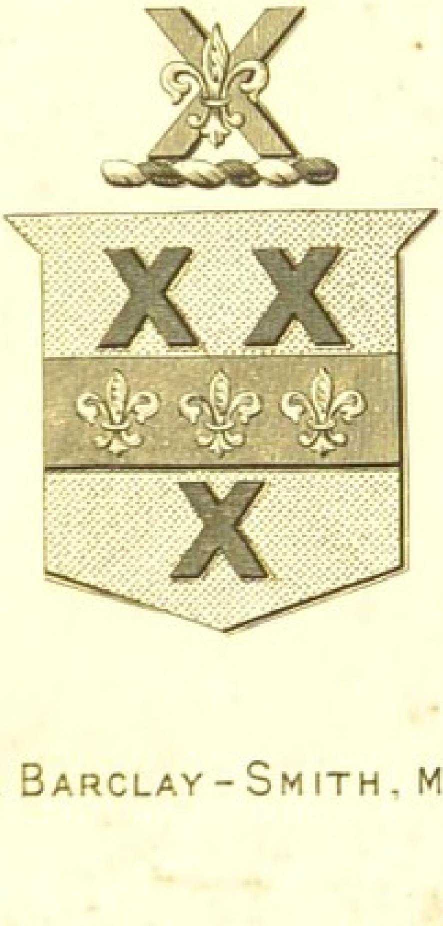
ENSHAW'S MANUA



E. BARCLAY-SMITH, M.D.

THOMPSON ON THE CHEST 3/6
SILVER'S PRACTICAL MEDICINE . . 5/0

W. J. Bruce

W. J. Brice

OUTLINES

OF

HUMAN OSTEOLOGY.

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OF

HUMAN OSTEOLOGY.

BY

F. O. WARD.

"True brevity consists, not in expressing ideas in a *small space*, but in conveying them in a *short time*."—AUTHOR'S PREFACE.

THIRD EDITION.

HENRY RENSHAW,
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COVENT GARDEN.

W. J. Bruce

PREFACE.

'HESE Outlines of Human Osteology are submitted, with eference, to the Medical Profession, as the result, partly f researches in the museum and dissecting-room, prose-uted at intervals during the last five years; partly of a ireful perusal and comparison of the best English and oreign works on the subject.

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With regard to style and language, my principal aim [i]n this work has been *brevity*. But holding that true [b]revity consists, not in expressing ideas in a *small space*, [b]ut in conveying them in a *short time*, I have not thought it inconsistent with this design to dilate freely upon some obscure and difficult points, which have been passed over in a few lines by previous writers.

The arrangement of the treatise is such that the *descriptive* and *relative* anatomy of the bones can be studied either separately, or in connexion with each other. The names of muscles, nerves, arteries, &c., are unintelligible and perplexing to the beginner who has never dissected nor seen these parts, and who finds the description of the bones themselves sufficiently complex and difficult to require his undivided attention. The advanced student, on the contrary, who refers to an osteological treatise, merely to refresh his memory, and to associate his earlier with his more recent acquisitions, finds it useful to be reminded of the names of those organs which, either by direct attachment, or by proximity, are related to the bones. To adapt the work to the necessities of these two classes of students, all names and details belonging to relative osteology have been carefully sifted out of the text, and thrown into notes at the foot of each page;—where they are as much out of the way of the beginner as if they were entirely removed from the work, and at the same time as accessible to the advanced student as if they were allowed to retain their usual position in the text. The success of Professor Partridge's Osteological Lectures, in which a similar plan is pursued, leads me to anticipate that this method of arrangement will be attended by a considerable saving of time and labour to the students who use this book.

In concluding this preface, I would draw the attention of anatomists to the prejudicial tendency of the custom now prevalent in our medical schools, of disconnecting the study of *anatomical forms* from that of *physiological actions* and *uses*. The lectures, and the elementary treatises, from which the student derives his earliest notions of anatomical science, are, with few exceptions, devoted entirely to the minute description of organs, and afford no information as to their functions, or the purport their structure and configuration. Such a practice nnot be defended on philosophical grounds; nor is it commended, so far as I can perceive, by any practical nvenience of tuition; on the contrary, it has a direct ndency to produce in the student's mind a bent towards re technical erudition, as contradistinguished from real entific knowledge and insight. It is true, indeed, that ganic beings are to be contemplated in the *static* as ll as in the *dynamic* point of view; at *rest*, as well as *action*. But these two orders of inquiry, though per-tly *distinct*, are, nevertheless, strictly *correlative;* and very contrast in which they stand, is such as to imply eir necessary scientific co-ordination.

With the view of exemplifying a sounder anatomical thod, and of promoting its general adoption, I have roduced into this work (though put forward only as a scriptive treatise), an analysis of the mechanism and es of each organ described, and have even ventured to vote about one hundred pages to original observations d experiments on the dynamic branch of the subject. re space, indeed, would willingly have been given to se topics, but for the fear of diminishing the practical lity of the work by too great an extension of its limits, too sudden a deviation from established usage. An portant object will, however, have been attained, if the ok, as it stands, should procure a more general assent the opinion, that *anatomical description* and *physio-ical explanation* should always go side by side; and it the study of *facts* ought not, in any case, to be dis-vered from that of *relations* and *laws*.

PREFACE

TO

THE THIRD EDITION.

This Edition has undergone a careful revision, and its statements of fact have been put to the test of a renewed comparison with the actual facts of Nature; and I trust that it may maintain the character for truth which, during forty years of service, it has gradually attained. The Introduction has also been extended, and brought into closer conformity with the results of recent histological research. The enlarged typographic form will, I hope, render it easier of perusal than the preceding issues: and should my life be spared to see further editions called for, I trust to improve each in succession.

F. O. Ward.

London, *October*, 1875.

W. J. Bruce

INTRODUCTION.

1. The human skeleton consists of a central *column*, of three great *cavities*, and of four *extremities* or *limbs*. The cavities are connected, one with each end of the column, and the third with its centre; and the four extremities are attached in pairs, two to the middle, and two to the lowest cavity. The column is called the *spine;* the upper cavity the *skull;* the middle the *thorax;* the lowest the *pelvis;* the upper extremities the *arms;* the lower the *legs*.*

2. The adult skeleton contains 208 separate pieces; of which twenty-four belong to the spine, thirty to the skull, twenty-six to the chest, four to the pelvis, sixty-four to the two upper, and sixty to the two lower extremities. In this enumeration, the *sesamoid*, *Wormian*, and other irregular bones are excluded; as also are the *teeth*, which are organs *sui generis*, differing from bones in structure, organization, and mode of growth. The series

* Philosophically considered, the cranium above, and the sacrum and coccyx below, are prolongations of the spinal column. The bones of which they consist are *vertebræ;* modified indeed for special functions, changed more or less in their proportions and mode of connexion, but still retaining certain general analogies to the pieces of the spinal column, which render it impossible to doubt that they are all moulded in one common type. These, however, are views belonging to transcendental anatomy; interesting as speculations, but not of practical importance; and therefore inconsistent with the design and limits of an elementary work. Some writers, indeed, have made a sort of compromise between philosophical accuracy and practical convenience, by connecting the *sacrum* and *coccyx* with the spine, while they describe the *cranium* as an independent cavity. I have retained the old division on account of its simplicity and clearness; and forty years' experience of the general approval and acceptance of this treatise, and of its constantly widening sale, bear witness to the advantage of its present form. Students wishing to enter more deeply into the transcendental aspect of osteology, will find a useful guide in Holmes Coote's "Homologies of the Human Skeleton."

of little bones in the ear, minute as they are, are counted as so many separate bones; save only that the *lenticular* ear-bone is often regarded as an appendage of the *incus*, and the *sphenoidal turbinated* of the *sphenoid;* while the *sacrum*, the *coccyx*, *hyoides*, *spheno-occipital*, and other bones originally formed in several pieces which subsequently unite, are counted as single bones.

The spheno-occipital is divided for convenience into two parts, which are usually counted as separate bones. If this artificial subdivision be admitted, there are thirty-one bones in the skull, and 209 in the skeleton.

3. The two expressions *osteology* and *skeleton*, are each of them derived from the Greek: the former, from ὀστέον (in our letters *osteon*), *bone*, and λόγος (in our letters *logos*), *discourse;* whence the Greek composite name ὀστεολογια, and our transcript thereof, *osteology*, the *science of bones*. The expression skeleton is usually described to mean the general framework, as formed collectively by all the bones; but its etymological derivation shows this definition to be neither quite correct nor quite complete. The word comes from the Greek verb σκελλω (in our letters *skello*), to *dry;* and it is only by aid of a series or "*set*" of bones, artificially prepared by a desiccating process, that a clear view can be obtained of the dimensions, shape, prominences, depressions, articular surfaces, and other peculiarities of the bones. And, without this preliminary knowledge, as its fundamental basis, the anatomy of the soft parts cannot be properly pursued.

4. The forms of the bones, varying with their purposes, afford a natural classification into *long*, *short*, *flat*, and *mixed* bones. The *long* bones form the strong levers of the extremities: the *short* or *cuboid* bones are employed where many joints are required, as in the spine; or where force is to be distributed over oblique surfaces, as in the carpus and tarsus: the *flat* bones generally form the walls of cavities, and are exemplified in the cranium and pelvis. The shapes of these three classes of bones are sufficiently indicated by their names; the *mixed* are so called because they partake of the characters of the long and of the flat bones, being extended in two of their dimensions considerably more than in the third. Such are the *sternum* and *ribs* in the chest, and the *lower jaw* in the skull.

5. Bone-tissue is composed, in nearly equal proportions by weight, of *organic* and *inorganic* ingredients; the former termed *bone-cartilage* or *ossein*, the latter consist-

ing chiefly of tribasic phosphate of lime and magnesia, and of common chalk, with small percentages of fluoride of calcium, chloride of sodium, sulphate salts and silica. These mineral ingredients do not form granular deposits visible to the eye, but are diffused as an impalpable fine powder throughout the bony tissue. We do not yet know whether the nature of the combination be of a chemical or physical nature; though experiment has shown that we may withdraw, at will, either the ossein of bones, leaving the mineral compounds intact, or, conversely, wash out the mineral constituents, leaving the ossein behind. In both experiments the material left preserves the original form of the bone, but with a very different effect in each case. When the ossein is removed, the mineral ingredients are left, robbed of all toughness and entirely inelastic and brittle; whereas, conversely, when the earthy compounds are washed away, the ossein remains, tenacious and flexible in every sense, but having very little resistance to the blade of a cutting instrument. For removing ossein, ebullition with plain water suffices; the effect being first to convert the insoluble ossein into soluble gelatin, which is washed out; while dilute solutions of acids decompose the chalk and drive out its carbonic acid, and dissolve its lime; and also remove two-thirds of the basic ingredients of the tribasic phosphates, and thus leave soluble monobasic phosphates, which are taken up by the water and carried away.

6. The interior structure of the bones, as displayed by their mechanical section, shows, in different bones and in different parts of the same bone, very different degrees of *substantiality;* some parts, solid and thick, being called *compact*, while others are of reticular or spongy disposition, full of small cavities, and designated *cellular*. These two forms of bone-structure are shown in conspicuous contrast in the upper end of the femur, when cut through the head, neck, and great trochanter, and down along the shaft; and this shaft is a cylindroid hollow, enclosed by a thick wall of *compact* bone, of oval contour; and this wall, as it ascends, spreads in trumpet-mouth fashion, and thins off to a mere lamina of paper-like tenuity, which encloses the articular surface of the head, and covers the back of the great trochanter. From the inner side of the shaft and trochanter, the neck of the femur stands, strongly rooted, in the trochanter above, and the expanding

shaft below; and the wall of the neck, thick at the root, thins off as it advances to the articular head, which it carries. Within the large cavernous space thus formed, is a mass of *cellular* bone—partly fibrous, partly lamellar, rising under the trochanter in pointed arches, branching and intersecting each other; and, in some parts, thickened into rib-like or rafter-like forms, which afford additional strength: while other fibres shoot out along the neck, and intersect and tie back the fibres that support the head of the bone; at intervals between these thickened parts, there are light, cavernous spaces, traversed only with thread-like fibrillæ, to give lightness and expansion where strength is not required at cost of extra weight. And below, in the interior of the shaft, a similar light cellular structure, partly lamellar, partly fibrillous, to assist in upholding the medulla; and, although, in different examples, the details of this intricate web-work vary, it is very curious and beautiful to trace, amidst the irregularities that seem at first to prevail, the operation of a general law—lines of force and stiffness, lines of elasticity and pliancy, lines of tenacity, and lines for distributing shocks. In the great articular condyles, at the lower end of the femur, similar mechanical principles of adjustment are observed, and similar explanations, *mutatis mutandis*, are applicable. And it may be added that the expansion and lightness of the ends of the femur give to the gliding surfaces of the joints wider bearing spaces, less pressure, less friction; and, in the various modes of progression (as in walking and running), the lightness of the limb obviates inertial resistance, at each swing of the limb, and so economizes the runner's muscular energy, and promotes his speed. These facts illustrate the mechanical advantages that attend the combined use, in bone-structure, of *compact* and *cellular* material in due relative proportion.

7. The bones are enveloped externally by a dense fibrous tissue, called the *external periosteum;* and this membrane turns down through the canals that admit blood-vessels into the cavity of the bone, and it lines their interior walls, and forms a more delicate and vascular membrane, called the *endosteum*, or *internal periosteum*. The compact parts of bone are traversed by canals called *Haversian*, which are occupied by blood-vessels, nerves, and lymphatics. The large cavities of the bones, such as those of the long-bone shafts, and the spaces of their cellular-tissue, are filled with soft material called in com-

mon parlance *marrow*. This, in the cellular tissue of bones, abounds in vessels, nerves, and lymphatics. The cavities also abound in *medulla*—a delicate connective tissue, traversed by blood-vessels, and containing numerous cells. In the wide canals of the long-bone shafts these cells are filled with a yellow fat. In the fine cancellous parts of the bones these cells are granular, but seldom contain fat; but the whole mass is coloured red by the abundance of blood-vessels. This sort of medulla is conspicuous in the short cuboid bones, in the extremities of the long bones, in the diploë of the flat and mixed bones, in the apophyses—in brief, in all the finely reticulated parts of the bones; and these medullary cells have a curious pulsating movement, expansive and retractile, resembling the motion of the *amœba*, and therefore called *amœbic*.

Under microscopic examination the osseous tissue displays two very characteristic features, the *matrix* and the *bone-corpuscles*. The *matrix* is a clear cartilaginous substance traversed by the Haversian canals, small channels referred to above. (See Par. 7.) The *bone-corpuscles* are minute cavities of lenticular form, which send out numerous canaliculæ, radiating, ramifying, and often anastomosing with each other; some opening into the medullary canals; some ending at the exterior surface of the bones; some having pointed, blind extremities. These *canaliculæ* contain minute floating bodies, regarded as germs, of *osteogenetic* properties—*i.e.*, as conducive to the generation of bone.

The bones are, with few exceptions, developed from a cartilaginous skeleton laid down at an early period. The cartilaginous bones resemble in form the definitive osseous bones which follow; and they have a similar matrix and corpuscules. Their transformation from cartilage into bone proceeds from certain points, called *points* or *centres of ossification*. In these centres appear tubes (cartilage canals) filled with a soft cellular mass, which receives blood by minute vessels from the perichondrium. The cartilage in and around these ossification-centres is supplied with lime-salts, and the white, firm character of bone appears. Spaces dilate around, filled with medullary matter containing blood-vessels. The adjacent cartilage is, in part, absorbed; and the impregnation with lime becomes more complete. The neighbouring cartilage becomes transparent, and shows compressed and flattened cells; to which succeed clear and large cells containing beautiful nuclei. These cells are arranged in rows, separated from each other with vertical trabeculæ of matrix; and where these trabeculæ do not exist, the cells touch each other. Sometimes the cells shrivel, and transverse trabeculæ stretch across like rings of a ladder supporting them, forming a very delicate structure. Beyond this, lime-salt-deposits in granules appear on the trabeculæ; and calcified cartilage appears in the form of rings, each surrounding one or several large cells; which shrink and appear as granules, much smaller and more numerous than the cells. Beneath these appear masses of protoplasm, each containing two or more average nuclei, and many of smaller size. Next appear granular cells, having processes, and forming an epithelium-like layer on the trabecular surfaces. Herein are seen delicate cells, fusiform and stellate, with other cells coarsely granulated, and blood-vessels.

Such are the anatomical aspects of the ossification of cartilage and the development of bone. Whence, how, by what activities do these changes arise? These are physiological questions, which do not belong to us here. Nor have we space to pursue the two other modes of ossification, membranous and periosteal. They go too far into histological details for our present purpose. They may be studied in Stricker's work quoted in the note below.

8. The reparation of bone, when broken, takes place by periosteal ossification. A cartilaginous capsule, called the *provisional callus*, forms in about a fortnight around the fractured part of the bone. This callus begins to ossify after three weeks, in five or six weeks it becomes entirely bone. The osseous case thus gained acts as a splint, adheres to each broken part, and holds them together; while the *definitive callus* is forming by ossification between the contiguous ends of broken bone, and thus its ossific continuity is restored. Meanwhile, the provisional callus, in proportion as it is less required, gradually shrinks; so that at the end of eight or nine months, the bone is found to have regained its normal size and strength; and its cavity, which was at first obliterated, gradually reappears.*

* For a more detailed account of the structure, development, and reparation of bone, and its microscopic features, the student is referred to Stricker's "Manual of Histology," produced by him with the aid of numerous collaborators, and published in England by the New Sydenham Society in 1870, with excellent engravings of the appearance of the osseous tissue, when submitted, in section, to microscopic examination.

8*a*. The terms used in osteology have reference to the size, shape, and situation of the object under description. Many of them are used in the common sense; some are technical, and require explanation. An articular cavity that is hemispherical is called *cotyloid;* one that is broad and shallow is called *glenoid;* if grooved like the wheel of a pulley, it is said to be *trochlear;* if nearly flat, it is called a *facet;* if deep and conical, it is called a *socket* or *alveolus*. Of processes, some are *serrated*, like the teeth of a saw; others *mastoid*, or nipple-like; *odontoid*, or tooth-like; *styloid*, pointed like an ancient pen; *coracoid*, curved like a crow's beak. There are, besides these, *prominences, tuberosities, tubercles, trochanters, and condyles;* with *lines, ridges, crests*, &c.; all of which have received accurate definitions, with which, however, we shall not trouble the student, as they are not very rigidly adhered to in practice. Again, we have *notches, holes, canals, clefts, and grooves*, which require no explanation; with *sinuses*, which are chambers, whose entrances are narrower than their cavities; and *fossæ*, in which, on the contrary, the aperture is wider than the interior.*

9. The skeleton is placed for description in the erect posture; the toes are turned forward, and the arms hang by the sides with the palms of the hands directed forward, and the thumbs turned outward. Terms expressive of situation, as *internal, external*, and the like; and of direction, as *inward, outward*, &c.; are used with reference to an imaginary line, called the *median line*, which is supposed to pass vertically through the head, down the centre of the trunk, to terminate between the feet. I have found it convenient, in describing the flat bones of the skull, chest, and pelvis, to use the terms *interior* and *exterior*, to intimate the position of their surfaces with reference to the centre of the cavity which they contribute to form; reserving the terms *internal* and *external* to express, as usual, their relation to the median line. The *direction* of a process is indicated by a line, connecting the centre of its base with its summit; the *direction* of a surface, whether plane or curved, is indicated by a line drawn perpendicular to its centre; the *inclination*

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* Many of these terms are used indiscriminately. Thus the sphenoidal *fissure* is also called the anterior lacerated *foramen;* the internal orbitar, the round, and the condyloid *holes*, are in fact *canals;* and the nasal *fossæ*, according to the definition, should be called *sinuses*.

of a surface is indicated by a line drawn parallel to it. Great confusion has been introduced into anatomical descriptions, otherwise accurate and perspicuous (those, for instance, of Cruveilhier and Cloquet), by using the term *direction*, sometimes in its proper sense, and sometimes to signify the *slope* or *inclination* of a surface. There is another source of ambiguity against which the student must guard. In describing the bones of the extremities, one is apt to use the terms internal and external with reference to the median line of the particular limb under examination; to consider a subcutaneous surface *external*, and one that is buried under muscles in the centre of the limb, *internal*. This meaning is never admitted; the subcutaneous surface is internal, if (as in the *tibia*) it be nearest the median line of the body; and the deep surface is external, if most remote from that line.

9a. The surfaces by which bones unite are called *articular;* and the place of junction, or joint, between any two bones, with its accompanying apparatus of ligament, cartilages, synovial membrane, &c., is called an *articulation*. The knowledge of the articulations involves that of the ligaments; a study which requires dissection. For this reason the study of the joints has been separated from osteology, and made a distinct branch of the science. As, however, we shall occasionally have to allude to their mechanism, a list of the classes into which they are divided, with their names and distinctive characters, is subjoined in a tabular form. (See pp. 7 and 8, infra.)

10. From these general explanations we proceed to the demonstration of the individual bones, which will be described in the following order: first, those of the *spine*, or central column of the body; next, those of the three great cavities, *skull, thorax,* and *pelvis*, in succession; and finally, those of the *extremities, superior* and *inferior*.

TABLE OF THE ARTICULATIONS.

1. SYNARTHROSIS. (συν, with; αρθρον, a joint.) Immovable articulation. Has surfaces connected by a thin plate of cartilage, not provided with a synovial membrane, and incapable of moving on each other.	SUTURA. (*a seam*) articulation by processes and indentations interlocked together.	VERA. (*true*) formed by indented borders.	DENTATA. (*dens*, a tooth) having long tooth-like processes.
			SERRATA. (*serra*, a saw) having fine processes like the teeth of a saw.
			LIMBOSA. (*limbus*, a selvage or margin) having bevelled or oblique margins.
		NOTHA. (*bastard* or *false*) formed by rough surfaces.	SQUAMOSA. (*squama*, a scale) formed by thin wide margins overlapping each other like the scales of a fish.
			APPOSITA. (*appono*, to apply) formed by the simple apposition of contiguous surfaces. This suture is commonly called *harmonia*.
	SCHINDYLESIS. (σχινδυλησις, a fissure) articulation by the reception of a thin plate into a cleft or fissure.		
	GOMPHOSIS. (γομφος, a nail) articulation by the insertion of a conical process into a socket.		

2. DIARTHROSIS.
(διa, through; αρθρον, a joint) movable articulation. Has smooth cartilaginous surfaces separated by a membranous bag which secretes an oily fluid called *Synovia*.

ARTHRODIA.—Gliding joint.
(αρθρον, a joint) articulation by plain surfaces which glide upon each other.

ENARTHROSIS.—Ball-and-socket joint.
(εν, in; αρθρον, a joint) articulation by a globular head received into a cup-like cavity, and capable of turning in all directions.

GINGLYMUS.—Hinge joint.
(γιγγλυμος, a hinge) articulation by surfaces fitted together so as to permit motion only in one plane.

