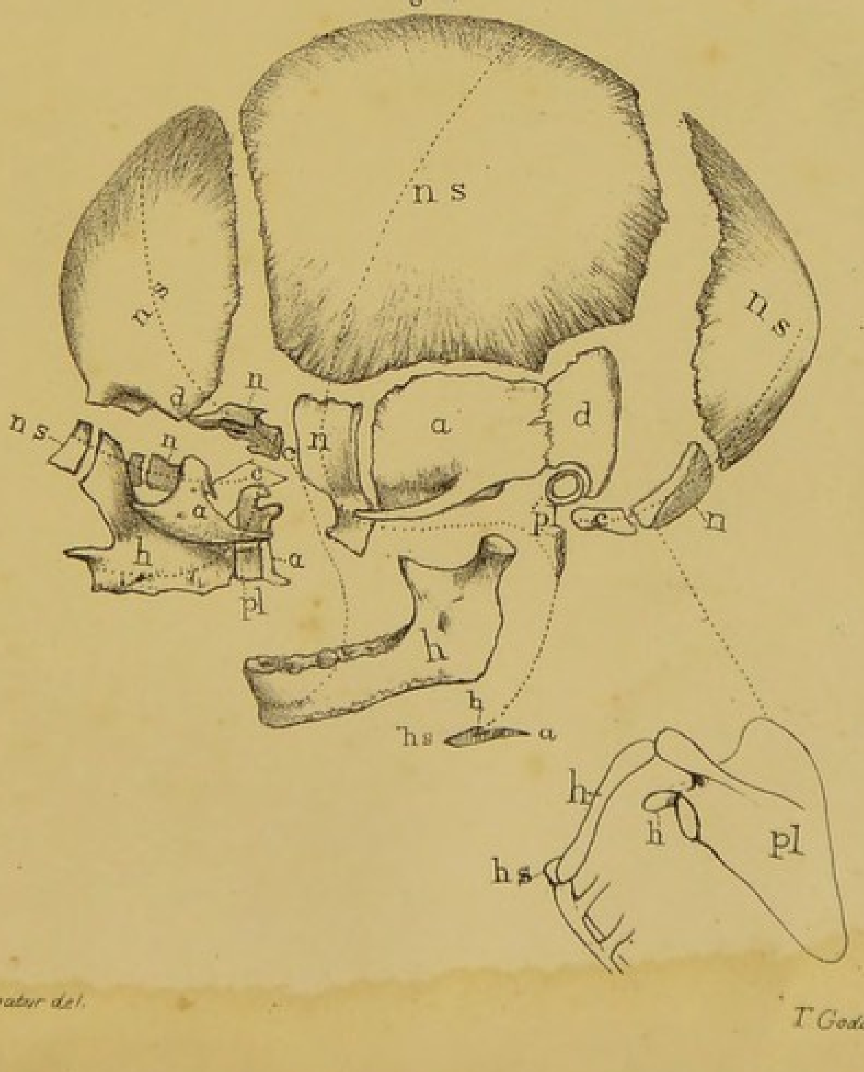


Fig. 2.



L. Holden ad natur del.

T. Godart Lith.

the bifid neural spine (n s). The external angular processes are the stunted diapophyses (d).

The hæmal arch is formed by the tympanic element (of the temporal bone) or stunted pleurapophysis (pl), the lower jaw is the largely developed hæmapophysis (h), and its symphysis is the hæmal spine* (h s). Though displaced far behind their own vertebra, to suit the requirements of the human skull, observe that the individual elements of the arch are not displaced from each other.

NASAL VERTEBRA. The nasal vertebra is the most modified of all in adaptation to the human face, which in place of being elongated, as in animals, forms a right angle with the forehead. Besides being over-arched by the neural spine of the frontal vertebra, the nasal segment contains the capsule of the sense of smell, and has two sets of appendages to fix it in position. In fig. 4, Plate LII., we have attempted a diagram of this segment, stripped of its appendages for the sake of perspicuity.

The vomer is the centrum (c). The perpendicular plates of the ethmoid form the neurapophyses (n): these are perforated by numerous foramina for the transmission of the olfactory nerves which ramify on the olfactory capsule (ol) or turbinal bones of the ethmoid. The nasal bones form the bifid neural spine (n s).

The hæmal arch is formed by the palate bones or pleurapophyses (pl), the superior maxillary or hæmapophyses (h). The pre-maxillary bones are the bifid hæmal spine (h s). This arch has two sets of appendages (a), Plate LIII. fig. 2; the first set belong to the pleurapophyses or palate bones, and consist of the pterygoid appendages: they become the internal pterygoid plates of the sphenoid, and extend backwards to bound the respiratory passage, and to fix the hæmal arch to an exogenous growth from the centrum of the parietal vertebra, namely the external pterygoid plate of the sphenoid. The second set of appendages consist of the malar bones, and the squamosal elements of the temporal. The other modifications of this arch will suggest themselves on reflection.