AXONOIDES.—Pivot joint.
(αξων, an axle or pivot; ειδος, form) articulation by a pivot-like process turning within a ring. This joint is commonly called *lateral ginglymus*, or *diarthrosis rotatorius*.

3. AMPHIARTHROSIS.
(αμφι, on all sides; αρθρον, a joint).

Mixed articulation. Has surfaces connected by a fibro-cartilage, not separated by a synovial bag, but capable of limited motion in every direction. It resembles diarthrosis in its mobility, synarthrosis in the continuity of its surfaces and the absence of a synovial sac.

CHAPTER I.

OF THE SPINE.

11. The spine is a flexuous column, consisting of twenty-four segments, called *vertebræ*, whose slight motions on each other give it considerable pliancy. It consists of two parts, which differ in form and function; an *anterior*, solid, for support: a *posterior*, hollow, for reception. The anterior solid part, or pillar, rests on the pelvis below, sustaining the chest in the middle, and the head above. The posterior cavity, or canal, lies parallel to the pillar, lodging a nervous cord,* which extends from the head to the sacrum, at the lower end of which it dwindles and disappears. Each vertebra, therefore, presents a segment of a pillar in front, a segment of a hollow cylinder behind. The former is called the *body*, and the latter the *arch*. The arch is formed by two *pedicles* and two *laminæ;* it supports seven *processes*, presents four *notches*, and, by uniting with the body, forms the *vertebral hole*. These several parts present, in every vertebra (with certain exceptions, which will afterwards be given), the following characters.

COMMON CHARACTERS OF THE VERTEBRÆ.

12. Body. Convex from side to side, and concave from above downward, in front; flat from above downward, and slightly concave from side to side behind, where it contributes to form the vertebral foramen; above and below, slightly concave, bordered with a kind of rim, and marked with the rough impressions of the intervertebral fibro-cartilages (13). The body presents several large vascular apertures behind, and a few smaller in front. As the spine tapers from below upwards, in a general sense, but, in some parts, tapers in the opposite direction, so also, of course, the body of each vertebra, tapers upward or downward, according to its position in this osseous chain. Pedicles. Project backward from the body, one on each side, at the upper part of the line of junction between the posterior and lateral surfaces. They form part of the arch, support the processes, and connect them with the body. Notches. Four in all. Two scooped out of each pedicle; one above, the other below. The lower are always the deeper. The notches, by their union, form the *interver-*

* The spinal cord.

tebral foramina (26). PROCESSES. Four *articular*, three *non-articular.*

Articular.

Two *superior*, having an articular surface always directed more or less backward.

Two *inferior*, also a little posterior to the former, having an articular surface, always directed more or less forward.

Non-articular.

Two *transverse*, passing outward one on each side, from the point where the articular processes join the pedicle.

One *spinous*, projecting backward from the centre of the arch. LAMINÆ. The two plates of bone which connect the spinous process with the pedicles. They complete the arch posteriorly, and may be regarded as the bifurcated root of the spinous process. HOLE. Bounded in front by the *body*, behind by the *arch*, i.e. by the *pedicles* and *laminæ.*

13. STRUCTURE. Body cellular, processes compact. DEVELOPMENT. By three points: one for the body, two for the arch. The tips of the processes are at first cartilaginous, then ossify and form separate epiphyses,* and subsequently form an intimate union with the rest of the bone. ARTICULATIONS. Each vertebra articulates, by its body and articular processes, with the vertebræ adjacent. A substance, called the intervertebral fibro-cartilage, which is elastic, like a cushion, in the middle, tough and fibrous at the circumference, is interposed between the bodies, binding them together, and allowing them some play both in the lateral and longitudinal directions, while the articular processes glide on each other by their cartilaginous surfaces. The body, laminæ, and processes are bound together by ligaments.

14. Of the twenty-four vertebræ, twelve are connected with the ribs, and contribute to form the thorax. These are called *dorsal.* Above the dorsal are seven smaller, belonging to the neck, and called *cervical;* below the dorsal, five larger, belonging to the loins, and called *lumbar.* The vertebræ of each region are distinguished

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* An *epiphysis* is a process developed as a distinct piece, and remaining for some time movable on the body of the bone, by the intervention of cartilage; an *apophysis* is a process that has never been separate from, or movable upon, the bone to which it belongs. The first term is derived from επιφυσις, an *ac*-cretion, something that grows *to* another: the second from αποθυσις, an *ex*-crescence, something that grows *from* another.

by peculiar characters. But as every vertebra bears a pretty close resemblance to the vertebræ immediately above and below it, the several regions merge, by an insensible transition, into each other; the seventh cervical assuming many of the characters of a dorsal; the twelfth dorsal, of a lumbar.

COMMON CHARACTERS OF THE VERTEBRÆ IN EACH REGION.

15. LUMBAR. The largest of the vertebræ. BODY. Greatest dimension the transverse; flat above and below; thicker before than behind. PEDICLES. Strong, and directed straight backward. NOTCHES. Deep and large, especially the lower. PROCESSES.

Articular.

The two *superior* are concave, look inward as well as backward, and are further apart than the

Two *inferior*, which are convex, and directed outward as well as forward.*

Non-articular.

Transverse. Thin, long, directed a little backward; sometimes terminated by an epiphysis, like a small rib.

Spinous. Broad, square, horizontal; thicker below than above. LAMINÆ. Broad and strong, but short. HOLE. Triangular; wider than in the dorsal, smaller than in the cervical region.

16. DORSAL. Next in size to the lumbar. BODY. Somewhat triangular in form; most extended in the antero-posterior dimension, and thicker behind than before. Its *posterior* surface is concave transversely; on each *lateral* surface, near the root of the pedicle, are two demifacets—one above, the other below—which, in the recent state, are covered with cartilage. When two dorsal vertebræ are applied, the upper facet of one and the lower of the other join to form a single cavity, which receives the head of a rib. NOTCHES. Smaller than in the lumbar, larger than in the cervical. PROCESSES.

Articular.

Flat; the two *superior* are directed upward and outward, as well as backward, and are very little in advance of the *inferior*, which have the opposite direction.

Non-articular.

Transverse. Long, thick, directed backward and a little

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* It is a general rule that the upper and lower articular processes of any vertebra look in opposite directions.

upward, as well as outward, with a clubbed extremity, bearing a concave cartilaginous facet, which is directed forward, outward, and upward, to articulate with the tuberosity of a rib.

Spinous. Long, inclined downward, prismatic, tubercular at the end. LAMINÆ. Broader and thicker than in the cervical. FORAMEN. Round, or slightly oval, and smaller than in the cervical and lumbar.

17. CERVICAL. The smallest of the vertebræ. BODY. Greatest dimension transverse, thicker before than behind, and on the sides than in the middle. Its *posterior* surface is flat; its *upper* surface is very concave transversely, slightly convex from back to front, with a little lip projecting upward on each side; its *lower* surface presents opposite characters, being convex transversely, concave from before backward, and furnished on each side with a shallow depression, to receive the corresponding lip of the adjacent vertebra. The lower surface of each cervical vertebra is *smaller* than the upper surface of the vertebra below, being embraced, when *in situ*, by the lips of the latter. The body is here also on a lower level, with regard to the processes, than in the dorsal and lumbar regions. PEDICLES. Directed very much outward, so as to give the arch a wide sweep. NOTCHES. More equal in depth above and below than in the dorsal and lumbar regions. The upper is continuous with a groove in the transverse process. PROCESSES. *Articular. Upper.* Flat, oval, directed upward and backward. *Lower.* Same characters, opposite direction. *Non-articular. Transverse.* Short, directed forward and a little downward, as well as outward; bifid at the summit, marked above by a groove, which runs downward and outward from the upper notch, and lodges a nerve,* perforated at the base by a hole for the transmission of an artery.† It arises by two roots; a posterior, larger, attached to the pedicle; an anterior, smaller, connected with the side of the body. It is between these that the arterial hole occurs. *Spinous.* Short, slightly inclined downward, terminated by two branches, which are often unequal in size. LAMINÆ. Narrow, long, thinner above than below, and inclined so as to imbricate over those of the subjacent vertebra. VERTEBRAL HOLE. Very large, and of the form of a triangle, with its sides slightly curved, and its angles rounded. It is more extensive below than above, on account of the inclination of the laminæ.

* One of the spinal. † Vertebral.

DEVIATIONS FROM THE REGULAR FORM IN CERTAIN VERTEBRÆ OF EACH REGION.*

18. Of the lumbar vertebræ, the *fifth* is peculiar in having a body which is much thicker in front than behind, on account of being bevelled off, so as to form with the sacrum the sacro-vertebral angle. The *fourth* is also a little thicker before than behind. The transverse processes of this region vary in length. In the following enumeration the lumbar vertebræ are arranged according to the length of their transverse processes, proceeding from longest to shortest:—*third, fourth, second, first, fifth.* Hence it appears, that the longest transverse processes are in the middle of the region, the shortest at its two extremes. Those of the fifth lumbar vertebra are of a conical form, and, though the shortest, very strong for the attachment of powerful ligaments.†

19. Of the dorsal vertebræ, the *first, ninth, tenth, eleventh,* and *twelfth* are distinguished. FIRST DORSAL. BODY. Largest transversely, upper surface concave and lipped like a cervical (17). Instead of a demi-facet above, it has an entire articulating surface, besides which it has the usual half facet below. SPINOUS PROCESS. Thick, long, horizontal. NINTH DORSAL. BODY. No demi-facet below. TENTH DORSAL. BODY. An entire articular facet above; no demi-facet below. ELEVENTH DORSAL. BODY. Large like a lumbar, with a single entire articular surface on each side, instead of the two demi-facets. PROCESSES. *Transverse.* Very short, no articular surface at the extremity. TWELFTH DORSAL. Same characters as eleventh; still more like a lumbar, *transverse* processes shorter, lower *articular* processes convex, and turned outward like those of the lumbar.

The *fourth* is the smallest dorsal vertebra. They increase in size from the fourth downward to the twelfth; and from the fourth upward to the first. Their spinous processes become shorter and more horizontal from the eighth downward.

20. Of the cervical vertebræ, the *first, second,* and *seventh* are peculiar.

21. FIRST CERVICAL, OR ATLAS. Has no *body, spinous process,* nor *pedicles.* It consists of two lateral masses,

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* The *peculiar* or *distinctive* points only are noticed in this section.

† Sacro-lumbar and ilio-lumbar.

connected by a small arch in front, and a larger behind. The ring thus formed may be divided into fifths, of which each lateral mass occupies one, the anterior arch one, and the posterior arch the remaining two. ANTERIOR OR LESSER ARCH. May be regarded as the front of a *body*, all the hinder parts of which have been removed to make room for the odontoid process of the second vertebra (22). Anteriorly the lesser arch is convex and tubercular; posteriorly it is concave, and marked in the middle with an oval smooth surface, which articulates with a similar one on the odontoid process. It has a thin border above and below. POSTERIOR OR GREATER ARCH. Terminates behind in a tubercle, which represents the spinous process, and gives origin to a muscle.* Above, it presents *posteriorly* a rounded *edge; anteriorly*, two *grooves*, one behind each lateral mass. These are sometimes converted into perfect *holes* by a little process of bone. Each transmits an artery,† which comes up through the hole in the transverse process, and curls round backward and inward behind the lateral mass. It also transmits a nerve.‡ The posterior arch presents, below, two other grooves just opposite to the last-mentioned, and situated, like them, behind the lateral masses. These grooves represent the *notches* of the atlas, and they are peculiar in lying *behind* the articular processes. LATERAL MASSES. Present, above, the *superior*, and below, the *inferior articular processes; internally*, two *tubercles* (one on each), for the attachment of a ligament,§ which, stretching across, divides the ring into two parts; and *externally*, the *transverse processes*,‖ long, strong, not bifurcated, but clubbed at the summit, inclined downward, and perforated at the base by a canal directed from below upward, backward, and outward. ARTICULAR PROCESSES. *Superior*. Large, concave, oval, longest diameter from before backward, nearer together in front than behind by nearly a quarter of an inch, directed upward, inward, and a little backward, and articulated with the condyles of the occiput. *Inferior*. Circular, slightly concave, directed downward, inward, and a little backward, and articulated with the axis, on which the atlas rotates. DEVELOPMENT. By three

* Rectus capitis posticus minor.

† Vertebral. ‡ Sub-occipital. § Transverse.

‖ These processes give attachment to the superior and inferior oblique muscles.

points, one for the anterior arch, and one for each lateral mass. Sometimes there are two more for the posterior arch; making five points of ossification in all.

22. SECOND CERVICAL, OR AXIS. A strong triangular vertebra, with *a body* whose anterior surface is deeper than the posterior, and marked with a ridge in the middle, separating two lateral depressions, for the insertion of muscles;* while its upper surface presents in the middle a strong, vertical, bluntly-pointed, tooth-like eminence, called *the odontoid process*, which passes up into the anterior division of the ring of the atlas between the lateral masses. This process has a smooth oval surface in front to articulate with the atlas, another behind to play on the transverse ligament, and is rough above for the attachment of ligaments.† On each side of this process the upper surface of the body presents a round, slightly convex, articular surface, directed upward and outward, and supporting the atlas. These, the *superior articular processes*, are anterior and internal to the *lower* ones. They are remarkable in being supported partly by the body, partly by the pedicles, and partly by the transverse processes. SUPERIOR NOTCHES. Superficial, and placed *behind* the corresponding articular processes. TRANSVERSE PROCESSES. Very small, not bifurcated, nor grooved; the arterial hole runs very obliquely, upward, outward, and backward. LAMINÆ. Thick and prismatic. SPINOUS PROCESS. Large and strong, deeply channelled underneath, and tubercular at the extremity for the insertion of muscles.‡ VERTEBRAL FORAMEN. Kidney-shaped. DEVELOPMENT. The axis has an extra point of ossification for the odontoid process.

23. It is chiefly to the two first vertebræ of the neck that the head owes its extensive mobility. Nutation and extension of the head are performed by the motion of the occipital condyles upon the cup-like articular surfaces of the atlas. In rotation of the head from side to side (as in looking back over the shoulder), the atlas turns round upon the pivot of the axis, carrying the head along with it. The first is a hinge joint; the second resembles a mortice and tenon. Their motions may be performed separately or simultaneously; being independent both of each other and of the slight movements which take place between the remaining vertebræ of the neck. It is from the combined

* Longi colli. † Odontoid.
‡ Recti capitis postici majores, and obliqui inferiores.

or successive actions of these several joints that the diversified motions and postures of the head result.

24. Seventh Cervical Vertebra. Large; *spinous* process long, thick, and not bifurcated; holes in the *transverse* processes small, irregular, and often wanting. This vertebra has sometimes two little epiphyses, in form and situation resembling rudimentary ribs, and remaining separate to the age of five or six years. These sometimes extend outward an inch or more on each side, becoming analogous to the cervical ribs of certain animals.

OF THE SPINE IN GENERAL.

25. Size and Direction. To the length of the vertebral column, which is a third of the entire height of the body, the lumbar region contributes seven parts, the dorsal eleven, the cervical five. The lumbar, and the nine lower dorsal vertebræ, form a truncated pyramid whose base rests on the sacrum. The six lower cervical form another truncated pyramid, whose base rests on the first dorsal, and whose summit is surmounted by the atlas, on which again is balanced the globe of the cranium. Between these two pyramids, and extending from the base of the upper to the summit of the lower, intervene the four superior dorsal vertebræ, which constitute a third, but inverted pyramid. Thus, though the whole column presents a cone whose base is somewhat more than double the diameter of the summit, yet this general pyramid is composed of three subordinate pyramids. The spinal column is concave anteriorly in the dorsal region, where it contributes to form the chest, convex anteriorly in the neck and loins. It has also a slight lateral curvature, the convexity of which is generally directed towards the right side. It presents for examination four *surfaces*, a *base*, a *summit*, and a *vertebral canal*.

26. Surfaces. *Anterior.** Presents the anterior surfaces of the bodies of the vertebræ, narrow in the dorsal region, wider in the cervical, widest in the lumbar; convex from above downward, above and below; concave

* This surface of the spine is covered by the anterior common ligament; it corresponds in the cervical region to the recti capitis antici majores, and longi colli; in the dorsal region to the vena azygos on the right side and the aorta on the left; and in the lumbar region to the crura of the diaphragm, the vena cava, the abdominal aorta, and the lumbar ganglia of the sympathetic.

from above downward, in the middle; everywhere convex transversely. *Posterior.* Presents in the median line the *spinous processes*, horizontal above and below, inclined and imbricated in the middle, separated by large intervals in the loins, by smaller in the neck, by smallest of all in the back. These intervals are closed in the recent subject by ligaments.* Immediately external to the row of spines, is seen on each side the *vertebral groove*, formed by the laminæ only, in the neck and loins, where it is shallow; by the laminæ and transverse processes in the back, where it is deep. It gradually contracts in width from above downward, and in the recent state is filled by muscles.† External to the vertebral grooves are seen the *articular processes*, and external to these the *transverse processes*, which in the *dorsal* region indicate the line of junction between the posterior and lateral surfaces. The *dorsal* transverse processes stand back on a plane posterior to that which is occupied by the transverse processes of the *cervical* and *lumbar* vertebræ; which latter evidently belong to the lateral regions of the spine, though not usually referred to them by anatomists. *Lateral.* Divided from the *posterior* surface, in the neck and loins, by the line of *articular* processes, in the back, by the line of *transverse* processes. Present, in front, the *bodies* of the vertebræ, marked in the dorsal region with the articular cavities which receive the heads of the ribs. Behind the bodies appear the *intervertebral foramina*, formed by the apposition of the *notches*, oval in shape, considerably larger in the lumbar than in the cervical region, and a little larger in the cervical than in the dorsal. They are situated between the transverse processes in the neck, anterior to them in the back and loins. With the exception of the first pair (between the atlas and axis), they are anterior to the *articular* processes. They transmit nerves.‡ In the cervical region the *transverse* processes project between the intervertebral foramina, and present a series of holes, which form a canal for the reception of an artery.§ In the lumbar region they stand on a plane posterior to the intervertebral holes, but anterior to the articular processes.

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* Ligamenta subflava.

† Longissimus dorsi, sacro lumbalis, semispinalis dorsi, multifidi spinæ.

‡ The spinal.

§ The vertebral.

(In the dorsal region they are posterior both to the inter-vertebral holes, and to the articular processes. It is only in the two former regions that they belong to the lateral surface of the spine.) BASE. Presents the lower surface of the fifth lumbar vertebra, which has been already described. (18.) SUMMIT. Presents the upper aspect of the atlas, already described (21). At each extremity appears the orifice of the VERTEBRAL CANAL. This canal following the flexuosities of the spine, opens into the cranium above, into the sacral canal below. Wide and triangular in the neck and loins, it is narrow and rounded in the back.*

27. USES. The vertebral column is a remarkable piece of mechanism. Strong enough to support several hundred weight, yet pliant and elastic; furnished with levers and muscles, by which it is bent in every direction, yet lodging an organ susceptible of injury from the slightest pressure; formed, for lightness, of a loose and reticular tissue, yet capable of sustaining, without fracture, shocks, strains, and contortions, of considerable violence: this column certainly combines the most opposite qualities, and performs functions apparently incompatible.

It transmits the weight of the head and trunk to the pelvis and lower extremities; is the seat of all the motions of the trunk; gives passage to the spinal nerves; and affords attachment to numerous muscles and ligaments.†

CHAPTER II.

OF THE SKULL.

28. THE skull, a strongly framed cabinet containing several organs whose security from concussion is essential to life, rests, poised as on springs and cushions, at the summit of the vertebral column. It is divided into two parts: the *cranium* above and behind, the *face* below and in front.

The former consists of eight, the latter of fourteen

* It contains the spinal cord and its appendages.

† These are so numerous, and their attachments so complicated that anything short of a complete description would be of little service, even to the advanced student; who is therefore referred to treatises on myology.

bones. Besides these, the head contains six ossicula *auditûs*, thirty-two *teeth*, and several irregular pieces.

OF THE CRANIAL BONES.

29. Four are single and median, the *occipital* behind, the *frontal* before, the *sphenoid* and *ethmoid* interposed at the base; four lateral and in pairs, the two *parietal* above, the two *temporal* below.

OF THE OCCIPITAL BONE.

30. This bone is situated at the posterior and inferior part of the cranium, and resembles in shape a lozenge, curved upon itself. It has a posterior vertical, and an anterior horizontal portion; and presents for examination two *surfaces*, four *borders*, and four *angles*.

31. SURFACES. *Exterior*. Presents, beginning at the summit of the vertical portion, and passing round the bone downward and forward—first, a *smooth* surface, on which in the recent state a muscle* plays; secondly, the *exterior occipital tuberosity*, an eminence which is situated half way between the summit of the bone and the foramen magnum, and gives attachment to a ligament;† thirdly, the *exterior occipital crest*, a ridge passing from the tuberosity to the foramen magnum; fourthly, the two *superior curved lines*, rough semicircular ridges passing outward, one on each side, from the occipital protuberance; fifthly, the two *inferior curved lines*, passing outward parallel to the former from the middle of the crest (these ridges, with several rough depressions that lie between them, give attachment to muscles;‡) sixthly, the *foramen magnum*, a large elliptical hole, with the longest diameter from behind forward, and with a rounded shelving margin that renders it more extensive above than below; (it transmits several important organs;§) seventhly, on each side of

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* Occipito-frontalis. † Ligamentum nuchæ.

‡ The superior curved line gives attachment by its internal third to the trapezius, by its external two-thirds to the occipito-frontalis and the sterno-mastoideus. The depressions between the semicircular lines attach the complexus internally, the splenius capitis externally. The inferior curved or semicircular line, and the depressions below it, give insertion internally to the recti capitis postici, majores and minores, externally to the obliqui superiores.

§ The spinal cord and its envelopes, the vertebral arteries, and the spinal accessory nerves.

the foramen magnum, the *occipital condyles*, two oval convex articular surfaces, directed downward and outward, nearer together in front than behind, rough within for the attachment of ligaments,* smooth and cartilaginous below for articulation with the atlas, and bounded, externally by a rough tubercular surface for the attachment of a muscle,† before and behind by the *anterior* and *posterior condyloid fossæ*; depressions perforated by holes, or rather canals, which are called after them the *anterior* and *posterior condyloid foramina*.—The *anterior condyloid foramina* are always present, they run from the bottom of the anterior condyloid fossæ upward, inward, and backward, to terminate in the interior of the cranium, at the margin of the foramen magnum: each transmits a nerve.‡ The *posterior* are less regular in size, and often wanting on one side or both; they run from below, upward, forward, and a little outward; and open above, near the notch which contributes to form the foramen lacerum posterius: (69) each transmits a small artery and vein;—eighthly, in front of the foramen magnum is the *basilar surface*, rough, horizontal, broader behind them before, and presenting, in the middle a longitudinal ridge called the *pharyngeal spine*,§ on each side depressions for the insertion of muscles.‖

Interior or Cerebral. Concave and smooth; presents near the middle of the vertical portion the *interior occipital tuberosity*, exactly opposite to the exterior occipital tuberosity. This central eminence is the point where three well-marked venous channels meet; one vertical, called *sulcus longitudinalis;* two transverse, called *sulci transversales* or *laterales;* the former passing upward to the superior angle of the bone, the latter outward to its lateral angles. The longitudinal channel, which generally lies somewhat on the right of the median line, lodges a large venous canal,¶ and its margins attach a fold of fibrous membrane.**

The transverse channels likewise lodge large venous canals,†† and their margins attach another fold of fibrous

* The odontoid.

† Rectus capitis lateralis. ‡ Ninth, or hypoglossal.

§ This attaches the tendinous raphe of the pharynx.

‖ Recti capitis antici, majores and minores, behind; superior constrictor of the pharynx in front.

¶ Longitudinal sinus. ** Falx major of dura mater.

†† The lateral sinuses.

membrane.* Where these three channels meet, which is usually a little to the right of the interior occipital protuberance, there is a depression in the bone.† Passing downwards from the interior occipital tuberosity to the foramen magnum is the *interior occipital crest*, a sharp, smooth edge, bifurcated below, corresponding in situation to the exterior crest, and giving attachment to a fold of fibrous membrane.‡ The channels, and the crest, just described, divide the interior surface of the vertical portion into four *fossæ;* two superior, called *cerebral fossæ of the occiput;* and two inferior, called *cerebellar* fossæ *of the occiput.* The *cerebral* fossæ are separated from each other by the longitudinal sulcus, and bounded below by the transverse sulci; they are smaller than the cerebellar fossæ and marked with cerebral impressions.§ The *cerebellar* fossæ are separated from each other by the interior crest, and from the cerebral fossæ by the transverse sulci: they are larger than the former, and perfectly smooth.|| All these fossæ present arterial impressions. In front of the crest is the interior opening of the *foramen magnum*, more extensive than the exterior. On each side of the foramen magnum are seen the interior orifices of the *condyloid foramina*, those of the *posterior* external to those of the *anterior*, and surmounted by a little bony arch. From the posterior condyloid foramen on each side, a short but wide groove runs backward and outward; it lodges part of the same venous canal which is contained in the transverse groove, but its relations can only be understood when the cranial bones are united. (73.) In front of the foramen magnum is the *basilar groove*, a shallow longitudinal depression, which slopes from behind upward and forward, and lodges an important part of the nervous system.¶ The narrow, horizontal portion of the bone on which this depression occurs, is called the *basilar process* of the occipital. This process presents on its upper surface, besides the basilar groove, a narrow channel on each side, which unites with a corresponding channel on the petrous portion of the

* Tentorium cerebelli.
† For the reception of the torcular Herophili.
‡ The falx minor of the dura mater.
§ They receive the posterior lobes of the cerebrum.
|| They lodge the hemispheres of the cerebellum.
¶ Medulla oblongata.

temporal bone to form the *inferior petrosal groove;* which lodges a venous canal (of the same name).

32. ANGLES. The *superior* is acute; the *inferior* is truncated, being represented by the square anterior surface of the basilar process; this surface in the child is articulated with the sphenoid by cartilage, but forms a perfect osseous union with it in the adult. The *lateral* angles are very obtuse, and correspond in situation with the outer ends of the transverse grooves.

33. BORDERS. *Superior.* Extends from the lateral to the upper angle on each side, is deeply denticulated, and articulates with the parietal. *Inferior.* Extends from the lateral to the inferior angle on each side. It is divided into two parts by the *jugular* process, a short stout eminence which projects outward on each side, and has a square cartilaginous surface at its extremity, to articulate with a corresponding surface on the petrous portion of the temporal bone. (61.) Between the jugular process and the *lateral* angle, the occipital articulates with the mastoid portion of the temporal. Between the jugular process and the inferior angle, the *inferior* margin presents from behind forward, first, a *notch*, which, with a similar one on the petrous portion of the temporal forms the *foramen lacerum posterius;* this notch is often divided by a little bony process into two parts; secondly, the *side* of the *basilar* process, which is rough and broad, slopes from behind forward and inward, and articulates with the petrous portion of the temporal. These two inferior borders instead of meeting to form a true inferior angle are separated by a square surface, which has been already described.

34. STRUCTURE. Of a cellular tissue called the *diploë*, between two compact layers, called the *exterior* and *interior tables*. The *interior*, from its extreme hardness and density, has been called the *vitreous table*. The *exterior* is less dense, but tougher.*

The occipital is thick at the ridges, protuberances, condyles, &c., but in the centre of the fossæ it is so thin as to be semitransparent; at these points it is destitute of diploë, and its two compact tables come into contact. DEVELOPMENT. The vertical portion is developed by four centres of ossification, which unite, long before birth, at the protuberance. The horizontal portion is developed

* This description applies to the flat cranial bones in general.

by three ossific points, one for each condyle and a third for the basilar process. Besides these seven regular points, an additional one is observed occasionally, in the posterior part of the margin of the foramen magnum. ARTICULATIONS. With the parietal, temporal, sphenoid, and atlas, by the points mentioned.

OF THE SPHENOID.

35. The SPHENOID is a wedge-like bone, situated at the anterior part of the base of the cranium, and articulated with all the other cranial bones, which it binds together, so as to contribute materially to the strength of the cranium. It has been compared to a bat with the wings extended; and, for convenience of demonstration, may be divided into *body*, or central part; *greater wings*, and *lesser wings*, extending outwards on each side; and *pterygoid processes* projecting below.

36. BODY. Is in the adult continuous, behind, with the basilar process of the occipital (for which reason Soemmering and Meckel have described the spheno-occipital as a single bone), and presents for examination six surfaces. SURFACES. *Superior or cerebral.* Presents from behind forward—first, a square lamina, inclined forward; whose posterior aspect presents a shallow depression, continuous with the basilar groove of the occipital; whose lateral borders are notched for the passage of a nerve;* and whose two upper angles terminate in two eminences, which vary in size, shape, and direction, and are called the *posterior clinoid processes*;†—secondly, a deep depression called the *pituitary fossa*, or *sella turcica*, which is bounded behind by the lamina that has just been described, perforated, during early life, with many little foramina, which transmit nutritious vessels to the bone, and filled in the recent subject by a peculiar appendage of the brain;‡—thirdly, a small tubercle called the *olivary process*;—fourthly, a shallow transverse depression, which ends at each side in the *optic foramen*: it lodges a nerve,§ and is called the *optic groove*:—fifthly, a smooth surface, presenting in the median line, a slight longitudinal eminence separating two shallow depressions, which receive two nerves.‖ This surface is prolonged forward

* External oculo-muscular.

† They attach the tentorium cerebelli.

‡ Pituitary body. § Optic commissure. ‖ Olfactory.

into a sharp angle, which articulates with the ethmoid bone, and is called the *ethmoidal process*. On each side of the body, just external to the sella turcica, there is a shallow depression, which first passes from behind and below, vertically upward; then runs horizontally forward; and then bends upward again. It lodges a venous sinus,* and a large artery.† It is called the *cavernous groove*. *Posterior*. Quadrilateral; covered with cartilage and articulated with the basilar process of the occipital during childhood; continuous with that bone in the adult. *Anterior*. Presents the opening of the cavity by which the body is hollowed. This cavity is divided by a vertical plate into two parts, called the *sphenoidal sinuses*. These sinuses do not exist in children, and their dimensions increase with age. Their form is various; they are often subdivided by irregular osseous laminæ, and the septum is frequently inclined to one side, or incomplete, or perforated by a hole. Their anterior and inferior walls are partly formed by two thin curved plates, originally separate, afterward adherent, and called the *sphenoidal turbinated bones*. Their orifices, contracted by these plates, open into the nasal fossæ. *Lower*. Presents, in the centre, a prominent triangular spine, called the *rostrum*, and, on each side, a deep *groove*, covered by a horizontal projecting *lamina*. These parts serve, as will be hereafter explained, to fix on the vomer (106.) External to the lamina on each side, a small groove runs from behind forward; it is sometimes partially converted into a canal by a thin plate of bone: it is completed in the articulated skull by the sphenoidal process of the palate-bone, (89) transmits vessels,‡ and contributes to form the pterygo-palatine canal. (89.) *Lateral*. These surfaces are smooth and even, they give attachment to the greater wings below, to the lesser wings above and in front, and are marked by the cavernous grooves already described.

37. Greater Wings. Two strong processes, which arise from the sides of the body, pass outward a little way, and then curve upward. They are also prolonged backward posteriorly, into a sharp angle called the *spine of the sphenoid*, which fits into the retiring angle formed by the squamous and petrous portions of the temporal bone, and is prolonged downward into a sharp eminence for the

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* Cavernous. † Carotid. ‡ Pterygo-palatine.

attachment of a muscle* and a ligament.† The greater wing presents for examination three surfaces, and a circumference. SURFACES. *Superior.* Concave and marked by cerebral impressions and arterial grooves.‡ Presents, at its internal part, proceeding from behind forward, first, the *foramen spinosum*, a short canal (sometimes double), which pierces the projecting angle that has been described as the *spine of the sphenoid*, and transmits an artery;§ secondly, the *foramen ovale*, which is much larger, and transmits a nerve,|| and thirdly, the *foramen rotundum*, which strictly speaking is a *canal;* it is directed forward and a little outward, and transmits a nerve.¶ There is sometimes seen, internal to the foramen ovale, a little hole, the orifice of a canal that descends to the pterygoid fossa (39), and transmits a small vein; it is called the *foramen Vesalii*. *Inferior.* Convex, and divided by a transverse ridge into two portions; a *superior*, larger, concave, from before backward, convex from above downward, furrowed by arteries,** covered by a muscle,†† and belonging to the *temporal* fossa; an *inferior*, smaller, concave, belonging to the *zygomatic* fossa, and also covered by a muscle.‡‡ It presents the lower orifices of the foramina, *spinosum* and *ovale*, and quite at its posterior part, the irregular pointed eminence into which the spine is prolonged below. *Anterior.* A smooth, quadrilateral surface, directed forward and inward, forming the chief part of the outer wall of the orbit, and thence called the *orbitar plate of the sphenoid.* It is bounded *externally* by a serrated margin, which articulates with the malar bone; *below* by a rounded border, which contributes to form the spheno-maxillary fissure; *internally* by a sharp edge, which forms the lower boundary of the sphenoidal fissure, and presents at its upper part a *notch* (sometimes a hole) for the passage of an artery;§§ and *above* by a triangular serrated surface, which articulates with the frontal bone. The orbitar plate sometimes presents at its upper part one or two small holes, which are called *external orbitar*

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* Laxator tympani.
† Internal lateral of lower jaw.
‡ Formed by the meningeal artery.
§ Middle meningeal.
|| Third division of 5th.
¶ Second division of 5th.
** Deep temporal.
†† Temporal.
‡‡ External pterygoid.
§§ A branch of the ophthalmic.

foramina, and transmit small arteries.* CIRCUMFERENCE. From the body to the spine of the sphenoid, the greater wing presents a short thick margin, the outer half of which articulates with the petrous portion of the temporal; while the inner half contributes to form the *foramen lacerum medium* (69), and presents the posterior orifice of the *vidian canal* (39) (surmounted by a little triangular process, which, when the bones are united, divides the foramen lacerum medium into two parts). External to the spine, the circumference of the greater wing presents a concave serrated border which articulates with the squamous portion of the temporal. It is bevelled at the expense of the inner surface below, and of the outer surface above, so that these bones mutually overlap each other. At the tip of the greater wing is a short margin, which is bevelled at the expense of the inner surface, and articulates with the anterior inferior angle of the parietal. Anterior and internal to this, the circumference presents a serrated triangular space, which separates the three surfaces of the greater wing, and articulates with the frontal: it forms the *upper* boundary of the orbitar plate, and is continuous internally with a thin margin, which is the *inner* boundary of the orbitar plate, and contributes to form the *sphenoidal fissure*. This margin, running downward and inward, joins the body of the sphenoid, and completes the circumference of the greater wing.

38. LESSER WINGS, OR PROCESSES OF INGRASSIAS. Two small pointed processes, each of which rises from the side of the body (at a point anterior and superior to the origin of the greater wing) by two roots, between which is the *optic foramen*, a round hole directed forward, outward, and a little downward, for the transmission of a nerve† and an artery.‡ The *upper* root is thin and horizontal; the *lower* is thick, oblique, often hollowed by a cavity which forms part of the sphenoidal sinus (36), and marked in front by a little *tubercle* which attaches a tendon common to three muscles of the eye.§ They support a triangular plate of bone, which has two *surfaces*, two *borders*, and two *extremities*. SURFACES. *Superior*. Is smooth, wider internally than externally, and forms part

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* Branches of the middle meningeal, one of which supplies the lachrymal gland.

† Optic.

‡ Ophthalmic.

§ Internal, external, and inferior recti muscles of the eye.

of the anterior fossa of the floor of the cranium. *Inferior.* Resembles the former in shape, contributes to the roof of the orbit, and forms the upper boundary of the *sphenoidal fissure*, or *foramen lacerum anterius;* which is a triangular fissure, lying, apex outward, between the greater and lesser wings of the sphenoid, and forming a communication between the cranium and orbit. BORDERS. *Posterior.* Concave and rounded, corresponding to a fissure of the brain.* *Anterior.* Convex, and bevelled at the expense of the lower surface, to overlap the orbitar plate of the frontal, with which it articulates. EXTREMITIES. *Outer.* Terminate in thin sharp points. *Inner.* Are thick and blunt, and extend backward over the sella turcica, under the name of the *anterior clinoid processes;* they frequently unite with the posterior clinoid processes.

39. PTERYGOID PROCESSES. Each projects vertically downward from the point where the body and greater wing unite. It is hollowed behind by the *pterygoid fossa*, which is filled by a muscle,† and divides the process into two *laminæ*, an *external* and an *internal*. The *external lamina* is wider, shorter, and turned a little outward; its outer surface belongs to the *zygomatic fossa* (138), and gives attachment to a muscle;‡ and its inner surface contributes to the *pterygoid fossa* just mentioned. The *internal lamina* is much narrower and longer, quite parallel with the median plane, and curved outward below into the *hamular process*, a little hook round which a tendon§ turns; by its outer surface it contributes to the *pterygoid*, by its inner to the *nasal* fossa; while its posterior edge forms the outer boundary of the posterior aperture of the nasal fossa, and gives attachment to a muscle.‖ This plate moreover presents at its upper part the *scaphoid depression*, an oval shallow cavity, which gives insertion to the muscle,¶ whose tendon plays round the hamular process. Above the scaphoid depression is seen the posterior orifice of the *vidian canal*, which perforates the root of the pterygoid process from before backward, and transmits vessels and nerves of the same name. The pterygoid process presents in front, from above downward; first, the *anterior* orifice of the vidian

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* Fissura Sylvii.
† Internal pterygoid.
‡ Internal pterygoid.
§ Of the circumflexus palati.
‖ Superior constrictor of the pharynx.
¶ Circumflexus palati.

canal; secondly, a *margin* which articulates with the perpendicular plate of the palate bone (89); and thirdly, a cleft (formed by the bifurcation of the two plates), into which the tuberosity of the palate bone is received. Superior and external to the anterior aperture of the *vidian canal* appears the anterior orifice of the *foramen rotundum;* a relation which it is important to remember.

Structure. Cellular in its thicker parts; elsewhere compact. Development. By seven points: one for the body; one at the base of each lesser wing; one at the root of each pterygoid process; and one for each internal pterygoid plate. The sinuses are gradually developed by age. Articulations. With the ethmoid, frontal, parietal, temporal and occipital bones; also with the vomer, sphenoidal turbinated, malar, and palate bones. Sometimes, moreover, it joins the upper maxillary, by the anterior border of the pterygoid process, or by the orbitar plate (85).

OF THE ETHMOID.

40. The Ethmoid is a light cubical bone, situated at the anterior part of the base of the cranium, and consisting of a *vertical plate*, which forms part of the septum of the nose; *a horizontal plate* contributing to the base of the cranium; two *bundles of cells* hanging from the sides of the horizontal plate; and an eminence called the *crista galli*, projecting into the cranium.

41. Horizontal, or Cribriform Plate. Fills up the ethmoid notch of the frontal bone, and presents above; first, in the middle a triangular crest of variable size and form, called the *crista galli*. The lower border of this crest joins the cribriform plate; the posterior, long, thin, and slanting, gives attachment to a fold of fibrous membrane:* the anterior, short, thick, and vertical, articulates with the frontal bone. Its summit presents two little eminences, which generally contribute to form the *foramen cæcum* (48); its sides are convex and smooth. On each side of the crista galli the cribriform plate is concave; pierced with the *olfactory holes*, for the transmission of nervous filaments,† and perforated in front by a small *fissure* for a particular nerve.‡ On each side of the cribriform plate are several *half cells*, completed by simi-

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* Falx major of dura mater. † Olfactory.
‡ Nasal twig of ophthalmic division of 5th.

lar ones on the frontal; and two small *grooves* passing from within outward and backward, which with the frontal form the *internal orbital foramina* (more properly called *canals*). The anterior is often connected with the *fissure* just mentioned by an oblique *groove*, which lodges the nerve that they both transmit.* The posterior gives passage to a small artery and vein.

42. VERTICAL PLATE. Joins the transverse by its upper border; by its lower, which slopes downward and forward, it articulates with the vomer; by its posterior, which is vertical, it corresponds to the septum of the sphenoidal sinuses; while its anterior is divided into two parts; an *upper*, shorter, and sloped forward, which articulates with the frontal spine, and the crest of the nasal bones; a *lower*, longer, and sloped backwards, to which a cartilage† is attached. On the sides of the vertical plate are seen grooves, and the orifices of canals whose upper extremities appear on the cribriform plate. They transmit nervous filaments.‡

43. LATERAL MASSES. Each presents, *externally*, a smooth square plate called the *os planum*, which forms part of the inner wall of the orbit. In the *upper* edge of this plate are seen the notches that concur to form the apertures of the internal orbitar canals: before and behind it are several half cells, the anterior closed by the lachrymal, the posterior by the sphenoidal turbinated bone: *below* it is an uneven surface, by which it unites, in front with the upper maxillary, and behind with the palate bone. The inner surface of each bundle of cells (*i.e.* the side next the perpendicular plate) presents at its upper and posterior part a curved lamina called the *superior turbinated bone* of the ethmoid, overhanging a horizontal groove called the *superior meatus*, in which is seen the orifice of the *posterior* ethmoid cells. Below this appears a second curved lamina (twice as long as the first), called the *middle turbinated bone* of the ethmoid, whose lower margin is free and thick, and whose concavity, directed outward, contributes to form the *middle meatus*, another horizontal groove which presents in front the orifice of the *anterior* ethmoid cells. The whole of this surface is rough, and marked with grooves and orifices, which transmit little nerves. The cells of each bundle are divided by a bony

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* Nasal twig of ophthalmic division of 5th.

† Triangular cartilage of the nose.

‡ Olfactory.

lamina into two sets, which do not communicate with each other. The *posterior* are the smaller and less numerous; they open into the upper meatus, and either communicate with the sphenoidal sinuses behind, or are closed by the sphenoidal turbinated bones, or by a plate belonging to the ethmoid itself. The *anterior* are more numerous, and one of them, which is long and flexuous, opening into the frontal sinus above, and into the middle meatus below, is called the *infundibulum*. In front of these there are some little half cells, covered by the ascending process of the upper maxillary. So that, in the united skull, the ethmoid cells are completed by the frontal, superior maxillary, lachrymal, and palate bones; and generally also by the sphenoidal turbinated bones.

44. Structure. Of compact tissue. Development. By three points, one for the middle, and one for each lateral portion. Solid and cartilaginous in the child, it becomes in the adult light, laminated, and cellular. Articulations. With the sphenoid, frontal, upper maxillary, inferior turbinated, vomer, nasal, lachrymal, and palate bones: also with the sphenoidal turbinated bones, which often form a complete osseous union with it.

OF THE FRONTAL.

45. This bone, resembling a cockleshell in shape, and situated at the anterior part of the cranium, consists of two portions, a *horizontal* below, a *vertical* above; of these the latter is by far the thicker and more extensive; each presents an *interior* and an *exterior* aspect.

46. Horizontal Portion. *Exterior aspect.* Is directed downward, and presents in the middle the *ethmoid notch*, a quadrilateral space filled up, when the bones are united, by the cribriform plate of the ethmoid. In front of this notch appears the *nasal spine*,* a sharp thin eminence which projects downward and forward, articulating in front with the crest of the nasal bones, behind with the perpendicular plate of the ethmoid. On each side of this spine appear the apertures of the *frontal sinuses;* two cavities, absent in the child, gradually developed by age, extending in the adult to a greater or less distance between the inner and outer tables of the vertical portion of

* Very fragile, and generally broken off in the separation of the bones.

the bone, and communicating with the infundibulum (43). The situation of these sinuses is indicated on the exterior of the bone by two projections, observed, more or less distinctly in different skulls, just above the root of the nose, and called the *nasal eminences*. To return to the *ethmoid notch;* it is bounded on each side by a narrow space, which overlaps the upper surface of the ethmoid, presents several half cells which cover the corresponding half cells of that bone, and also two *grooves* which are completed by grooves of the ethmoid, already described, and contribute to form the *internal orbitar canals* (41). Still further outward this aspect presents on each side the *orbitar vault*, a smooth, triangular, concave surface, which presents at its anterior and *external* part the *lachrymal fossa*, a shallow depression for the reception of a gland;* at its anterior and *internal* part a slight *tubercle* (or *depression*) for the attachment of a fibrous pulley, through which the tendon of a small muscle† is reflected.

47. VERTICAL PORTION. *Exterior aspect.* Presents in the median line, during childhood, a vertical suture, which usually, but not always, disappears in the adult. At the lower end of this suture, and just above the nasal notch, are the *nasal eminences* above described. On either side, and proceeding from above downward, are seen, first, a smooth surface, covered in the recent subject by the aponeurosis of a muscle;‡ secondly, the *frontal protuberance*, a rounded eminence, which indicates the point where ossification commenced, and is very distinct during childhood; thirdly, the *supra-ciliary ridge*, a curved transverse eminence, corresponding to the eyebrow, continuous at its inner extremity with the nasal eminence, and separated from the frontal protuberance by a slight depression; fourthly, the *supra-orbital arch*, a curved transverse margin which separates the vertical from the horizontal portion of the bone, forms the anterior boundary of the orbitar surface, and presents at the junction of its inner and middle thirds a *notch*, which is converted into a hole either by a bony process, or a ligament, stretching across it; it goes by the name of the *supra-orbitar notch* or *foramen*, and serves for the transmission of vessels and a

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* This can scarcely be called a separate fossa; it is rather, as Prof. Partridge has observed, a deeper part of the general concavity of the surface.