* This is a distinct bony element in fishes and reptiles.

Such are the *general* homologies of the bones of the human skull. Subjoined is a table of the names given to them by Owen, according to their *special* homologies. The names apply alike to all the vertebrate kingdom.

SPECIAL NOMENCLATURE OF THE ELEMENTS OF THE CRANIAL VERTEBRÆ.

	OCCIPITAL.	PARIETAL.	FRONTAL.	NASAL.
NEURAL SPINE...	super occipital	parietal.........	frontal	nasal.
NEURAPOPHYSIS.	exoccipital ...	ali sphenoid ..	orbito sphenoid	pre-frontal.
DIAPOPHYSIS ...	....	mastoid	post frontal.	
CENTRUM	basi occipital...	basi sphenoid .	pre-sphenoid...	vomer.
PLEURAPOPHYSIS	scapula	stylo hyal	tympanic	palatine.
	a. bones of arm	a. thyro hyal.		a. pterygoid.
HÆMAPOPHYSIS .	coracoid	cerato hyal ...	mandible	maxillary.
				a. malar.
				squamosal.
HÆMAL SPINE ...	manubrium ...	basi hyal	dentary	pre-maxillary.

General homologies of the VERTEBRAL COLUMN.

Let us now examine the general homologies of the vertebral column, and for this purpose take examples from the cervical, dorsal, lumbar, sacral, and coccygeal regions in succession.

A cervical vertebra is represented in Plate LII. fig. 5. The body is the centrum (c); the laminæ are the neurapophyses (n), and the neural arch is completed by the bifid spinous process (n s); the articular processes are the zygapophyses (z). The transverse processes are stunted pleurapophyses (pl): they are forked at their ends; the anterior prongs or roots coalesce with the parapophyses (p); the posterior with the diapophyses (d), and thus they circumscribe lateral canals for the vertebral arteries. In the drawing these elements have been artificially separated.

A dorsal vertebra is represented in fig. 6. The centrum neurapophysis and neural spine are plain. The hæmal arch is formed by the rib or pleurapophysis (pl); the articular surface on the centrum for the head of the rib is all that remains of the parapophysis (p). The transverse process is the diapophysis (d), and is well developed, in order to support the tubercle of the rib. In the first seven dorsal vertebræ the hæmal arch is completed by the costal cartilages or hæmapophyses, and the sternum or hæmal spine. In the five lower dorsal the hæmal arch is incomplete.

Fig. 7 represents a lumbar vertebra. The "so-called" transverse processes are formed by stunted pleurapophyses (pl), which are confluent with the diapophyses (d). The little exogenous tubercles (spoken of at page 48) are termed by Owen the "meta-" and "anapophyses." Their relative positions are better shown in Plate XLV. fig. 2. The hæmapophyses of the lumbar vertebræ are represented by the "lineæ transversæ" of the abdomen.

The five sacral vertebræ coalesce to form the single bone termed the sacrum. The five centra are plain. In the first four vertebræ the neural arch and their neural spines unite to form a lofty crest for the origin of the erector spinæ. In the last the neural arch is incomplete. The "so-called" lateral masses are made up of pleurapophyses and diapophyses coalesced with each other and with the centra.

The pelvic arch includes the hæmal arches of the first and second sacral vertebræ. The pleurapophysis is divided; one part coalesces with the centrum, the other, enormously developed, forms the ilium. The pubes is the hæmapophysis, and its symphysis is the hæmal spine.

The ischium is the hæmapophysis of the second sacral vertebra. It coalesces with the pubes, but is separated from its own pleurapophysis by the enormously expanded ilium.

The first coccygeal vertebra has a centrum, stunted neurapophyses, and zygapophyses (cornua), which join those of the last sacral vertebra. The second has only rudimentary neurapophyses besides the centrum. The third and fourth are reduced to the centra only.

Correspondence between the bones of the extremities.

The bones of the extremities tally with each other. The femur is the "homotype" of the humerus, the tibia of the radius, the fibula of the ulna.

The eight bones of the carpus are arranged in two transverse rows to give greater *breadth* for the support of the hand.

There are corresponding bones in the tarsus. Those of the second row tally bone for bone with the second row of the carpus.

But those of the first row are arranged one behind the other, for the obvious purpose of increasing the length of the foot, by the projection of the heel for the support of the body. Compare the following tables.

CARPAL BONES.

SECOND ROW.	Trapezium, trapezoides, os magnum, unciforme.
FIRST ROW . .	Scaphoides, lunare, cuneiforme, pisiforme.

TARSAL BONES.

SECOND ROW.	1. Ento Cuneiforme. 2. Meso Cuneiforme. 3. Ecto Cuneiforme. Cuboides.
FIRST ROW	Scaphoides Astragalus......(lunare) Os calcis.......(cuneiforme, pisiforme).

The bones of the metacarpus and phalanges of the fingers correspond bone for bone with those of the metatarsus and the toes.

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