† Obliquus superior oculi. ‡ Temporal.

nerve.* The supra-orbitar arch is surmounted by a slight transverse depression which separates it from the supra-ciliary arch; and it terminates at each end in a serrated process: these processes are called respectively the *internal*, and *external, angular process*. The *external angular process* is thick, prominent, and articulates with the malar bone. Running upward and backward from it there is a prominent *curved line*, called the *temporal ridge*, which joins a corresponding ridge on the parietal bone, and gives attachment to a fascia.† Behind and below this ridge the bone is slightly concave, forms part of the temporal fossa, and gives origin to a muscle. The *internal angular processes* are less prominent than the external, and articulate with the lachrymal bones. Between them is a rough serrated interval, called the *nasal notch*, which articulates in the middle with the nasal bones, and on each side with the nasal process of the upper maxillary.

48. VERTICAL PORTION. *Interior aspect.* Marked in the middle with a vertical groove, which is called *sulcus longitudinalis*, or *the groove for the longitudinal sinus*, and lodges the venous canal of that name. Several small irregularly shaped fossæ, for the reception of certain little bodies discovered by and named after Pacchioni, are seen on each side of this groove. Its margins unite below to form a ridge, called the *crista frontalis*, to which a fold of fibrous membrane‡ is attached. This crest terminates below at a small canal called the *foramen cæcum*, which is generally completed by the ethmoid (41); it lodges a process of fibrous membrane§ and frequently transmits a minute vein. On each side of the longitudinal sulcus is a concave surface, traversed by arterial furrows, marked with eminences and depressions which fit the convolutions of the brain, and presenting in the middle a shallow depression, called the *frontal fossa*, correspondent in situation, and proportionate in size, to the frontal *protuberance* of the exterior surface.

49. HORIZONTAL PORTION. *Interior aspect.* Presents, in the middle, the *ethmoidal notch*, and on each side, the convex upper surface of the *orbitar plates*, smooth, strongly marked with cerebral impressions, and forming part of the floor of the cranium.

50. MARGINS. *Vertical portion.* Thick, denticulated,

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* Frontal.
† Temporal.
‡ Falx major of dura mater.
§ The tip of the falx major.

curved, cut obliquely at the expense of the interior surface above, of the exterior below; articulated with the parietal bones, which it supports below, but overlaps and rests upon above. This margin terminates below, on each side, in a triangular rough surface, which articulates with the greater wing of the sphenoid. *Horizontal portion.* Thin, nearly straight, interrupted in the middle by the ethmoidal notch, bevelled at the expense of the interior surface, and articulated with the lesser wings of the sphenoid.

51. STRUCTURE. *Horizontal portion.* Of a thin compact lamina. *Vertical portion.* Of a cellular *diploë*, contained between two compact tables, of which the exterior is thick and tough, the interior thin, but very hard and brittle, hence called *vitreous.** DEVELOPMENT. In two separate pieces, by two points of ossification, situated at the frontal eminences. ARTICULATIONS. With the parietal, sphenoid, ethmoid, nasal, superior maxillary, lachrymal, and malar bones, by the points described.

OF THE PARIETAL BONES.

52. A pair of large flat bones, situated at the upper and lateral parts of the cranium, irregularly quadrilateral in form, and presenting for examination, two *surfaces*, four *angles*, and four *edges*.

53. SURFACES. *Exterior.* Convex, smooth, presenting in the middle an eminence called the *parietal protuberance*, which surmounts a curved *ridge*, continuous with the *temporal ridge* of the frontal, (47) and forming the superior limit of an uneven surface, which is marked with arterial furrows, gives attachment to a muscle,† and belongs to the *temporal fossa.* *Interior.* Concave, marked with cerebral impressions, and with arterial furrows which run upward and backward from the anterior inferior angle. Along the upper margin runs a half groove, which, with a similar one on the opposite bone, forms a longitudinal furrow, continuous with the longitudinal furrow of the frontal before, and with the longitudinal furrow of the occipital behind; it transmits a venous sinus.‡ On each

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* This structure is a general characteristic of the flat bones of the cranium.

† The temporal. ‡ The longitudinal.

side of this groove are seen several small *Pacchionian fossæ*. (48).

54. Edges. *Superior*. The longest; straight, denticulated, and joined to the opposite bone to form the *sagittal* suture. *Inferior*. Divided into three portions; an *anterior*, straight, thin, bevelled at the expense of the outer surface, and overlapped by the end of the greater wing of the sphenoid; a *middle*, curved, thin, bevelled at the expense of the outer surface, and overlapped by the squamous portion of the temporal; a *posterior*, straight, thick, serrated and articulated with the mastoid portion of the temporal. *Anterior*. Joins the frontal, forming the *coronal* suture; it is cut obliquely, in such a manner as to overlap the frontal below, to be overlapped by it above. *Posterior*. Joins the occipital, forming the *lambdoidal* suture. The *parietal foramen*, a hole for the transmission of a vein,* is seen at the upper part of this suture, or at the upper part of the parietal bone near it.

55. Angles. *Anterior superior*. A right angle, substituted in childhood by a membranous part, called the superior fontanelle. *Anterior inferior*. Prolonged downward and forward to fit into the angle between the frontal and sphenoid, and marked internally by an arterial groove.† *Posterior superior*. An obtuse angle, which corresponds to the junction of the sagittal and lambdoidal sutures. (64) *Posterior inferior*. A truncated angle, which joins the mastoid portion of the temporal, and is grooved horizontally by a venous channel‡ continuous with the transverse one that has been described on the occipital. (31)

56. Development. By one point of ossification, at the parietal protuberance. Articulations. To its fellow, to the frontal, sphenoid, temporal, and occipital, by the points described.

OF THE WORMIAN BONES.

57. These are irregular bones, of variable form and size, occurring in the sutures of the cranium, and chiefly in the *sagittal* and *lambdoidal*. (64) The upper angle of the occipital, and the anterior superior angle of the

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* One of the emissary veins of Santorini.

† For the middle meningeal artery. ‡ For the transverse sinus.

parietal, are sometimes substituted by quadrilateral Wormian bones of considerable size. The extremity of the greater wing of the sphenoid, and the anterior inferior angle of the parietal, are also occasionally formed by Wormian bones. I have seen a skull in which one half of the lambdoid suture was formed by large Wormian bones, disposed in a double row, and jutting deeply into each other. Dumontier mentions a similar one; and Bourgery refers to another specimen of the same kind in the Anatomical Museum of Val-de-Grace. Béclard has described a skull in which the whole of the occipital bone above the upper curved lines was formed by two large triangular Wormian bones, united by a vertical suture, continuous with the sagittal. I have seen a skull (now, I believe, in the possession of Dr. Todd) which presents a similar arrangement. In other instances, they are no bigger than a pin's head, very numerous, and formed entirely in the outer table. According to M. Cloquet, they never occur at the base of the cranium, and seldom in heads of a rounded form. My own observations compel me to differ from M. Cloquet on both these points. I have examined more than 100 skulls of various nations, and have often found the Wormian bones numerous in rounded heads, and comparatively few in others of an oblong, or misshapen form. To take a single instance; the Turkish skull in the Museum of Bartholomew Hospital (marked No. 21) presents four large Wormian bones, and several smaller ones; while of the African skulls there are two (Nos. 2 and 10) which contain scarcely any of these bones. Yet the former has the globular shape peculiar to the skulls of the Turkish nation; and the two latter are well-marked specimens of the elongated negro cranium. Again, I have a sphenoid bone, whose lesser wing presents a small Wormian bone, now adherent by a kind of suture, but evidently developed originally as a separate piece. And I have also found (in the Museum of King's College) a skull in which the suture between the sphenoid and ethmoid bones presents deep denticulations (some a quarter of an inch long), and contains four distinct Wormian bones. I mention these facts because they appear to suggest some modification of the received theory of the formation of Wormian bones, as I shall endeavour to show in another place. Their use is questionable. Bichat believes that they are designed to strengthen the cranium. I am rather inclined to think with Cruveilhier, that they are irregular productions, not at all essential to the mechanism of the skull; for they are sometimes quite smooth and undenticulated at the margin; and, when small, are often enclosed between the denticulations of one and the same bone. To which may be added, that when they are unequally distributed over the cranium, we do not find the side in which they are most numerous stronger or more difficult to disarticulate than the other. However, I have observed in several skulls a pair of oval Wormian bones, equal in size, and placed one on each side, about an inch and a half from the median line,—the same point at which a remarkably large and long denticulation is frequently seen. Certainly, it is possible that in such instances they may act somewhat in the manner of cramps, to hold the occipital and parietal bones together.

In structure, development, and mode of articulation, they resemble the other cranial bones.

OF THE TEMPORAL BONES.

58. A pair of complex bones, situated at the lateral and inferior parts of the cranium, and divided into three portions; the *squamous*, anterior and superior; the *mastoid*, posterior; and the *petrous*, projecting internally from the point of junction of the two former; these parts, separate in childhood, form but one piece in the adult. Their surfaces and borders will be described in succession.

59. Squamous Portion. *Exterior surface.* Smooth, convex, and marked slightly with arterial* impressions; it gives attachment to a muscle,† forms part of the temporal fossa, and is divided from the mastoid portion by a *curved ridge.* This ridge is continuous with one on the parietal bone; (53) it attaches an aponeurosis,‡ and forms the posterior boundary of the temporal fossa. At the lower part of the exterior surface arises the *zygomatic process;* a flat branch of bone which has two surfaces and two edges; which runs first outward and then forward; and which is so twisted that while running outward its *surfaces* are superior and inferior, but while running forward its *edges* become superior and inferior.

* Of the deep temporal arteries. † The temporal muscle. ‡ The temporal.

The *upper edge* of this process is long, thin, level, and attaches an aponeurosis; * the *lower* is short, thick, curved, and gives origin to a muscle.† The *outer surface* is convex and subcutaneous, the *inner* concave. The *extremity*, cut obliquely at the expense of the lower edge, and (generally) of the outer surface, is serrated for articulation with the malar bone. This process arises by two roots, the description of which shall follow that of the *glenoid cavity*. This is an oval depression, directed downward, forward, and a little outward, and divided by a narrow slit, called the *Glaserian fissure*, into two parts; an *anterior*, formed in the *squamous* portion, and covered with cartilage, for articulation with the condyle of the lower jaw; a *posterior*, less even, and non-articular, which is formed chiefly by the vaginal process of the petrous portion, and lodges part of a gland.‡ The *Glaserian fissure*, which effects this division, leads into the tympanum, and transmits a tendon, a bony process, and some vessels. (146) Of the roots of the zygomatic process, the *anterior*, which is also inferior and transverse, forms the front boundary of the glenoid cavity, is covered, in the recent state with cartilage, and is continuous with a ridge that runs horizontally forward on the temporal bone, to join the horizontal ridge seen on the outer surface of the great wing of the sphenoid: (37) the *posterior*, also superior, subdivides into two branches; an *inferior*, short and tubercular, which terminates at the outer end of the Glaserian fissure; a *superior*, likewise posterior, which sweeps upward to the circumference of the bone; being in fact identical with the curved line that has been already described as dividing the mastoid from the squamous portion. Just where the anterior and posterior roots unite to form the zygomatic process, there is a tubercle for the attachment of a ligament.§ *Interior aspect.* Concave, marked with cerebral impressions and arterial furrows. *Border.* Thin, semicircular, and bevelled at the expense of the interior surface, at the *upper* part, where it overlaps the parietal, and forms the squamous suture; (64) thick, denticulated, and bevelled alternately at the expense of the interior and exterior surface, at its *lower* and *anterior* part, where it articulates with the sphenoid.

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* The temporal. † The masseter. ‡ The parotid.
§ External lateral of lower jaw.

60. Mastoid Portion. *Exterior aspect.* Presents, at its upper part, a rough surface, perforated by a hole called the *mastoid foramen.* This hole transmits vessels;* its position and size are irregular; it is often found in the suture between the mastoid portion of the temporal and the occipital. The mastoid portion is prolonged inferiorly into a large conical eminence, called the *mastoid process.* This process, which presents many varieties of size and form in different individuals, gives attachment to several muscles.† *Interior aspect.* Presents, above, a deep, curved, venous channel (into which the mastoid foramen, just described, opens). This channel is continuous with the transverse groove formerly described on the occipital (31) and parietal bones, (55) and transmits the same sinus.‡ Below it appears the internal side of the mastoid process, marked with the *digastric groove,* which attaches a muscle of the same name; and, more internally, with the *occipital groove* (parallel to the former, but much smaller, and often not distinctly seen), which transmits an artery of the same name. *Borders.* Rough and serrated; the *superior* articulates with the parietal; the *posterior* with the lower border of the occipital, between its jugular process and transverse angle. *Angle.* This is the hindmost point of the bone, formed by the junction of the two borders just described.

61. Petrous Portion. A very hard pyramidal process, which contains the organs of hearing, and presents for examination a *base,* a truncated *apex,* three *edges,* and three *surfaces.* Of these surfaces the *anterior* and *posterior* are situated within the cranium: while the *inferior* is seen on its exterior aspect. The exact direction of the three surfaces is as follows. The *anterior* looks upward and inward, as well as forward; the *posterior* looks upward and outward, as well as backward; the *inferior* looks a little inward and backward, as well as downward. The exact direction of the entire process is from without, inward, forward, and a little downward. Base. The upper part of the base is entirely concealed by the squamous and mastoid portions to which it is fixed; but its lower part, appearing in consequence of the divergence of those portions, presents the oval expanded

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* A small artery, and an emissary vein of Santorini.
† Sterno-mastoid, trachelo-mastoid, splenius capitis.
‡ Transverse.

orifice of the *meatus auditorius externus*, a canal leading to a chamber in the petrous process, called the *tympanum*. This orifice lies between the mastoid process and the glenoid cavity; its lower margin is rough for the attachment of the cartilage of the ear, and formed by a curved plate of bone common to it and the glenoid cavity; its upper margin is generally smooth and rounded. The description of the canal itself will be included in that of the ear. (144) SURFACES. *Anterior*. Continuous with the interior surface of the squamous portion; to which it is joined by a sort of suture, that remains distinct even in old age, and indicates the original separation of these two portions of the bone. It is marked with cerebral impressions, belongs to the middle fossa of the cranium, and presents in front a small shallow *groove*, leading backward to an aperture called the *hiatus Fallopii;* which opens into a canal called the *aqueductus Fallopii*. (164) The groove, which is sometimes double, lodges a nerve* and a small artery, which enter the aperture, and pass along the canal. Just in front of it this surface presents a notch or deficiency; so that the carotid canal which lies immediately below, is here, as it were, unroofed. Above this notch there is a depression, generally shallow, but sometimes deep and distinct, for the reception of a nervous ganglion.† Lastly, above and behind the hiatus Fallopii, this surface presents an eminence, which indicates the position of the *superior semicircular canal*. (155) *Posterior*. Continuous with the interior surface of the mastoid portion, marked with cerebral impressions, and belonging to the posterior fossa of the cranium. It presents, nearly in the centre, the smooth rounded orifice of the *meatus auditorius internus;* (164) and behind this a little slit, covered by a triangular plate of bone, and forming the expanded orifice of a minute canal, called the *aqueductus vestibuli*. (154) Between these two apertures, but on a somewhat higher level, there is a little depression of variable form and size, which gives attachment to a slip of fibrous membrane‡ and transmits a little vein into the cancellous tissue of the bone. *Inferior*. An uneven complex surface, which forms part of the base of the cranium, and presents, passing from the summit towards

* Cranial branch of vidian nerve.

† Gasserian ganglion of 5th nerve. ‡ Dura mater.

the base of the process (*i.e.* from within and before, outward and backward), the following objects:—First, a rough quadrilateral surface, which gives attachment to two muscles;* behind this, two holes, one round and very large, situated externally: the other triangular and very small, situated close to the posterior border of the process. The former is the lower aperture of the *carotid canal;* the latter is the lower aperture of the *aqueductus cochleæ.* The *carotid canal* runs from its lower orifice at first vertically upward; then, making a sudden bend, passes horizontally forward and inward, so that its other end appears at the summit of the process. It transmits a large artery,† and some nervous filaments.‡ The *aqueductus cochleæ* will be described with the internal ear. (163) Behind these holes is a large depression, called the *jugular fossa,* which varies in depth in different skulls, and even on the opposite sides of the same. It lodges a large vein,§ and is bounded externally by a sharp-edged prominent plate of bone, which extends from the carotid canal back to the mastoid process, separating the jugular fossa from the glenoid cavity. This plate, which is called the *vaginal process,* divides at its posterior part into two laminæ; from between which projects a long and very remarkable process of bone, called the *styloid process.* This epiphysis, which in animals forms a separate bone, in man is generally continuous with the vaginal process, which encloses its base like a sheath; occasionally, however, it is a movable piece connected by cartilage with the rest of the bone. It is about an inch long, runs downward, forward, and inward, and gives attachment to three muscles,‖ and two ligaments.¶ Behind these two processes there are a *hole* and a *fissure.* The hole, which lies between the styloid and mastoid processes, is called the *stylo-mastoid foramen;* it is the inferior orifice of the aqueductus Fallopii, (164) and transmits a nerve.** The fissure, which is very narrow, and extremely variable in depth,†† is called the *auricular fissure;* it separates the vaginal from the mastoid process, and lodges a small nervous

* Levator palati mollis, and tensor tympani.

† Carotid. ‡ Carotid plexus. § Jugular.

‖ Stylo-hyoideus, stylo-glossus, stylo-pharyngeus.

¶ Stylo-hyoid, stylo-maxillary. ** Facial.

†† Sometimes a quarter of an inch deep, sometimes scarcely perceptible, sometimes absolutely deficient.

ament.* The two processes, fissure, and hole, just
scribed, are *external* to the jugular fossa; *behind* it
ere is a square facet called the *jugular surface*, which
ticulates with the jugular process of the occipital bone.
nese are the principal objects that appear on the lower
irface of the petrous portion: some minuter points will
mentioned in the description of the tympanum. EDGES.
uperior. The longest and most even. It is marked by
channel, which is called the *superior petrosal groove*,
id lodges a venous sinus of the same name. It presents,
its inner extremity, a semilunar depression, on which a
ervet† rests. *Posterior.* The second in length, uneven,
it not denticular, and articulated, by apposition, with
ie basilar process of the occipital. Its inner half is
iarked by a groove, which, when completed by one on
ie corresponding border of the occipital, is called the
iferior petrosal groove, and transmits a venous sinus of
ie same name. Its outer half presents a large notch,
hich corresponds in size and situation with the jugular
ossa, and, with a similar notch on the occipital, forms
ie *foramen lacerum posterius*. A little sharp eminence
ften projects from the centre of this notch, dividing the
ole into two portions. (The *jugular surface*, and the
queductus cochleæ, are sometimes referred to this border.)
nterior. Divided into two parts; an *inner*, free and
rticulated with the spine of the sphenoid (which is
eceived into the retiring angle formed between this border
nd that of the squamous portion); an *outer*, joined to
he squamous portion above by a suture, but separated
rom it below by a narrow interval, already described as
he Glaserian fissure. In the apex of the retiring angle
ust mentioned, are seen the orifices of two small canals,
ying one above the other, and only separated by a thin
amina. The upper of these lodges a little muscle of the
ear,‡ while the lower is the bony portion of the *Eustachian
ube.* When the bones are joined, these canals open at
a point internal to the spine of the sphenoid. They both
ead into the tympanum, and will be further described
when we speak of that cavity. (145) SUMMIT. Is irregular
and obliquely truncated, presents the anterior orifice of
the carotid canal, and forms the posterior and external
boundary of the *foramen lacerum medium.*

* An auricular branch of the facial nerve. † Third.
‡ Tensor tympani.

62. STRUCTURE. Petrous portion exceedingly hard and dense; mastoid portion cellular; squamous portion like the other flat bones of the cranium. DEVELOPMENT. In the child the styloid process is articulated to the petrous by a cartilage, and the external meatus is a separate ring of bone, imperfect above. These two parts have each a separate point of ossification, as also have the mastoid, petrous, and squamous portions, and the zygomatic process; making six in all. ARTICULATIONS. With the sphenoid, occipital, parietal, malar, and lower maxillary bones.

ARTICULATIONS OF THE CRANIAL BONES.

63. The bones that have now been described form by their junction thirteen *sutures.* (7) These are often described incidentally, in demonstrating the regions which they respectively traverse; but they are perhaps more easily remembered when studied in connexion with each other. They are best distinguished by designations compounded of the names of those bones between which they are respectively formed; as *fronto-parietal, inter-parietal, &c.* Several have also received names derived from their situation, or particular appearance; as, *coronal, sagittal, lambdoidal, basilar, &c.*

64. CRANIAL SUTURES. *Sagittal.* Is formed by the junction of the two parietal bones, and runs along the top of the cranium, from the summit of the occipital to the centre of the frontal bone. In children, and in adults also when the two sides of the frontal remain separate, it is continued forward to the root of the nose. It sometimes presents towards its posterior extremity, the *parietal hole* (54); and in front, where it joins the coronal suture, frequently bifurcates to enclose a large quadrilateral Wormian bone. *Coronal.* Cuts the sagittal at right angles, sweeping round transversely over the top of the cranium, from the extremity of one greater wing of the sphenoid, to the corresponding point on the opposite side. It is formed between the frontal and parietal bones, and is so disposed that the frontal rests on the parietal above, and *vice versâ* below. *Lambdoidal.* Passes from the angle of the mastoid portion of the temporal on one side, to the same point on the other; describing in its course two sides of a triangle. It is formed between the occipital and the two parietal bones,

very deeply denticulated,* and usually contains several ɔrmian bones. *Masto-parietal. Squamous. Spheno-rietal.* These three sutures are subdivisions of a gle suture, formed between the lower border of the rietal, and the two adjacent bones (temporal and ıenoid); and consequently extending from the lower l of the lambdoidal suture behind, to the lower l of the coronal in front. *Masto-parietal.* A short ıticulated suture joining the *posterior* division of the erior border of the parietal, with the mastoid por-n of the temporal. Cloquet, followed by several other iters, has described this as part of the squamous ure. But since it is *denticulated*, it is better not to l it *squamous*. *Squamous.* A curved suture formed the squamous portion of the temporal overlapping the *ddle* division of the lower border of the parietal. *heno-parietal.* A very short suture formed by the end the greater wing of the sphenoid overlapping the *terior* division of the lower border of the parietal.

The remaining sutures traverse the *base* of the nium.

Basilar. The line of junction between the sphenoid l occipital bones. It runs transversely in front of the silar process, contains a layer of cartilage in childhood, l disappears in adult age, in consequence of the ion of the sphenoid and occipital bones. Between the ter extremity of the basilar, and the lower extremity the lambdoidal suture, occur two other sutures; the e formed by the junction of the *petrous portion* of the nporal with the occipital, the other by the junction of e *mastoid portion* of the temporal with the occipital. In e first, or *petro-occipital*, the bones are separated by a n layer of cartilage. The second, or *mastoid* is very ghtly denticulated, and often presents the *mastoid amen.* Between the outer end of the *basilar* suture d the posterior end of the *spheno-parietal*, two more

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In all *suturæ dentatæ* (see Table of the Articulations, page 7) denticulations of the exterior table are much deeper than those the interior or vitreous table. In this suture for instance, the ıticulations may be half an inch long on the exterior surface; ile on looking from within the cranium one sees borders merely ced in apposition. This is perhaps on account of the brittleness the vitreous table, as John Bell believed. In some skulls, how-r, one sees every here and there long jagged denticulations even the interior table.

sutures intervene. The first, or *petro-sphenoidal*, is formed between the great wing of the sphenoid and the petrous portion of the temporal; and here the bones are merely placed in apposition (exemplifying the *sutura apposita*, or *harmonia*). The second, or *squamo-sphenoidal*, is formed between the great wing of the sphenoid and the *squamous* portion of the temporal; and here the bones are cut obliquely, and serrated (exemplifying the *sutura limbosa*).

Two sutures, the *sphenoidal* and the *ethmoidal*, remain. The *sphenoidal suture* is formed between the anterior superior border of the sphenoid and the bones with which it articulates—viz., the ethmoid and sphenoidal turbinated bones in the middle, the frontal laterally. Viewed from below, this suture is observed to have three portions; 1st, a *central* portion which runs across from one external angular process to the other, traversing the roofs of the orbits, and forming a curve whose concavity is directed forward; 2nd and 3rdly, two *lateral* portions, lying one on each side, between the external angular process and the anterior end of the spheno-parietal suture. At the central part of this suture the bones are thin and merely apposed to each other without denticulation; towards the external angular process they join by a broad denticulated surface; laterally the sphenoid is squamous, and overlaps the frontal. The *ethmoidal* suture is formed by the junction of a broad margin around the ethmoid notch of the frontal, with a corresponding margin on the upper surface of the ethmoid. In this suture, which forms three sides of a parallelogram, and enters the sphenoid suture at right angles, several small *cells*, and the *internal orbitar canals*, are observed.

OF THE CRANIUM IN GENERAL.

65. The shape and articulations of the cranial bones having now been severally described, it remains to take a general view of the chamber which they unite to form. The cranium is an ovoid, larger behind than before, flattened laterally and at the base, smooth above, uneven and perforated with many holes below. It is nearly, but seldom perfectly, symmetrical. Its relative size presents considerable variations, dependent on age, sex, and class. Thus it is proportionately larger in the fœtus than in the adult, in the male than in the female, and in the Cauca-

.n than in either the Ethiopian or Mongolian races of
en. The form of the cranium, especially of its upper
gment or *vault*, presents very marked and charac-
ristic varieties in different tribes; and also some minor
culiarities in different individuals of the same tribe.
ith regard to these latter, it is asserted by Cloquet,
ruveilhier, and others, that the cranium usually gains
one dimension what it loses in another, so that its
neral capacity remains nearly uniform throughout each
ass. But an extensive series of observations published
Professor Tiedemann, in the Philosophical Transac-
ons for 1836, leads to very different conclusions. Thus,
e capacities of the negro crania, which he measured,
ried from 31 to 42 ounces; of the German, from
to 45; of the English, from 38 to 45. My own
servations accord with those of Tiedemann. I gauged
his method two French, two Chinese, and two
ythian skulls (all of male adults), with the following
sults.

		Weight of skull without lower jaw. lbs.	oz.	drs.	(avoirdupois)	Weight of millet seed contained. oz.	drs.
French	1	1	10	9		42	8
	2	1	4	1		31	9
Chinese	1	2	2	8		37	4
	2	1	11	0		39	4
Scythian	1	2	8	4		34	0
	2	2	0	0		35	12

(N.B. The two French skulls were the largest and
mallest among 73; with the Chinese and Scythian, I
ad no opportunity of selection. Hence the greater dis-
repancy between the capacities of the former.)

The thickness of the walls of the cranium varies in
ifferent skulls and in different parts of the same.
Wherever there is a ridge or protuberance, it is greatly
ncreased; while at the bottom of the fossæ it is often so
nuch reduced that the bone becomes semitransparent.
The texture and consistence of the bone itself likewise
vary in different skulls. In the negro it is generally
very dense, hard, and white; so that on a section, it
resembles ivory rather than bone. I am informed by a
dealer in human bones, that the skulls of the Belgians,
besides being misshapen and ill-developed, are of a soft
and oily consistence. The crania of barbarous nations
appear to be in general harder, thicker, and heavier, than

those of Europeans. My limits will not allow me to pursue this subject further. In Mayo's Physiology the student will find a clear and masterly sketch of the national peculiarities of the cranium: and for original investigations on the subject he may consult the works of Daubenton, Cuvier, Blumenbach, Lawrence, Prichard, Owen, &c. The development of the cranium usually bears an inverse proportion to that of the face; the subject of its comparative mensuration will therefore be treated, when that division of the head has been described, and the entire skull comes under review. The cranium presents for examination an *exterior* and an *interior* surface, each of which is divided, for convenience of demonstration, into *regions*.

66. EXTERIOR SURFACE OF THE CRANIUM. This is loosely divided into the *sinciput* in front, the *occiput* behind, the *bregma* at top, the *base* below, and the *temples* on each side. But for accurate description it is divided into four definite regions; a *superior*, an *inferior*, and two *lateral*. In considering these regions we shall merely recapitulate such points as have already been pointed out in the description of the separate bones; examining more in detail the objects that result from their union.

67. SUPERIOR REGION. Bounded in *front* by the nasal eminences, and the supra-orbitar arches; *behind* by the exterior tuberosity, and superior curved lines, of the occipital bones; *intermediately* by a line carried from the outer end of the superior curved line of the occipital along the temporal ridge of the parietal and frontal bones, to the external angular process of the frontal. This region is oval, smooth, traversed by three sutures, the *sagittal* in the middle, the *lambdoidal* behind, and the chief part of the *coronal* in front. It presents, from behind forward, 1st, the smooth upper part of the *occipital* bone; 2ndly, the even vault of the *parietal* bones, marked, behind, by the *parietal holes*, anteriorly and externally, by the *parietal protuberances;* 3rdly, the vertical portion of the *frontal*, on which are seen the *frontal eminences* surmounting the *supra-ciliary arches*. The flat, tendinous expansion of a muscle* covers and plays over this region.

68. LATERAL REGIONS. Bounded, *above*, by a line beginning at the external angular process of the frontal,

* Occipito-frontalis.

ssing along the temporal ridge, and continued back to
e exterior occipital tuberosity; *below*, by a line com-
encing also at the external angular process, and passing
ong the zygomatic arch to the mastoid process, and
ence to the occipital tuberosity. Ending thus in a
int before and behind, and bounded by a curve above
d below, this region is of an irregularly elliptical form.
is traversed by the *spheno-parietal*, *masto-parietal*, and
uamous sutures; and by part of the *coronal*, *sphenoidal*,
astoid, and *lambdoid* sutures. It is concave in front,
nvex behind, and divided into an anterior larger, and a
sterior smaller portion. The former is the cranial
rtion of the temporal fossa. This space is bounded in
ont, above, and behind, by the *temporal ridge;* a line
at begins at the external angular process, passes
oward and backward over the frontal and parietal, and
en curves downward over the temporal, to terminate at
e root of the zygomatic process. *Below*, the temporal is
parated from the zygomatic fossa by a horizontal crest
the outer surface of the great wing of the sphenoid.
This will be further explained when we speak of the
anio-facial fossæ). The large space thus circumscribed
convex posteriorly, concave in front, and traversed all
er by the impressions of arteries.* It gives origin to
large muscle,† whose fascia is attached to the
mporal ridge. The posterior smaller portion of
e lateral region is convex, and presents from behind
rward, 1st, the *mastoid hole;* 2ndly, the outer surface
the *mastoid process;* 3rdly, the *meatus auditorius
xternus.*

69. Inferior Region or Base.‡ Bounded, *behind*, by
e external occipital tuberosity, and superior semi-
ircular ridges; in *front*, by the nasal eminences and
upra-orbitar arches; *laterally*, by a line extending from
he external angular process to the zygomatic process,
hence to the mastoid process, and thence to the outer
nd of the superior semicircular ridge. Oval, uneven,

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* Deep temporal. † Temporal.

‡ In studying this aspect, the student should bear in mind that
he cranium is turned upside down, so that when any point is de-
cribed as *above* another, he must, on account of the inverted posi-
ion of the skull, look for it *below*. A similar caution is necessary
n tracing on the *lower* surface of any bone the points described in
ooks.

convex,* articulated in front with the bones of the face, in the middle with the summit of the spine, and free in the rest of its extent, this surface presents, from behind forward, the following objects. The *exterior occipital tuberosity*, with the *exterior occipital crest* passing downward and forward from it. From the tuberosity pass outward the *superior curved lines;* from the middle of the crest, the *inferior curved lines.* The tuberosity gives attachment to a ligament,† the superior curved line to three muscles,‡ the inferior curved line to two muscles.§ Between the curved lines is a surface marked with the rough impressions of two muscles,|| and in front of the lower curved line is a rough surface, which also attaches a muscle.¶ In front of the occipital crest appears the *occipital hole*, or *foramen magnum*, which transmits several important organs,** and is bounded on each side by the *condyles* (which give attachment internally to ligaments),†† and by the *anterior* and *posterior condyloid fossæ*, which receive the articulating processes of the atlas in extension and flexion of the head, and are perforated by the *foramina* of the same name.‡‡ External to the condyle is an uneven surface for the insertion of a muscle;§§ external to this is seen the *jugular process* of the occipital, articulating with the *petrous portion* of the temporal; and external again to this appear the lower extremity, and the digastric groove, of the *mastoid process*, each of which gives attachment to a muscle.|||| In front of the occipital hole is the *basilar surface*, presenting in the middle the *pharyngeal spine*, and on each side depressions for muscular insertion.¶¶ Anterior and internal to

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* This character is important, as indicating a great downward development of the brain. In the chimpanzee and orang-otang the basis of the cranium is nearly flat.

† Ligamentum nuchæ.

‡ Occipito-frontalis, trapezius, sterno-mastoideus.

§ Rectus capitis posticus major, and obliquus superior.

|| Complexus, and splenius capitis.

¶ Rectus capitis posticus minor.

** Spinal cord, with its envelopes, vertebral arteries, and spinal accessory nerves.

†† Odontoid.

‡‡ The anterior transmitting the ninth nerve, and the posterior a small vein.

§§ Rectus capitus lateralis.

|||| The former to the sterno-mastoid, the latter to the digastric.

¶¶ Recti capitis antici, majores and minores.

the mastoid process is the *stylo-mastoid foramen*, which transmits a nerve;* in front of that the *styloid*† and *vaginal* processes; anterior and external to these again, the *glenoid cavity*, with its *Glaserian fissure*.† Between the mastoid process and glenoid cavity externally, and the basilar process internally, is seen the inferior surface of the petrous portion of the temporal bone, presenting (besides the *styloid* and *vaginal processes*, and the *stylo-mastoid foramen*, already mentioned) the following objects: the *jugular fossa*,‡ a deep cavity, completed internally and posteriorly by the occipital bone, and generally larger on the right side than on the left.§ At the bottom of this fossa there is an irregular aperture, called the *foramen lacerum posterius*, divided by a little process (sometimes of the occipital, usually of the temporal bone) into two parts; an *anterior*, smaller, which transmits several nerves;‖ a *posterior*, larger, which transmits a large vein,¶ and a small artery.** In front of this fossa appear the lower orifices of the *carotid canal*, and the *aqueductus cochleæ*. In front of these is seen a rough quadrilateral surface, for the attachment of two muscles.†† Internal and anterior to this surface occurs an irregular and somewhat triangular aperture, called the *foramen lacerum medium*: its apex is directed backward; its *anterior* margin presents the posterior orifice of the *pterygoid*, or *vidian* canal; and its *posterior* margin presents the anterior orifice of the *carotid canal*. It is closed in the recent state by a fibro-cartilaginous substance, and does not give passage to any organ.‡‡ It is formed in front by the great wing of the sphenoid, behind by the summit of the petrous process, and internally by the body of the

* Facial.

† For the relations of the styloid process, see § 61, and for those of the Glaserian fissure, see § 146.

‡ It lodges the commencement of the internal jugular vein.

§ I examined the size of the jugular fossæ in 105 adult male Caucasian skulls. In 12 they were of equal size; in 15 the left was larger than the right; in the remainder (78) the right was larger than the left.

‖ Glosso-pharyngeal, pneumogastric, and spinal accessory.

¶ Internal jugular.

** Posterior meningeal.

†† Levator palati mollis, and tensor tympani.

‡‡ The vidian nerve and the carotid artery enter the cranium at the margins of this orifice; but nothing passes directly through it.

sphenoid and the basilar process of the occipital. When the *mastoid*, *basilar*, *petro-occipital*, and *petro-sphenoidal* sutures (64) are mentioned, the description of the posterior half of the base of the cranium is finished. The remaining portion is articulated with the bones of the face, and can only be studied in a skull from which they have been removed.

In front of the basilar process is the body of the sphenoid, with the *rostrum* in the middle, and the *laminæ* on each side. Between these laminæ and the rostrum appears a part of the *sphenoidal turbinated bones.* These have been already described (36) as thin curved triangular plates, having a *vertical* portion, which is situated between the sphenoid and ethmoid bones, and separates the sphenoidal sinuses from the ethmoid cells, and a *horizontal* portion, which forms part of the floor of the sphenoidal sinuses; it is this latter part which appears on the base of the cranium. External to the body descends the pterygoid process of the sphenoid, perforated at the base by the vidian canal,* bifurcated at the extremity to receive the tuberosity of the palate bone, and divided behind by the *pterygoid fossa*† into two plates, the inner of which presents the *scaphoid depression*‡ at its base, and the *hamular process* (†) at its extremity. Near the base of the pterygoid process, in front, appears the anterior orifice of the short canal, called *foramen rotundum*,§ situated superior and external to the anterior orifice of the vidian canal. External to the pterygoid process is that portion of the exterior aspect of the great wing of the sphenoid, which belongs to the *zygomatic fossa*, separated by a ridge from the portion which belongs to the *temporal fossa*, and presenting from behind forward; 1st, the *spinous process*‖ of the sphenoid; 2ndly, anterior and internal to this, the *foramen spinosum*;¶ 3rdly, anterior and internal to this

* Which transmits the vidian nerve.

† Which lodges the internal pterygoid muscle.

‡ The circumflexus palate arises from the scaphoid depression, and its tendon turns round the hamular process.

§ Transmits the second branch of the fifth.

‖ This process is very irregular in size and shape; it is often bifurcated, and I have not unfrequently seen it connected by a branch of bone with the external plate of the pterygoid process. It attaches the internal lateral ligament of the jaw, and the laxator tympani major muscle.

¶ Which transmits the middle meningeal artery.

again, the *foramen ovale.** *Internal* to the spine of the sphenoid is seen the orifice of the bony portion of the *Eustachian tube;* on its *outer* side appears the lower part of the *squamous suture;* and external to this again is the *zygomatic process*, rising in front of the *glenoid cavity*, and presenting, at its *base*, a rough tubercle which attaches a ligament,† at its *extremity*, an oblique border which articulates with the malar bone. Returning to the median line, we find, in front of the body of the sphenoid, the inferior aspect of the *ethmoid* bone, presenting in the middle the *vertical plate*, and on each side the *lateral mass.* Between the vertical plate and the lateral mass, on each side, there is a deep groove, which contributes in the united skull to the nasal fossa. These grooves are open in front, closed behind by the anterior wall of the sphenoidal sinuses, and separated from the cavity of the cranium by the horizontal or cribriform plate of the ethmoid. They present the *turbinated bones of the ethmoid;* the *superior* and *middle meatus* of the nose; the *olfactory foramina;* the apertures of the *anterior* and *posterior ethmoid cells;* and, generally those of the *sphenoidal sinuses.*‡ The relations of these parts will be explained in the description of the nasal fossæ. (135) External to these grooves are seen the lower aspects of the *lateral masses* of the ethmoid, marked with some *half cells*, which are completed, in the united skull, by the superior maxillary, palate, and lachrymal bones. Behind the ethmoid we have a partial view of the *sphenoidal turbinated bones*, interposed between the sphenoid and ethmoid, and of the junction of the vertical plate of the ethmoid with the septum of the sphenoidal sinuses. In front of the ethmoid are seen the *nasal notch* and the *nasal spine* of the frontal. On each side of the ethmoid appear the *orbitar vaults*, two smooth, concave surfaces, formed in front by the *orbitar plates* of the frontal, and behind by a small part of the under surface of the lesser wings of the sphenoid. They are triangular in form, and present at the *apex*, which is directed backward, the *foramen*

* Which transmits the third division of the fifth nerve.

† The external lateral of the jaw.

‡ These sinuses are usually said to open into the posterior ethmoid cells; a communication which I have never seen, and believe to be very rare.

opticum. The *base*, directed forward, is formed by the *supra-orbitar arch*, interrupted at the junction of its inner and middle thirds by the *superciliary notch*,* and ending in the *external* and *internal angular processes.* Behind the former of these processes lies the *lachrymal fossa;* † behind (and about three lines above) the latter is a little inequality for a tendinous pulley.‡ The orbitar vault is bounded externally by the orbitar plate of the sphenoid, which contributes to the outer wall of the orbit; internally by the orbitar plate of the ethmoid, which forms part of its inner wall. In the suture between the orbitar plate of the ethmoid, and the frontal, are seen the apertures of the *internal orbitar canals;* § in the orbitar plate of the sphenoid, and in the suture between the frontal and molar, are the small foramina, called the *external orbitar holes;* ‖ their number is uncertain, and they are often altogether deficient. Lastly, between this plate and the lesser wing of the sphenoid, is the triangular interval called the *sphenoidal fissure.*¶

70. INTERIOR SURFACE OF THE CRANIUM. This surface is divided by a line passing round from the foramen cæcum to the interior occipital protuberance, into two regions, the *vault* and the *base.*

71. VAULT. A smooth concave surface, marked all over with cerebral and arterial** impressions, traversed in the median line by the *longitudinal sulcus*, a smooth furrow which rises behind from the interior occipital protuberance, becomes narrower as it passes forward, and terminates in the *frontal crest;* a sharp raphé which

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* In fœtal skulls this notch constantly presents the orifice of a canal, which transmits nutrient vessels upward into the substance of the frontal bone. It is often of considerable size, sometimes double. It generally remains pervious in the adult, and may be called the *supra-ciliary canal.* Of 105 adult skulls, I found it present in 72.

† Which lodges the lachrymal gland.

‡ For the tendon of the obliquus superior oculi.

§ The *anterior*, transmitting the nasal twig of the ophthalmic division of the fifth; the *posterior*, a small vessel.

‖ That which is formed in the orbitar plate gives passage to a small artery which supplies the lachrymal gland; the other transmits a filament of the malar nerve from the orbit to the temporal fossa.

¶ For the transmission of the third, fourth, and sixth nerves; the ophthalmic, or first division of the 5th; and a small vein.

** Formed by the middle meningeal artery.

descends, diminishing in prominence, to disappear just above the foramen cæcum. In this channel is seen the *inter-parietal* or *sagittal suture*, and on each side of it several *Pacchionian depressions*;* here also, when they exist, appear the *parietal holes*.† Laterally we observe in the vault, passing from behind forward, the *cerebral fossæ of the occiput*, the *occipito-parietal* or *lambdoid suture*, the *parietal fossæ*, the *fronto-parietal*, or *coronal suture*, and the *frontal fossæ*.

72. BASE. Consists of three fossæ; an *anterior*, lying in front of the lesser wings of the sphenoid; a *posterior*, lying behind the upper edges of the petrous processes; and a *middle*, which occupies the intervening space. These fossæ are on different levels, rising successively, like a flight of steps, from the posterior to the anterior. The anterior and posterior fossæ are widest in the median line; the middle fossa, on the contrary, is narrow in the median line, and expands on each side. The anterior fossa is convex; the two others are deeply concave. POSTERIOR FOSSA. Formed chiefly by the occipital and temporal bones, and traversed by the *mastoid* and *petro-occipital sutures*. It presents, at its posterior part, the *cerebellar fossæ of the occiput*, separated from each other by the *interior occipital crest*,‡ and surmounted by the *sulci laterales* or *transversales*, which pass horizontally outward, one on each side, from the interior occipital protuberance, then curving downward, groove successively the posterior inferior angle of the parietal, the mastoid portion of the temporal, and the occipital, just behind its jugular process; terminating at the posterior division of the *foramen lacerum posterius*. In this channel are seen the interior openings of the *mastoid*§ and *posterior condyloid*‖ holes. This channel, and the hole in which it terminates, are usually larger on the right side than on the left. In front of the cerebellar fossæ is the *foramen magnum*, in the sides of which open the *anterior condyloid foramina* or *canals*. In front of the foramen magnum is the *basilar process*, hollowed by the *basilar groove*,

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* For the Pacchionian bodies.

† For the transmission of small veins.

‡ Which attaches the falx minor of the dura mater.

§ For the transmission of small veins.

‖ The *posterior* division of this hole transmits the internal jugular vein, the *anterior* and smaller division transmits the glosso-pharyngeal, pneumogastric, and spinal accessory nerves.

interrupted in the child by the *basilar suture*, and forming, by junction with the petrous process on each side, the *petro-occipital suture;* a suture, the posterior half of which is interrupted by the *foramen lacerum posterius;** while its anterior half is marked by the *inferior petrosal* groove. This channel belongs partly to the basilar process of the occipital, partly to the petrous portion of the temporal; it transmits a sinus of the same name. Above the foramen lacerum posterius, on the posterior surface of the petrous portion, is the orifice of the *meatus auditorius internus;*† behind and *above* which again is a little triangular depression, which gives insertion to a fold of dura mater, and transmits a minute vein into the cancellous tissue of the bone; while behind and *below* it is the narrow orifice of the *aqueductus vestibuli.*‡

The *line* which separates the posterior from the middle fossa, is formed on each side by the upper border of the petrous portion, which presents externally the *superior petrosal groove*, and internally the semi-lunar depression on which a nerve§ rests; in the middle the boundary line coincides with the *basilar suture.*

MIDDLE FOSSA. Formed chiefly by the sphenoid and temporal bones, with a small part of the parietal; traversed by the *squamous*, *spheno-parietal*, *spheno-temporal*, and *petro-sphenoidal* sutures. Narrow in the middle, where it consists only of the *sella turcica*,‖ and dilating on each side into a large convex surface, which is formed, *behind* by the anterior surface of the petrous portion, *externally* by the squamous portion, and by part of the parietal, in *front* by the greater wing of the sphenoid. In the median line this fossa presents from behind forward, first, the *square plate* which bounds the sella turcica behind, and supports the *posterior clinoid processes*; secondly, the *sella turcica* or *pituitary fossa* itself; thirdly, the *olivary tubercle;* and fourthly, the *optic groove*,¶ terminating at each end in the *optic foramen.*** On each side of the sella turcica is seen the *cavernous groove;*†† a wide shallow channel, horizontal in

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* See note ‖, p. 53. † Transmits the facial and auditory nerves.

‡ Transmits a minute vein. § The trifacial.

‖ Which lodges the pituitary body.

¶ Lodges the optic commissure.

** Transmits the optic nerve.

†† Lodges the cavernous sinus and the internal carotid artery.

the middle, bending down posteriorly to terminate in the *foramen lacerum medium*, and curving upward in front, beneath the *anterior clinoid process* (which sometimes converts it at this point into a hole). Further outward appears, on each side, a deep fossa, wider externally than internally, sometimes called the *lateral fossa* of the middle region, and destined to support the middle lobes of the brain. This fossa presents posteriorly the *eminence* formed by the superior semicircular canal; anterior and internal to this the *hiatus Fallopii*,* with the *groove* (sometimes double) which leads from that orifice to the foramen lacerum medium; anterior and internal to this the *foramen spinosum*;† anterior and internal to this, the *foramen ovale*;‡ anterior and internal to this, the *foramen rotundum*;§ and finally, in front of this, the *sphenoidal fissure*;|| formed below by the greater and above by the lesser wing of the sphenoid; and completed internally by the side of the body of the sphenoid, externally by the orbitar plate of the frontal. Between the foramina ovale and rotundum, there are generally one or two small apertures, varying in size in different individuals, and frequently in the same individual on opposite sides. They are the upper orifices of little canals, which open below in the pterygoid fossa, just external to the *scaphoid depression*. The largest and most constant of them is called the *foramen Vesalii*; it transmits a little vein, one of the *emissary veins of Santorini*. They generally disappear in old skulls; and are probably connected (like the holes in the sella turcica) with the nutrition of the bone. This surface is marked with cerebral impressions, and with an arterial channel, which begins at the foramen spinosum, runs outward a little way, and divides into two branches; a *posterior* that ramifies upward and backward; an *anterior* and larger that runs upward and forward to the anterior inferior angle of the parietal, in which it forms a deep groove, frequently a perfect canal, afterwards dividing into

* Transmits the cranial branch of the vidian, and the little artery that accompanies it.

† For the middle meningeal artery.

‡ For the third division of the 5th nerve.

§ For the second division of the 5th nerve.

|| Transmits the 3rd, 4th, and 6th nerves: the first division of the 5th, and a small vein, give the arrangement.

numerous ramifications on the interior surface of that bone.

The *line* which separates the middle from the anterior fossa, is formed in the centre by the anterior margin of the *optic groove;* on each side by the *posterior edge of the lesser wing* of the sphenoid, and by the *anterior clinoid process,** into which the inner extremity of the lesser wing is prolonged.

ANTERIOR FOSSA. Formed by the horizontal plate of the frontal, by the cribriform plate of the ethmoid, and by the ethmoidal process, and lesser wing of the sphenoid. Traversed by the *ethmoidal*, and by part of the *sphenoidal* suture, and widest in the median line, where it presents from behind forward, first, an inconsiderable *eminence* separating two slight longitudinal *furrows* (often nearly imperceptible), which are designed for the reception of a pair of nerves;† secondly, the *crista galli;*‡ thirdly, the *foramen cæcum*, a canal formed between the frontal bone and the crista galli of the ethmoid, and communicating, according to Bertin and Cloquet, with the anterior cells of the ethmoidal notch. It generally transmits a small vein. (I have a skull in which it runs forward for three-eighths of an inch, between the plates of the septum of the frontal sinuses; and another in which it runs downward and to the left side, for about one-eighth of an inch, and then terminates in a cul-de-sac. Mr. Henry Lee, of King's College, London, has a skull in which it descends in the substance of the right nasal bone, and opens on the middle of its anterior surface. Very often it descends directly into the nose. The crista galli seldom does more than complete its upper orifice; and sometimes it is formed entirely in the frontal bone. It is often partially or completely impervious, especially in the skulls of old persons; and even when fully developed its course and termination vary in different individuals. The contradictory accounts given of it by different anatomists have doubtless arisen from this variability.) On each side of the crista galli is seen the *olfactory groove*, formed by the *cribriform plate* of the ethmoid bone, perforated all over

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* The clinoid processes attach the folds of dura mater which form the cavernous sinuses. † 1st, or olfactory.

‡ Attaches the falx major. (I have seen a skull in which this process is unusually large, and hollowed by a sinus communicating with the right frontal sinus.)

by little *holes*,* and in front by a small *fissure*;† in its external margin are seen the orifices of the *internal orbitar foramina*. The anterior of these orifices occurs near the middle of this margin, and is usually connected with the fissure just mentioned by a little groove, which lodges the nerve that they both transmit.‡ The posterior (which transmits a small vein) communicates below with the cavity of the nose, and opens also into the cranium, at the hinder extremity of the cribriform plate, where it is overarched by a little projecting lamina of the sphenoid. Laterally the anterior fossa presents a convex surface, corresponding to the roof of the orbit, and marked with cerebral and arterial impressions.

73. The cavity, which is encompassed by the surface that has just been described, is of an ovoid form, smaller before than behind, and continuous below with the vertebral canal; of which it may be considered the enlarged extremity. Of its use we shall speak in reviewing the entire skull.

OF THE FACIAL BONES.

74. Of the fourteen facial bones two are single and median—viz., the *inferior maxillary*, and the *vomer:* twelve lateral and in pairs, viz., two *superior maxillary*, two *malar*, two *nasal*, two *palate*, two *inferior turbinated*, and two *lachrymal bones*. Of these six pairs the four first are most considerable in size and importance; the two latter being small appendages within the nasal and orbitar fossæ. All these bones are united by suture, with each other and with the cranium, except the lower jaw, which moves upon a hinge-joint. The face is frequently divided into *upper jaw*, consisting of thirteen bones; and *lower jaw*, consisting of one bone. This division, however, is too unequal to assist the memory; nor can such bones as the *vomer*, the *lachrymal bone*, the *cheek-bone*, &c., be included under the common designation *upper jaw*, without a latitude of expression almost amounting to inaccuracy.

75. After the description of the facial bones, that of the thirty-two *teeth*, and of the *hyoid bone*, may be conveniently, and perhaps not altogether unnaturally intro-

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* Transmit the filaments of the olfactory nerves.

† Transmits the nasal twig of the ophthalmic.

‡ Nasal twig of ophthalmic.

duced; as the former, though differing from bone in structure and mode of growth, are yet directly inserted into the maxillary bones; while the latter, though strictly speaking a solitary bone, is connected by proximity, and by the intervention of several muscles and ligaments, with the lower jaw.

OF THE SUPERIOR MAXILLARY BONES.

76. A pair of large irregular bones, occupying the middle and anterior part of the face, and presenting for examination two *aspects*, an *external* and an *internal*; a *circumference* which separates these aspects; and four *processes*, one belonging to each aspect, the remaining two to the circumference.

77. External Aspect. That part of the bone which can be seen without separating it from its neighbours. It presents in the centre the *malar process*, which, as it divides this aspect into three parts, will be described first. Malar Process. A rough triangular eminence, directed upward and outward, articulated above with the malar bone, hollowed behind where it forms part of the temporal fossa, more slightly concave in front where it forms part of the canine fossa, most prominent below where it gives rise to a blunt ridge which passes vertically to the lower border of the bone, becoming less prominent as it descends. That part of the external aspect which lies in front of this ridge is the *facial* surface; the part which lies behind it is the *zygomatic* surface; while the remaining part, which lies superior and internal to the malar process, is the *orbitar* surface. We shall begin with the Orbitar Surface. Smooth, irregularly quadrilateral, and directed upward, outward, and forward. Bounded internally by a thin uneven margin, which articulates with three bones; in *front*, by a notch sometimes called the *incisura lachrymalis*, with the lachrymal bone; in the *middle* with the ethmoid; *behind* with the palate bone. Bounded externally by the *malar process*; anteriorly by a short rounded edge, which forms part of the circumference of the orbit; posteriorly by a rounded edge, which contributes to form the *spheno-maxillary fissure*, and which sometimes, at its anterior extremity, articulates with the orbitar plate of the sphenoid. (85) This surface is marked by a channel which commences at the middle of the posterior border, and passes forward and

ownward, gradually deepening till it becomes a canal, which divides into two branches; an *anterior* called the *ifra-orbitar canal*, which is wider and shorter, pursues he original direction of the groove, and opens at the *nfra-orbitar hole*;* a *posterior* which is longer and maller, and descends in the anterior wall of the maxillary inus, under the name of the *anterior dentar canal*.† FACIAL SURFACE. Looks forward and outward, and resents two depressions; first, the *canine fossa*, large nd deep, situated just below the orbit, perforated at its pper part by the *infra-orbitar hole*, and presenting, bove and below that opening, rough impressions for the ttachment of muscles;‡ secondly, the *myrtiform* or *ncisive fossa*, smaller and less distinct, situated above he incisor teeth, and separated from the other by a vertical ridge (the *canine eminence*) caused by the socket of the canine teeth. (81) This fossa gives origin to a muscle.§ ZYGOMATIC SURFACE. Looks backwards and outward; presents at its lower part a rounded eminence, more prominent before than after the growth of the wisdom tooth, and called the *maxillary tuberosity*.‖ About the middle of this surface appear the apertures, two or three in number, of the *posterior dentar canals*;¶ and at the inner and lower part there are some inequalities which articulate with the tuberosity of the palate bone, (89) and sometimes (but very rarely) with the pterygoid process of the sphenoid.

78. INTERNAL ASPECT. Divided by the *palatine process* into two portions of unequal size; the superior and larger belonging to the cavity of the nose, the inferior and smaller to that of the mouth. This division, however, is not perfect, for the palatine process is deficient behind, so as to allow a communication between the two portions. We shall hereafter find that the deficiency is supplied, and the separation completed, by the palate bone.

79. PALATINE PROCESS. A strong plate of bone, projecting horizontally inward from the internal surface of

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* Transmits the infra-orbitar vessels and nerve.

† Transmits the anterior dental vessels and nerves.

‡ The upper gives origin to the levator labii superioris; the lower to the levator labii superioris alæque nasi.

§ Depressor labii superioris alæque nasi.

‖ This name is sometimes applied to the whole of the zygomatic surface.

¶ Transmit the posterior dental vessels and nerves.

the bone, thicker before than behind, forming the floor of the nose, and the roof of the mouth, and presenting for examination two *surfaces* and four borders. SURFACES. *Superior*. Smooth, level from before backward, concave from side to side, and perforated in front by a canal, which descends forward and inward, and joins the similar canal of the opposite side to form the anterior *palatine or incisive canal*,* (only seen when the bones are united). *Inferior*. Rough, concave from back to front, perforated with many little apertures for nutrient vessels, and marked with a longitudinal furrow (in some skulls indistinct, in others very deep, sometimes covered by a bony arch which converts it into a complete canal, sometimes double) for the transmission of vessels and nerves.† It presents anteriorly when joined with the opposite bone the *palatine foramen*, which is the lower orifice of the anterior palatine canal above mentioned. BORDERS. *Outer*. Continuous with the rest of the bone. *Inner*. Rough, vertical, thicker before than behind; surmounted by a ridge, which, with the corresponding crest of the opposite bone, forms a groove for the reception of the vomer, and marked at its anterior inferior part by a groove which contributes to form the *anterior palatine canal*. *Anterior*. Short, thin, smooth, curved; forming part of the anterior orifice of the nasal fossæ; and prolonged forward, internally, into an acute angle, which unites with the opposite to form the *anterior nasal spine*. *Posterior*. Short, denticulated, bevelled at the expense of the upper surface, and articulated with the palatine plate of the palate bone.

80. INTERNAL ASPECT. *Superior* or *nasal division*. Broad and vertical, forming the outer boundary of the nasal fossæ, and the inner wall of a large triangular chamber, which excavates the body of the maxillary bone, and opens near the middle of the internal aspect. This cavity, which is called the *maxillary sinus*, or *antrum of Highmore*, is bounded above by the orbitar plate; below by the base of the alveolar process; in front by the facial surface; and behind by the zygomatic surface. Its apex, directed outward, is formed by the malar process; and its base, directed inward, by the outer wall of the nose. Like

* Transmits the anterior palatine vessels and nerves, and lodges the naso-palatine ganglion.

† Posterior palatine.

ıe frontal, sphenoidal, and other sinuses of the cranium, is often subdivided by little projecting laminæ; its roof traversed by the *infra-orbitar canal*, and its outer wall y the *posterior dentar canals*, which, commencing above nd behind, near the centre of the zygomatic surface, weep round it downward and forward, sometimes to open n the facial surface, or in the cavity of the antrum, or ı the alveoli of the teeth; sometimes to be lost in the ellular tissue; sometimes to degenerate into grooves, hich run a little way on the wall of the antrum, and nen disappear. They transmit vessels and nerves (of ne same name) to the teeth. The floor of the antrum is requently pushed up, sometimes even perforated, by the angs of the teeth. Its inner wall is perforated, near the niddle, by a large irregularly shaped aperture, through hich it communicates with the nasal fossæ. The margin f this aperture is thin and ragged; in the united skull ; is overlapped, above by the ethmoid, below by the nferior turbinated, behind by the palate bone. It is ometimes double. I have seen two skulls in which it is raversed by several little tongues of bone, which give it cribriform appearance. Above this aperture are several alf cells completed by the ethmoid; below it is a smooth oncave surface, belonging to the inferior meatus of the ose, and traversed by a fissure, which runs from the rifice of the antrum obliquely downward and backward, o receive the *maxillary process* of the palate bone; (89) ehind it is an uneven surface which articulates with the ertical plate of the palate bone. This last surface is raversed by a groove which commences at the middle of he posterior border, runs obliquely downward and orward, and contributes to form the *posterior palatine canal.** In front of the orifice of the antrum is a deep groove, sometimes converted into a canal by a lamina of bone, directed upward and forward, and forming part of the *naso-lachrymal* canal. (135) In front of this groove is a nearly horizontal ridge, which articulates with the inferior turbinated bone, and is called the *inferior turbinated crest.* Above this crest is the internal surface of the nasal process; which will be presently described. Below it is a smooth surface, concave from above downward, and belonging to the inferior meatus of the nose.

* Transmits the posterior palatine vessels and nerves.

Inferior or *Oral division.* Small, uneven, concave, marked with little furrows and apertures for nutrient vessels.

81. The CIRCUMFERENCE, or line of separation between these aspects, presents below, the *alveolar process*, a curved eminence, thicker behind than before, hollowed by eight deep conical cavities (called *alveoli*) for the insertion of the teeth, and marked internally and externally by a series of alternate eminences and depressions, which correspond to the alveoli, and to the intervals between them. The *alveoli* vary in size and form according to the teeth they respectively contain. Those of the *incisors* are deep, narrow, and single; those of the *grinders* are wide, and subdivided into minor cavities corresponding to the fangs of the teeth; those of the superior canine, or *eye-teeth*, are the deepest and most prominent externally, where they form on each side, a vertical ridge called the *canine eminence*, that separates the infra-orbitar from the myrtiform fossa. *Anteriorly* the circumference presents, first, a deeply concave edge, which is called the *nasal notch* of the upper maxillary, and contributes to form the anterior aperture of the nasal fossæ; below this, an eminence which forms half of the *anterior nasal spine;* and below this again, a short vertical border, which unites with that of the opposite bone. *Posteriorly*, the circumference is indicated by the *maxillary tuberosity. Above*, it is formed by the inner border of the orbitar plate, and in front of that by the ASCENDING or NASAL PROCESS. This is a stout triangular eminence, directed upward, inward, and backward; smooth, concave, and marked with vascular apertures, on its external surface, where it gives attachment to muscles;* less even within, where it presents, at its upper part, some rugosities (occasionally a little half-cell), covered by a plate of the ethmoid; below these a horizontal crest, which articulates with the middle turbinated bone, and is called the *middle turbinated crest* of the upper maxillary; and below this again a horizontal shallow groove, marked with arterial furrows, and belonging to the middle meatus of the nose. This groove is bounded below by the *inferior turbinated crest* of the upper maxillary (a horizontal ridge which marks the line

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* Levator labii superioris; and levator labii superioris alæque nasi.

junction between the nasal process and the rest of the)ne). Such are the *surfaces* of the nasal process; its *mmit* presents denticulations which join the internal ıgular process of the frontal; its *anterior border* is thin, ıd bevelled at the expense of the inner surface above, of ıe outer surface below, to articulate with the nasal)ne; its *posterior border* is very thick, and divided by groove into two edges, of which the *internal* (also *osterior*) articulates with the *lachrymal* bone; the *ternal* (also *anterior*) is free, and forms part of the cir- ımference of the orbit; while the intervening groove ontributes to form the *naso-lachrymal canal.* (135) ust where this border joins the body of the bone, there a little angle described by Bourgery, as the *lachrymal ıbercle.* It was pointed out by Lisfranc, who considers to be of importance, as affording a surer guide than ıe tendon of the orbicularis, in the operation for fistula ıchrymalis.

82. STRUCTURE. Processes cellular, walls of the antrum ompact. DEVELOPMENT. By separate points for the alatine, malar, and nasal processes; by a point for the ody; by several points (which are the first to appear) or the alveolar process; and sometimes by an extra oint for a little piece analogous to the intermaxillary one of quadrupeds. This portion is indicated in young ones by a fissure, which if perfect would cut off the nterior corner of the bone, including the two incisor eeth. But this fissure, though often deep and distinct nternally, is seldom continued on the facial surface of he bone. Another fissure, indicating in like manner an mperfect division of the bone during fœtal life, extends in young specimens) from the anterior end of the orbitar groove to the infra-orbitar foramen. When these clefts ıave disappeared, their former position is still indicated, n many bones, by little sutures. The maxillary sinus levelops gradually by age. ARTICULATIONS. With the rontal, nasal, malar, lachrymal, ethmoid, palatine, nferior turbinated, vomer, opposite maxillary, teeth, ınd sometimes sphenoid, by the several points above nentioned.

OF THE MALAR BONES.

83. A pair of irregularly quadrilateral bones, occupying the upper and outer part of the face, and consisting of a *body* and a *process.* Each of these parts presents for

examination two *surfaces*, and four *borders:* the body also presents four *angles.*

84. BODY. The largest and thickest part of the bone. Placed vertically in the face, it forms the cheek in front, and contributes behind to the temporal and zygomatic fossæ. SURFACES. *Outer* or *anterior.* Smooth and convex, directed outward, forward, and a little upward, covered in the recent state, by a muscle,* and marked near the centre by a small *hole*—sometimes by more than one. These are the apertures of little passages called the *malar canals*, which will be presently described. *Inner* or *posterior.* Directed backward, inward, and a little downward; presents *internally* a triangular rough surface, which articulates with the malar process of the upper maxillary; at its *outer* and *posterior* part a smooth surface, narrow and very concave *above*, where it belongs to the temporal fossa, wider but less concave *below*, where it contributes to the zygomatic fossa, and presents the aperture of a *malar canal.* ANGLES. The *superior*, thick and serrated, articulates with the external orbitar process of the frontal; the *anterior*, thin and pointed, and the *inferior*, obtuse and thick, articulate with the malar process of the superior maxillary; while the *posterior*, denticular, prominent, and bevelled, articulates with the zygomatic process of the temporal. BORDERS. If a line be drawn vertically from the upper to the lower angle of the bone, two of the borders will be found *anterior*, and two *posterior* to it. Of the former, one is *anterior-superior*, and forms part of the orbit; the other *anterior-inferior*, and articulates with the malar process of the upper maxillary. Of the latter, one is *posterior-superior*, and corresponds to that part of the inner surface which contributes to the temporal fossa; the other is *posterior-inferior*, and corresponds to that part of the inner surface which contributes to the zygomatic fossa. *Anterior-superior*, or *orbitar* border. Is smooth, concave, and rounded, and forms a considerable part of the circumference of the orbit. *Anterior-inferior*, or *maxillary* border. Rough, and bevelled at the expense of the outer surface, to articulate with the upper maxillary; which here overlaps the malar. *Posterior-superior*, or *temporal* border. Curved like an italic *f*, and continuous *below*

* Orbicularis palpebrarum.

with the upper border of the zygomatic process, *above* with the temporal ridge of the frontal. It forms the anterior limit of the temporal fossa, and attaches a strong aponeurosis.* *Posterior-inferior*, or *zygomatic*. Thick, especially in front, continuous with the lower border of the zygomatic process, and uneven for the attachment of a strong muscle.†

85. ORBITAR PROCESS. A thin curved plate which projects backward from the orbitar margin of the bone, at right angles to the posterior surface of the body. Its upper surface, smooth and concave from side to side, contributes to the floor, and to the outer wall of the orbit. Its *lower* surface, also smooth, but convex, contributes to the temporal fossa. Of its *borders*, the *anterior* is identical with the orbitar border of the body already described; the *superior* is serrated, horizontal, and articulated to the frontal bone just behind its external angular process; the *posterior*, also serrated, is vertical, and joins the orbitar plate of the sphenoid; the *inferior* (or *internal*) is serrated like the former, and horizontal for articulation with the orbitar plate of the superior maxillary bone. At the angle of junction between the two last-mentioned borders (*i.e.* the *sphenoid*, and the *maxillary*), there is generally a very short rounded margin, which forms the anterior boundary of the *spheno-maxillary fissure*. Its length varies with the width of the fissure; sometimes it is entirely wanting. In this case the malar bone does not enter into the formation of the fissure, which is then completed in front by the junction of the upper maxillary and sphenoid. (This disposition is sometimes seen in one orbitar fossa, while on the opposite side of the skull the spheno-maxillary fissure is completed by the malar bone.) Upon the upper surface of the orbitar plate appear the orifices of one or two *malar canals*. We have already described similar apertures on the two surfaces of the body; and may now speak of the canals themselves. Though seldom entirely wanting, they are very irregular as to size, number, and course. A common disposition is the following. From the hole on the zygomatic surface of the body a canal runs a little way forward and upward, and then divides into two branches, one that ascends to open on the orbitar surface, another that descends to

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* Temporal. † Masseter.

open on the anterior or facial surface. Sometimes there are several canals unconnected with each other; and one or more may cease within the substance of the bone. Some of them give passage to small nervous filaments;* others admit little nutrient vessels into the cancellous tissue of the bone.

86. STRUCTURE. Compact externally, cellular within. DEVELOPMENT. By a single point. ARTICULATIONS. With the upper maxillary, frontal, temporal, and sphenoid.

OF THE PALATE BONES.

87. A pair of complex bones, situated between the palatine plate of the superior maxillary and the pterygoid process of the sphenoid, and each consisting of two plates joined at a right angle; an inferior *horizontal*, and a superior *vertical*.

88. HORIZONTAL OR PALATINE PLATE. Thick, quadrilateral, and continuous with the *palatine* process of the superior maxillary; like which process it presents two *surfaces* and four *borders* for examination. SURFACES. *Upper*. Smooth, concave from side to side, level from back to front, forming part of the floor of the nose. *Lower*. This surface, level though rough, forms the back part of the hard palate, presents posteriorly a transverse *ridge* (often indistinct) for the attachment of a muscle,† and at the outer extremity of this ridge, the oval orifice of the *posterior palatine canal*. Near this hole there are frequently the smaller orifices of one or two *accessory posterior palatine canals*. Lastly, from this aperture a groove runs forward, to become continuous with a similar groove on the palatine process of the upper maxillary, (79) and to transmit the same vessels and nerves.‡ EDGES. *External*. Joins the vertical plate. *Internal*. Straight, thick, and serrated, for articulation with the opposite bone; surmounted by a *crest* which helps to form a *groove*, continuous with the groove formed by the two upper maxillary bones, and, like that, designed for the reception of the vomer. *Anterior*. Serrated, bevelled at the expense of the lower surface, and supported by the palatine plate of the superior maxillary.

* Filaments of the malar branch of the ophthalmic nerve, which pass through the malar bone to anastomose with the facial.

† Circumflexus palati. ‡ Posterior palatine.

Posterior, or *Guttural*. This border, thin, smooth, and concave, terminates the *hard* palate, and gives attachment to the *soft*.* By uniting with the internal border, it forms a projecting angle, which, when joined with that of the opposite side, constitutes the *posterior nasal spine*.

89. Vertical Plate. Thin, quadrilateral, oblong, and inclined from below upward, and a little inward. Presents for examination *two surfaces, four borders, two processes*, and a *notch*. Surfaces. *Internal*. Presents from below upward, first, a shallow horizontal *groove*, which belongs to the inferior meatus of the nose; secondly, a horizontal *crest*, with which the *inferior* turbinated bone articulates; thirdly, another horizontal *groove* belonging to the middle meatus; fourthly, a second *crest*, to which the *middle* turbinated bone is attached. These crests are called respectively the *superior* and *inferior turbinated crests* of the palate bone; they are on a line with the corresponding crests of the superior maxillary bone already described (80). *External*. Uneven, marked with arterial impressions, and closely fitted to the inner surface of the upper maxillary; with the posterior part of which it articulates in the united skull. It is traversed obliquely by a groove, which, with one that has been described on the superior maxillary, (80) forms the upper part of the *posterior palatine canal:* and it presents superiorly a little smooth surface, which appears in the zygomatic fossa. Edges. *Inferior*. Joins at right angles the horizontal or palatine plate. *Anterior*. Uneven, thin, and prolonged forward at its lower part into an angular process which contracts the entrance of the antrum. It is received into a slit of the upper maxillary bone just below that orifice, whence it is often called the *maxillary process* of the palate bone. Its form varies considerably in different skulls.—I have seen it a long ragged denticulation, wider at the extremity than at the root; at other times it is very short; it is usually triangular, with the apex directed forward; and it always occurs below the level of the inferior turbinated crest. (It is very fragile, and frequently breaks during the separation of the bones.) *Posterior*. Uneven, hollowed by a narrowed groove which receives the anterior edge of the pterygoid process of the

* Also called the velum pendulum palati.

sphenoid. The angle formed by the junction of this border with the guttural border of the horizontal plate, is prolonged into a triangular eminence called the PYRAMIDAL PROCESS, or TUBEROSITY of the palate bone. This process projects downward, outward, and backward, and is received into the bifurcation of the pterygoid process of the sphenoid. It is fluted behind by three vertical grooves lying side by side, of which the *inner* is the deepest, and receives the internal plate of the pterygoid process; while the *outer*, less deep and distinct,* but rougher, is joined to the external plate of the pterygoid process; and the *middle*, wider, shallower, and smoother than the others, fills up the space left by the bifurcation of the pterygoid plates, and so completes the pterygoid fossa. The *lower* surface of the pyramidal process belongs to the palatine arch, and presents the orifices of one or two small *accessory posterior palatine canals.* Its *outer* surface is uneven, and articulates with the inner surface of the upper maxillary. *Superior edge* (*of the vertical plate*). Supports two *processes* separated by a *notch.* Of the processes, the posterior and shorter stands upward and inward, and is called the *sphenoidal* process; the anterior and longer stands upward and outward, and is called the *orbitar* process; while the intervening space is called the *spheno-palatine notch.* SPHENOIDAL PROCESS. Presents three surfaces, an *internal*, *external*, and *superior;* and two borders, an *anterior* and a *posterior.* The *internal* surface is smooth, and contributes to the outer wall of the nasal fossa. The *external* surface is divided into two parts; a posterior articulated to the inner surface of the pterygoid process of the sphenoid; and an anterior, of less extent, free, and forming part of the zygomatic fossa. The *superior* surface or *summit*, articulates with the anterior part of the floor of the sphenoidal sinuses, *i.e.*, with the horizontal portion of the sphenoidal turbinated bone (which sometimes remains separate from the sphenoid, and is united to this process), and presents a groove which contributes to the *pterygo-palatine canal.* Of the borders, the *posterior*, which is thin and uneven, rests against the pterygoid process, while the *anterior*, which is thicker and more even, forms the posterior boundary of the spheno-palatine notch. ORBITAR PROCESS. A hollow

* Sometimes not a groove, but a mere serrated line.

apophysis, formed of thin laminæ which include a cell, and supported upon a contracted pedicle or neck. At the base of this pedicle occurs the *superior turbinated crest* of the palate bone (already described); and just above that crest, on the inner surface of the pedicle, is a little transverse *groove* belonging to the upper meatus of the nasal fossa. The orbitar process presents three aspects, an *inner*, an *outer*, and an *upper;* which last is called the *summit.* But the inner and outer aspects are each subdivided into an *anterior* and *posterior* part, so that there are altogether five surfaces for description; viz., an orbitar, a maxillary, a sphenoid, an ethmoid, and a zygomatic. The respective directions of these several surfaces are best observed by joining the palate bone to the upper maxillary, and successively applying the contiguous bones. *Upper aspect* (or *orbitar surface.*) Directed upward and outward; smooth, triangular, continuous with the orbitar plate of the upper maxillary, and consequently forming part of the floor of the orbit. *Outer aspect, anterior division* (or *maxillary surface.*) Directed outward, downward, and forward; oblong, uneven, and articulated to the inner surface of the upper maxillary. *Outer aspect, posterior division* (or *zygomatic surface.*) Directed outward, downward, and backward; oblong, smooth, free, continuous with the zygomatic surface of the upper maxillary, and belonging to the zygomatic fossa. *Inner aspect, anterior division* (or *ethmoidal surface.*) Directed inward, upward, and forward, to articulate with the ethmoid. *Inner aspect, posterior division* (or *sphenoidal surface.*) Directed inward, upward, and backward, to articulate with the anterior wall of the sphenoidal sinus, *i.e.,* with the vertical portion of the sphenoidal turbinated bone. On one or other of the two last-mentioned surfaces appears the large ragged orifice of the cell that excavates this process. When this cell opens on the *ethmoidal* surface, it communicates with the posterior ethmoid cells; when on the *sphenoidal* surface (which is the usual arrangement), it communicates with the sphenoidal sinus. I have a specimen in which this process contains two cells, one communicating with the ethmoid cells, the other with the sphenoidal sinus. SPHENO-PALATINE NOTCH. Round and smooth, converted into a hole called the *spheno-palatine* foramen by the sphenoidal turbinated bone, or sometimes by a slip of bone passing horizontally between the two processes just described.

This hole is sometimes crossed by little threads of bone, which divide it into several smaller foramina. I have a palate bone in which it is triple. It forms a communication between the nasal and zygomatic fossæ, lodges a nervous ganglion,* and transmits an artery.†

90. STRUCTURE. Compact where thin, cellular in its thicker parts. DEVELOPMENT. By a single point, which appears at the base of the pyramidal process. ARTICULATION. Principally with the upper maxillary, to which it is a kind of appendage; also with the opposite palate bone, the ethmoid, sphenoid, sphenoidal turbinated, inferior turbinated, and vomer.

OF THE NASAL BONES.

91. A pair of small oblong bones, situated in the upper and middle part of the face, and concurring to form the bridge of the nose; they slant from above obliquely downward and forward, are rather variable in form, and present for examination two *surfaces* and four *borders*.

92. SURFACES. *Anterior.* Directed forward, upward, and outward; smooth, more or less concave from above downward, convex transversely, covered in the recent state by a muscle, marked with minute arterial furrows, and perforated in the middle by a small hole for the transmission of a little vein. This hole is sometimes absent on one side or both; at other times it is double, or surrounded with several smaller ones. The foramen cæcum of the cranium has been seen to open on this surface. (72) *Posterior.* Convex from above downward, concave from side to side, traversed by minute arterial furrows, and by a very distinct longitudinal groove (sometimes a complete canal) which transmits a small nerve.‡ This surface also presents the inner orifice of the little venous foramen described above.

93. BORDERS. *Superior.* Short, thick, serrated, convex, and articulated with the nasal notch of the frontal. *Inferior.* Longer and thinner than the upper, sloped obliquely downward, backward, and outward, articulated to the lateral cartilage of the nose, and interrupted in the

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* Spheno-palatine.

† Nasal branch of the internal maxillary.

‡ A filament of the internal nasal twig of the ophthalmic.

middle by an angular notch for the transmission of a nerve.* The angle of junction between this border and the internal is very acute, and concurs with the similar angle of the opposite bone to form a sharp eminence, sometimes called the *nasal angle*. *External.* Thicker above than below, slightly serrated, and bevelled at the expense of the anterior surface above, of the posterior surface below. It articulates with the nasal process of the upper maxillary; overlapping it below; overlapped by it above. *Internal.* Shorter than the external, thicker above than below, prolonged behind into a longitudinal *crest* (more prominent above than below), which with the corresponding ridge of the opposite bone forms a groove that receives the nasal spine of the frontal, and the perpendicular plate of the ethmoid.

94. STRUCTURE. Cellular internally, especially at the upper part, where it is thickest. DEVELOPMENT. By a single point in the centre. ARTICULATION. With the frontal, upper maxillary, ethmoid, and opposite nasal.

OF THE INFERIOR TURBINATED BONES.

95. A pair of little oblong porous bones, situated in the nasal fossæ, the outer walls of which they traverse horizontally, one on each side, just below the orifice of the antrum. Their size is very variable.† Their figure is like that of a scroll, being curved, or as it were, *rolled up*, so as to present a convexity towards the nose, a concavity in the opposite direction. They have two *surfaces*, two *borders*, two *extremities*, and three *processes*.

96. SURFACES. Spongy, free, perforated with vascular holes, and covered in the recent subject with the lining membrane of the nose. The *internal* is convex, and traversed by one or two longitudinal furrows (sometimes complete canals) for small arteries; the *external* is concave,‡ and contributes to form the inferior meatus of the nose.

97. EDGES. *Lower.* Free, cellular, thick, especially in

* A filament of the internal nasal twig of the ophthalmic.

† A person in the habit of separating skulls informed me that in the finest skulls these bones are sometimes shrivelled and small; while in skulls, otherwise imperfectly developed, they are frequently large and well marked.

‡ Sometimes so much so as to present almost the appearance of a sinus.

the middle, and convex in the longitudinal direction. *Upper.* Thin, often very uneven, and divided into three portions; a *posterior*, which articulates with the *inferior turbinated crest* of the *palate* bone; (89) an *anterior*, which articulates with the *inferior turbinated crest* of the *upper maxillary;* (80) and a *middle*, which passes across the lower part of the orifice of the antrum, so as to diminish its extent. Just in *front* of this intermediate portion arises a little pyramidal eminence, called the *lachrymal process.* This articulates by its summit with the angle of the lachrymal bone, and by its two borders with the lips of a groove (80) on the upper maxillary, with which it concurs to form the *naso-lachrymal canal.* Just *behind* the intermediate portion another little angle called the *ethmoidal process* ascends to join the ethmoid bone. It varies much in size and form, and is sometimes double. Lastly, between these two eminences a small lamina of bone curves downward and outward, hooking over the lower edge of the orifice of the antrum. This is commonly called the *maxillary* (by Bertin, the *auricular**) *process;* it fixes the bone very firmly in its place, hanging it, as it were, upon the outer wall of the nasal fossa.

98. Extremities. *Posterior.* Long and sharp. *Anterior.* Short and rounded.

99. Structure. Of numerous laminæ of *compact* tissue, so irregularly disposed, that the whole resembles a mass of cellular or spongy tissue. Development. By one central point. Articulations. With the upper maxillary, palate, ethmoid, and lachrymal bones.

OF THE LACHRYMAL BONES.

100. These, the smallest, thinnest, and most fragile of the facial bones, are situated at the anterior part of the inner wall of the orbit, and present for examination two *surfaces* and four *borders.*

101. Surfaces. *External* or *orbitar.* Divided by a vertical ridge into two unequal parts; a *posterior* and larger, flat, smooth, and continuous with the orbitar plate of the ethmoid; an *anterior* and narrower, perforated with little vascular foramina, and concave transversely so

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* So called from its resemblance, which is often very striking, to the pendulous ears of some dogs.

.s to form a longitudinal channel, which, together with one that has been described on the nasal process of the upper maxillary, forms the *lachrymal groove* of the orbit. This groove lodges a little sac of the same name, and is continuous below with the *naso-lachrymal canal*,* (135) by which it communicates with the inferior meatus of the nose. The ridge itself is sharp and prolonged forward below into a little hook-like process, which articulates with the lachrymal tubercle of the upper maxillary, and completes the upper orifice of the *naso-lachrymal canal.* This extremity is sometimes a separate piece, which has been described as the *lesser lachrymal bone.* *Internal* or *nasal.* The exact reverse of the outer; traversed by a vertical *groove*, corresponding to the external *crest;* and presenting an anterior convex part, which corresponds to the lachrymal *groove*, and belongs to the middle meatus; a posterior and wider portion, which corresponds to the orbitar plate of the outer surface, is uneven, and articulates with the ethmoid, completing its anterior cells.

102. BORDERS. *Superior.* Short, thick, and articulated to the internal angular process of the frontal. It often presents a little half cell, which is completed by the frontal. *Inferior.* Divided by the end of the vertical ridge into two parts; a *posterior*, straight, and articulated to the orbitar plate of the upper maxillary; an *anterior*, elongated into a sharp process which is called the *angle* of the lachrymal bone; and which, descending to meet the lachrymal process of the inferior turbinated bone, assists to form the naso-lachrymal canal. *Posterior.* Thin, uneven, and articulated with the anterior border of the orbitar plate of the ethmoid. *Anterior.* This is the longest border; it articulates with the inner of the two lips or edges that occur at the back of the nasal process of the upper maxillary, and frequently

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* The upper part of this passage is frequently called the *lachrymal canal*, while the lower portion is distinguished as the *nasal canal.* This subdivision is very loose and indefinite, and if it were accurate would serve no useful purpose. It seems inconsistent to distinguish the opposite ends of the same canal by separate names, while the two portions of the glenoid cavity, entirely different in form and function, situated on two different portions of the temporal bone, and separated by a deep fissure, are included under a common designation, and remain undistinguishable except by a periphrasis.

presents a narrow groove, into which that lip is received.

103. STRUCTURE. Of extremely thin, compact tissue. DEVELOPMENT. By a single point. ARTICULATIONS. With the upper maxillary, frontal, nasal, and inferior turbinated bones.

OF THE VOMER.

104. This is a thin, flat, quadrilateral bone, single and median, set up vertically in the nasal fossæ, and forming the posterior part of their septum. It is frequently bent so as to be convex on one side and concave on the other,* in which case the nasal fossæ are of unequal size. It is sometimes perforated by a hole which forms a communication between these cavities; it is compared to a ploughshare, as to form; and it presents for examination two lateral *surfaces* and four *borders*.

105. LATERAL SURFACES. These are smooth, and marked with slight vascular furrows; each presents at its lower part the *naso-palatine* groove, which runs obliquely downward and forward, to the upper orifice† of the *anterior palatine canal.* (79) It becomes deeper as it advances; and it lodges a nerve of the same name.

106. BORDERS. *Upper*, or *Sphenoidal.* The thickest part of the bone; presents two laminæ (called the alæ of the vomer) separated by a deep *groove*. The *groove* receives the rostrum of the sphenoid, and the *alæ* are overlapped and retained by two little projecting laminæ of the sphenoid, formerly described. Between the surfaces of this articulation a space is left for the transmission of small nerves and vessels to the substance of the bone. *Inferior.* The longest border. Broad and uneven anteriorly, thin and sharp posteriorly, it is received in front into the groove formed by the junction of the upper maxillary bones, and behind into that which results from the union of the palate bones. *Posterior.* Thick and bifurcated above, thin below, everywhere smooth and free. It is sometimes straight, but generally concave, and it separates the posterior apertures of the nasal

* Sometimes so much so as to touch the inferior turbinated bone of one side.

† This canal, it will be remembered, bifurcates above, and opens by two orifices, one on either side of the septum. Each of the naso-palatine grooves, therefore, has its corresponding aperture.

fossæ. *Anterior.* Channelled in its *upper* half to receive the vertical plate of the ethmoid; sometimes channelled, sometimes single *below,* where it unites with one of the nasal cartilages.* The channel of this edge is continuous with that of the upper. Of these four edges the upper and lower are horizontal; the anterior and posterior slope obliquely from above downward and forward.

107. STRUCTURE. Of two laminæ of compact tissue, separated by a few cellules above, and coalescing below. DEVELOPMENT. By a single point of ossification; which, however, is divisible into two lateral laminæ. ARTICULATIONS. With the sphenoid, ethmoid, upper maxillary, and palate bones; also (by its upper border) with the sphenoidal turbinated bones.

OF THE INFERIOR MAXILLARY BONE.

108. This, the largest of the facial bones, single and symmetrical, consists of a lower curved part called the *body;* and of two straight portions which rise nearly at right angles from the body behind, and are called the *rami* or *branches.*

109. BODY. A thick, strong plate of bone, curved upon itself like a horseshoe, and presenting for examination, two *surfaces,* and two *borders.* SURFACES. *Anterior.* Convex from side to side, concave from above downward; and marked in the middle by the *symphysis of the chin,* a vertical ridge formed by the union of the two pieces of which the bone consisted in childhood;† this terminates below in a triangular subcutaneous eminence, called the *mental process.* On each side of the symphysis, and above the mental process, there is a shallow depression for the attachment of a muscle;‡ and external to this appears an oval hole called the *foramen menti.* This hole lies exactly beneath the second bicuspid tooth, is the external orifice of the *inferior dentar canal,* and gives passage to vessels and nerves.§ From the base of the mental process on each side arises a ridge, which, running at first horizon-

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* The triangular cartilage.

† These pieces remain separate in many animals; in serpents they are united by a movable articulation which allows the jaw to open laterally, and enables the reptile to swallow a prey larger than his own head.

‡ Levator menti.

§ Inferior maxillary.

tally backward, afterward backward and upward, is continued into the anterior border of the ramus. This is called the *external oblique line;* it gives attachment to several muscles.* *Posterior.* Concave from side to side, convex from above downward, presenting in the middle a vertical *furrow* corresponding to the ridge on the opposite side, and like it indicating the symphysis of the chin. Beneath this are seen four little tubercles placed in two pairs, one above the other, and called the *genial processes.* They vary in prominence, are frequently indistinct, and sometimes appear to coalesce into one irregular tubercle (in three or four skulls I have here a sharp spine a quarter of an inch long); they serve for the attachment of muscles.† (I have often observed here two little holes for the transmission of nutrient vessels, one above, the other below, these tubercles; the upper is the larger and more constant.) On each side of the genial processes is a shallow, smooth, oval cavity, called the *sublingual fossa,* which lodges a salivary gland of the same name. Below this fossa, on each side, is a rough depression for the insertion of a muscle.‡ At the outer extremities of these cavities commence the *internal oblique lines,* ridges which are more prominent than the corresponding external lines, and which run backward and upward along the body to the rami, where, making an angle, they ascend nearly vertically to form the inner lip of the groove which marks the anterior border of the ramus. They increase in prominence as they approach the ramus; and they give attachment to two muscles.§ Beneath the most prominent part of the internal oblique line is seen an oblong shallow cavity, called the *submaxillary fossa,* which lodges a salivary gland of the same name. EDGES. *Inferior.* Horizontal, rounded, thicker before than behind; and traversed just where it joins the lower border of the ramus by a polished, shallow, vertical depression, over which an artery‖ turns. This border gives attachment to a muscle.¶ *Upper* or *alveolar.* Narrow in front, wide

* Depressor labii inferioris, and depressor anguli oris, above; platisma myoides below.

† Upper pair to the genio-glossi, lower pair to the genio-hyoidei.

‡ Digastric.

§ Mylo-hyoideus in front, superior constrictor of the pharynx behind.

‖ Facial.

¶ Platisma myoides.

and turned a little inward behind, and pitted with sixteen *alveoli* or sockets for the teeth. Of these the ten anterior (which receive the incisor, canine, and bicuspid teeth) are single; while the three posterior on each side (for the large grinders) are each subdivided into two or three cavities which receive the fangs of the teeth. These sockets are perforated at the bottom by holes for the transmission of vessels and nerves to the teeth; and, like those of the upper jaw, form a series of prominences separated by depressions on the outer and inner surfaces of the alveolar arch. In the old edentulous jaw the alveoli, rendered useless by the loss of the teeth, are absorbed, the height of the body is diminished, and but little of it appears above the oblique line. In the infant, on the contrary, when the teeth are still contained within the jaw, the alveolar process is proportionably deeper than in the adult, and the chief part of the body lies above the oblique line.

110. Rami. Two quadrilateral flat plates of bone which ascend in the lateral regions of the face, and present for examination two *surfaces*, four *borders*, and two *processes*, separated by a notch. Surfaces. *External.* Uneven and slightly concave, turned a little outward at its lower part, where it presents the rough impressions of a strong muscle,* by which, in the recent subject, it is entirely covered. *Internal.* Presents in the centre the oval oblique orifice of a passage in the bone, called the *inferior dentar canal.* This canal descends obliquely forward in the substance of the ramus, enters the body, runs horizontally forward beneath the alveoli (diminishing in size as it proceeds) till it reaches the incisor teeth; here it turns back to terminate at the *mental* foramen, giving off, however, from its angle two little canals, a superior and an inferior, which run forward beneath the incisor teeth, and lose themselves in the cellular tissue of the bone. The walls of this canal are compact near its extremities, cellular in the middle; it is perforated with holes leading into the alveoli, and conveys vessels and nerves† to the teeth. In the posterior two thirds of its course it is nearest the internal surface of the jaw; in the anterior third to the outer surface. The margin of its superior orifice is prolonged upward, *internally,* into a

* Masseter. † Inferior dentar.

spinous process, for the insertion of a ligament;* and presents, *posteriorly*, a notch which gives passage to a nerve.† From this notch a small groove runs obliquely downward and forward, to terminate at the posterior extremity of the sublingual fossæ. It is called the *mylohyoid groove*, and transmits a nerve and vessels of the same name. Lastly, this surface presents, at its lower part, some rugosities for the attachment of a muscle.‡ BORDERS. *Anterior*. Smooth, concave, and nearly vertical, but sloped a little from above downward, forward, and inward. It presents a groove which is continuous with the alveolar border of the body, and gives origin to a muscle.§ The two lips of this groove are formed by the terminations of the internal and external oblique lines. *Posterior*. Thick, smooth, rounded, nearly parallel to the anterior, and forming by junction with the inferior, the *angle of the jaw*. This is a rounded, blunt angle, deflected a little outward, rough on each side for the insertion of a muscle,‖ and intermediately for the attachment of a ligament.¶ Its shape varies considerably at different periods of life. In infancy, before the jaws are separated by the growth of the teeth, it is very obtuse. In the adult, when the ramus becomes almost vertical (in order to leave room between the jaws for the teeth), it is nearly a right angle. In the aged, when the teeth are shed and the jaws fall together, it again becomes obtuse: then the chin is thrown forward, the lips fall in, the face shortens, and the countenance assumes the appearance peculiar to old age. *Inferior*. This border is short, thick, straight, and continuous with the lower border of the body: the point of junction is indicated by a shallow arterial groove, already described. *Superior*. This border, which is thin and curved, supports two processes; an anterior, non-articular and turned a little outward, called the *coronoid process*; a posterior, articular, and directed somewhat inward, called the *condyloid process*. These are separated by an interval, called the *sigmoid notch*. CORONOID PROCESS. A thin, smooth, triangular eminence of variable shape and size; it is flat internally

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* Internal lateral of jaw.

† Mylohyoid branch of inferior dentar.

‡ Internal pterygoid.

§ Buccinator.

‖ Masseter externally; internal pterygoid internally.

¶ Stylo-maxillary.

nd externally, presents a thin margin before and behind, nd by its summit attaches a large muscle.* CONDYLOID 'ROCESS. Is shorter, but thicker than the former, and onsists of two parts, the *condyle*, and the *neck*. The *eck* is the contracted portion which supports the conyle; it is flattened from before backward, smooth and onvex posteriorly, hollowed in front by a concavity, alled the *pterygoid fossa*, for the attachment of a uscle;† narrow internally and externally, in which itter direction it presents a tubercle for the attachment f a ligament.‡ The *condyle* is of an oblong shape, with ne long axis transverse; it is convex from before back-ard, and from side to side, and set obliquely on the eck, in such a manner that its outer extremity rises omewhat higher than the inner, and is also turned a ttle more forward. Thus the long axes of the two conyles, if prolonged inward, would form an angle, with the pex directed downward and backward. A corresponding bliquity is observed in the glenoid fossæ of the temoral bones, and it facilitates considerably the rolling of ne condyles, in the transverse motions of mastication. 'he condyles are covered with cartilage, which extends irther on the posterior than on the anterior surface, and ney articulate by the intervention of an articular fibro-artilage, or *meniscus*, with the anterior part of the lenoid cavity of the temporal bone. (59) *Sigmoid otch*. A large semilunar depression formed between the rocesses just described, and closed above (in the united kull) by the zygomatic arch. The space thus circum-cribed gives passage to nerves and vessels.§

111. STRUCTURE. Of reticular tissue, enclosed in a com-act layer, and traversed by the dentar canal. DEVELOP-ENT. By two principal centres of ossification, which fterwards unite at the symphysis; in addition to which re two points for the two coronoid processes, and one or a separate plate, which forms the lower edge of the one in the fœtus. ARTICULATIONS. With the temporal ones, and the teeth.

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* Temporal.

† External pterygoid.

‡ External lateral.

§ Masseteric.

OF THE TEETH.*

112. Small, extremely hard, calcareous organs (differing in position, organization, and mode of growth, from the bones), implanted in the alveoli of the jaws, and presenting in general the form of an irregular cone, whose apex, single or divided, corresponds to the bottom of the sockets, while its base projects into the cavity of the mouth. There are distinguished in every tooth, a part which is concealed within the jaw, called the *root;* a part which is external and covered with hard enamel, called the *crown;* and a line of junction between the two, which being somewhat contracted is called the *neck.* The teeth, of which in the adult there are thirty-two, sixteen in each jaw, are divided into three clases; *incisors* or *cutting teeth, canine* or *tearing teeth,* and *molar* or *grinding teeth.* In each class the crown and the root present certain characteristic peculiarities of form and size.

113. INCISORS. The four front teeth in each jaw. *Crown.* Wedge-shaped, straight and sharp at its free border, slightly convex in front, and concave behind: its enamel is thinner behind and laterally than in front, and terminates at the neck in a curved margin, the concavity of which is turned toward the cutting-edge. *Root.* Single, conical, transversely flattened, thicker before than behind, and marked on each side with a slight longitudinal furrow.

The superior incisors are larger and stronger than the inferior. In the upper jaw the two middle are larger than the two lateral incisors. In the lower jaw, on the contrary, the two lateral are larger than the middle pair.

114. CANINE. These, four in number, are the longest

* Strictly speaking the description of these organs does not belong to osteology. The transcendental anatomists, who regard the lower jaw as a pair of cephalic prehensile organs, or limbs, united in front, consider the teeth as terminal organs of these limbs, analogous to the talons or nails by which the limbs of the trunk are armed at their free extremities: they therefore place them among the few vestiges of the *splanchnal* skeleton which remain in the higher mammalia. Nevertheless, as they are intimately connected with the bones, and usually remain attached in the preserved specimens which fall under the notice of the student, he will find it convenient to study their descriptive anatomy in this place. A compendious account of their structure and development will be found in Mayo's "Outlines of Physiology," 4th edition, p. 460.

of the teeth. They are placed, two in each jaw immediately behind the incisors, which they separate from the grinding teeth. *Crown.* Somewhat pyramidal, concave, and rather uneven behind, convex in front, and terminated at the summit by a blunt point. *Root.* Like that of the incisors, but very long and thick.

The two upper canine (vulgarly called *eye-teeth*) are longer and larger than the two lower, and are situated a little behind them. In some subjects they extend to the base of the nasal process. Cruveilhier mentions specimens in which he has seen the canine developed in the substance of the nasal process, and in an inverted position (the root being turned downward, and the crown upward).

115. MOLAR. These, the largest of the teeth, are twenty in number, ten being situated in the upper, and ten in the lower jaw. In the upper jaw they occupy the space between the canine tooth and the maxillary tuberosity; in the lower jaw they fill up the interval between the canine tooth and the ramus. They are counted from before backward, the first pair being next the canine, while the last are contiguous to the ramus. The *root* of the molar teeth is divided into fangs; the *crown* is wide, short, flattened at the summit, and provided with tubercles, by which it is adapted to grind the morsel of food that has been cut off by the incisors, or torn by the canine teeth. They differ in bulk, and in the number of their tubercles; and these variations have led to their division into two classes. The first two pairs in each jaw are smaller than the rest, and have only *two* tubercles; hence they are called *small molars*, or *bicuspidati*, the three remaining pairs in each jaw are large, and present *several* tubercles; hence they are called *large molar*, or *multicuspidati* teeth. BICUSPIDATI. Are eight in all; four being situated in each jaw, two on the right, and two on the left side. The upper correspond to the canine fossa, and the lower are placed immediately under them. *Crown.* Irregularly cylindrical, flattened before and behind, where it touches the adjacent teeth, convex internally and externally, and terminated at the summit by two blunt points, separated by a deep notch. *Root.* Single, deeply grooved on each side, perforated at the summit by two holes, and separated from the crown by a nearly circular neck. It is sometimes bifid; especially in the upper jaw.

The superior bicuspid teeth are distinguished from the inferior by their greater size. Their tubercles also are more pointed, and separated by a deeper groove; their roots are more frequently bifid; indeed, the second of the superior bicuspidati is known by its root being *generally* bifurcated. The first inferior bicuspid is distinguished by the prominence of its outer tubercle, which give it somewhat the appearance of a canine tooth. MULTICUSPIDATI. Of these there are three pairs in each jaw. They are designated numerically, first, second, and third; the last pair being also called, from the lateness of their appearance, the *wisdom teeth*. *Crown*. Large, cuboid, flat before and behind where it corresponds to the contiguous teeth, convex externally and internally. The grinding surface generally presents four tubercles separated by two grooves which cross each other in the middle. There are sometimes five tubercles; and the surface, in other instances, presents an irregular wrinkled appearance. *Root*. Generally double in the lower, triple in the upper large grinders: sometimes divided into four or five fangs. These are generally divergent; sometimes parallel, and sometimes curved at the point so as to embrace a portion of the jaw. When there are two, one is anterior, the other posterior; when there are three, one is internal, two are external. The large grinders are distinguished from each other by their size, which diminishes from the first to the last. The wisdom tooth, which is the latest to appear, presents considerable variety in its form and growth. Sometimes its fangs coalesce into one; sometimes it remains buried within the jaw; I have seen it growing straight forward from the ramus.

116. The permanent teeth are preceded by a deciduous set, similar in their general characteristics, but smaller, of a more delicate texture, less firmly rooted in the jaws, and fewer in number, than the permanent. They amount to twenty only; four incisors, four molars, and two canine, in each jaw. The deciduous *incisors* have a serrated appearance, produced by little tubercles of enamel surmounting their cutting margin; the *canine* are more pointed and prominent in the deciduous than in the permanent set; and the *molar* have sharper tubercles, and seldom more than three branches to their roots. They appear about the sixth month, and begin to be shed about the sixth year; the permanent rising, pair after pair, to supply their places.

OF THE HYOID BONE.

117. This is a bony arch, of the shape of a horseshoe, formed of three segments, called the *body*, and the *cornua*, or *greater horns*, and presenting at its upper part two little appendages, called the *cornicula*, or *lesser horns*. In youth these five pieces articulate by cartilaginous surfaces, and are held together by ligaments. Towards middle age the three segments of the arch generally coalesce; the cornicula remain movable much longer; but in very old subjects the five pieces are commonly united into a single bone.

This compound bone, which derives its name from its resemblance to the Greek Upsilon, is suspended horizontally in the neck beneath the lower jaw, to the body of which it is parallel. It is supported in its position entirely by the muscles and ligaments to which it gives insertion; being the only instance in the human body of a strictly solitary bone.* To facilitate its study, we shall describe, first, the *body*, secondly, the *greater horns*, and lastly, the *lesser horns*.

118. Body. This is the anterior and central portion of the arch. It is of a quadrilateral shape, presenting for examination, an anterior, a posterior, and two lateral *surfaces*, and an upper and lower *margin*. Surfaces. *Anterior*. Convex, directed forward and upward, and traversed by two ridges; one *horizontal*, dividing it into an upper and a lower portion; the other *vertical*, crossing the former at right angles, and subdividing each portion into two lateral halves, each of which presents an oval depression. At the point of intersection of the two ridges there is a prominent *tubercle*. The portion above the horizontal ridge is directed more upward than the portion below, and is sometimes described as the upper *border* of the body; in such descriptions what we call the *lower division* of the anterior surface, constitutes the *entire*

* The transcendental anatomists consider this bone, together with the teeth and the cartilages of the larynx and trachea, to represent in the higher mammalia the *splanchnal* skeleton of the inferior orders, just as the epidermis and its appendages are vestiges of the *dermal* skeleton. The office of the former skeleton is to separate the animal from foreign objects admitted into its interior, as that of the latter is to separate it from external nature. Their conceptions on this, as on many other points, appear to me to be philosophical and just.

anterior surface.* The upper division gives attachment to three pairs of muscles;† the lower to two pairs of muscles;‡ and to an aponeurosis.§ *Posterior.* Concave, directed backward and downward, and separated in the recent state by a membrane,|| and by a quantity of yellow cellular tissue, from the *epiglottis* (or lid of the larynx). *Superior.* Rounded and uneven; attaches part of two pairs of muscles,¶ and of a membrane.** *Inferior.* Longer and thinner than the superior, and situated in a plane somewhat in advance of it. It attaches three pairs of muscles.†† *Lateral.* Short, oval, slightly convex, and either covered with cartilage for articulation with the *greater horns;* or joined to them by an osseous union.

119. GREATER HORNS, or CORNUA. Project backward, and a little outward, from the body, diminish in size from before backward, and terminate behind in a tubercular extremity. Each presents two *surfaces*, two *borders*, and two *ends*. SURFACES. *Outer.* Looks outward and upward, is continuous with the anterior surface of the body, and gives attachment to part of two muscles.‡‡ *Inner.* Looks inward and downward, and is covered in the recent state by a membrane.§§ BORDERS. *Superior.* Sharper and shorter than the inferior; attaches part of two muscles,§§ and of a membrane.|||| *Inferior.* Situated on a

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* This is why the attachments of the muscles to the hyoid bone appear to be so variously stated by different anatomists; some attributing to the *border* what others refer to the *surface.*

† Genio-hyoidei in front, and part of genio-hyo-glossi and linguales, behind.

‡ Mylo-hyoid internally, stylo-hyoid externally.

§ Aponeurosis of the digastric. || Thyro-hyoid.

¶ Part of genio-hyo-glossi, and linguales (which are, however, principally attached to the upper division of the anterior surface—see note †).

** Thyro-hyoid. (This membrane is almost universally described as being attached to the *lower* border of the bone. Cruveilhier and Bourgery are the only anatomists (as far as I know) who have described its connexion correctly. The fact, however, is quite certain; as any one may satisfy himself by passing up the handle of a scalpel between the *posterior* surface of the bone, and the *anterior* surface of the membrane).

†† Sterno-hyoid in front, thyro-hyoid behind; and omo-hyoid externally, just at the junction of the body and greater horn.

‡‡ Thyro-hyoid below, hyo-glossus above.

§§ Superior constrictor of pharynx and hyo-glossus.

|||| Thyro-hyoid membrane.

plane external to the former; gives attachment to part of a muscle.* ENDS. *Anterior.* Grows to the body in the adult, articulates with it in youth by a concave cartilaginous surface. *Posterior.* Is smaller than the anterior, and presents a round tubercle for the attachment of a ligament.*

120. LESSER HORNS, or CORNICULA. Two little pyramidal eminences, varying considerably as to size and shape, in different individuals, or even in the same individual on opposite sides. Each is articulated by its *base* to the point of junction between the body and greater horn; and by its *summit*, which is directed backward, upward, and outward, gives attachment to a ligament.†

121. STRUCTURE. Cellular in the body, compact in the horns. DEVELOPMENT. By an ossific point for each of the five pieces of which the bone consists. CONNEXIONS. With the various muscles and ligaments mentioned in the notes. The ligaments by which the lesser horns are connected to the styloid process are sometimes ossified. This irregularity establishes an analogy between the *appareil hyoidien* of man, and that of animals: in which the hyoid bone has a regular osseous connexion with the styloid process of the temporal.

OF THE FACE IN GENERAL.

122. The facial bones form by their union a very irregularly shaped six-sided framework. The superior surface or aspect of this framework articulates with the base of the cranium; the inferior forms the roof of the mouth; the anterior and two lateral surfaces constitute, when covered with the flesh, the countenance, or *face*, in the ordinary acceptation of the term; the posterior articulates, near the middle, with the pterygoid processes of the sphenoid, and presents on each side the posterior border of the ramus of the lower jaw. In regarding the face from above or below, we observe that its transverse diameter is greater behind than before: when we view it in profile, we see that its vertical diameter is greater before than behind; and when we examine it from behind, we observe that its height in the median line (measured

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* Thyro-hyoid. † Stylo-hyoid.

from the upper border of the vomer above, to the palatine arch below) is considerably less than its height on each side (measured from the condyle to the angle of the lower jaw). These aspects of the face are so irregular that it is difficult accurately to define their boundaries. The superior aspect being articulated to the cranium seldom comes under our notice; the others will be successively described. The sutures, which are of less practical importance here than in the cranium, will be described with the regions in which they occur.

123. Anterior Region. Extends vertically from the root of the nose to the point of the chin, and is bounded on each side by the prominence of the cheek-bone, and by the anterior edge of the ramus of the lower jaw. Its greatest transverse diameter is at the level of the cheek-bones. Its greatest vertical diameter is in the median line. It presents from above downward—1st, the nose; a vaulted eminence, convex from side to side, more or less concave in the opposite direction, formed by the nasal bones, and by the nasal processes of the superior maxillary bones. In the middle of this eminence is the *inter-nasal suture*, formed by the junction of the nasal bones; and external to that on each side the smooth external surface of the nasal bone, perforated by some vascular apertures, covered in the recent subject by a muscle,* and limited by the *naso-maxillary suture*,—which is formed between the nasal bone and the nasal process of the superior maxillary. 2ndly. Below the arch of the nose appears the anterior orifice of the nasal fossæ, resembling in shape the heart upon playing cards, with the broader end downward. Its margin (which is connected with the lateral cartilages of the nose) is sharp and thin, formed by the nasal bones above, where it presents in the middle an angular projection flanked by two deep notches, formed by the upper maxillary bones below, where it presents the *anterior nasal spine*. Below this appear in succession the *inter-maxillary suture;* the *incisor* teeth; the vertical ridge, called the *symphysis of the chin;* and the *mental process*.

On each side, and again proceeding from above downward, this region presents—1st, the *circumference of the orbit;* inferior and external to which is the quadrilateral

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* Pyramidalis nasi.

anterior surface of the malar bone, perforated near the centre by one or two *malar canals.** Inferior to the orbit, and internal to the malar bone, appears the *canine fossa*, perforated by the *infraorbitar foramen*,† and marked by two muscular impressions,‡ one above, the other below that orifice. Inferior and internal to the canine fossa, and separated from it by the *canine eminence*, is seen the *myrtiform fossa*, which attaches a muscle.§ Below the canine and myrtiform fossæ appear the *alveolar* and *dentar arches;* which latter vary in form, but when regular are parabolic. The teeth in man are set almost vertically in the jaws, and form an uninterrupted series; in the lower animals they are always more or less inclined, and separated in certain places by intervals. The free edge of the superior dental arch descends slightly from the first incisor to the last molar, forming a curve convex downward; the inferior dentar arch presents on each side a corresponding concavity. Below the dental arches on each side are observed, the *mental foramen*,‖ the *external oblique line*,¶ and the inferior border of the body of the lower jaw, interrupted at its junction with the ramus, by a shallow arterial groove.**

124. Posterior Region. This region is bounded on each side by the posterior edge of the ramus of the lower jaw; in the median line it extends vertically from the upper border of the vomer to the posterior border of the hard palate; on each side it extends vertically, from the condyle to the angle of the lower jaw. It presents, in the median line, the *posterior edge of the vomer*, and the posterior nasal spine;†† external to these appear the oval orifices of the nasal fossæ;‡‡ below these again are the posterior edges of the *horizontal plates* of the palate

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* For the transmission of small filaments from the malar branch of the ophthalmic; also of little arteries.

† For the transmission of a nerve and vessels of the same name.

‡ The upper gives origin to the levator labii superioris; the lower to the levator labii superioris alæque nasi.

§ Depressor labii superioris alæque nasi.

‖ Transmits the inferior maxillary vessels and nerve.

¶ Attaches the depressor labii inferioris and depressor anguli oris above; the platisma myoides below.

** For the facial artery.

†† Attaches the azygos uvulæ.

‡‡ Attach at the external and inferior part of their circumference the superior constrictors of the pharynx.

bones,* and the *tuberosities* of the palate bones† (the latter appearing, one on each side, between the plates of the pterygoid process). Beyond these on each side is an empty space, filled in the recent subject by muscles,‡ and bounded externally by the posterior border of the ramus of the lower jaw, which expands above into the *condyle*, and bends a little outward below, where it joins the lower border to form the *angle* of the jaw.

125. INFERIOR REGION. This region forms the cavity of the mouth, and is sometimes classed with the nasal and orbitar cavities, under the name of the *oral fossa*. It is divided into a superior horizontal portion, called the *palatine vault;* and an inferior vertical portion, formed by the inner surface of the teeth, and of the lower jaw. PALATINE VAULT. Presents, in the median line, from behind forward; 1st, the lower surface of the *posterior nasal spine;* 2ndly, the suture of the palate and maxillary bones, elevated into a ridge, sometimes called the *palatine crest,* and presenting in front the lower orifice of the *anterior palatine canal.*§ On each side of this longitudinal suture is seen, from behind forward, 1st, the lower surface of the tuberosity of the palate bone, perforated by two or three *accessory posterior palatine canals;*|| 2ndly, the lower surface of the *palatine plate* of the palate-bone, presenting posteriorly a little transverse *ridge* for the attachment of a muscle, externally the lower orifice of the posterior *palatine canal;* and, leading forward and inward from this hole a *groove,* which lodges the nerves and vessels that pass through the canal. 3rdly, the *transverse palato-maxillary* suture.¶ 4thly, the concave, uneven surface of the palatine plate of the upper maxillary, which is traversed by the continuation of the groove above mentioned, and perforated by many nutrient foramina. Some of these, situated

* Attaches the velum pendulum palati.

† That part of the tuberosity, which appears in the pterygoid fossa, attaches a few fibres of the internal pterygoid muscle.

‡ Internal and external pterygoid.

§ Lodges the naso-palatine ganglion.

|| Transmit small palatine arteries and nerves.

¶ This suture, which is formed between the palatine plates of the palate and upper maxillary bones, is called *transverse*, to distinguish it from the *vertical* palato-maxillary suture; which is formed between the nasal plate of the palate bone and the inner surface of the upper maxillary.

near the alveolar margin, for the transmission of nerves and vessels to the incisor teeth, constantly seen in young subjects, and sometimes pervious even in the adult, are called the *incisive foramina*. VERTICAL PORTION. Formed entirely by the inner surfaces of the dental and alveolar arches, and of the lower jaw-bone, which have already been sufficiently described.

126. LATERAL OR ZYGOMATIC REGIONS. Bounded in front by the ridge that descends from the malar process of the upper maxillary; behind, by the posterior border of the ramus of the jaw; above, by the zygomatic arch; below, by the inferior border of the ramus of the lower jaw. This region presents two planes; an *external*, formed by the ramus of the lower maxillary bone already described; (110) an *internal*, formed chiefly by the zygomatic surface of the upper maxillary bone, and contributing to the zygomatic, and spheno-maxillary fossæ; which will be described in the next section.

OF CERTAIN PARTS FORMED BY THE UNION OF THE CRANIUM AND FACE.

127. Besides the parts already described as proper to the cranium, or to the face, there are several fossæ and sutures, referrible to neither of these divisions of the skull in particular, but resulting from the union of both. These we proceed in this section to describe.

128. CRANIO-FACIAL FOSSÆ. Of these there are five pairs; the *orbitar*, the *nasal*, the *zygomatic*, the *spheno-maxillary*, and the *temporal*.

OF THE ORBITAR FOSSÆ.

129. These are two pyramidal cavities, situated in the upper and anterior part of the skull, and having their base directed forward and outward, and their apex backward and inward.* They present for examination four *walls*, four retiring *angles*, formed by the junction of the *walls*, a *circumference* or *base*, and an *apex*.

130. WALLS. *Upper*, or *Vault*. Directed downward

* This divergence of the axis of the orbits results entirely from the oblique position of their outer walls; the inner walls being parallel to each other, and to the median plane.

and a little forward;* formed chiefly by the concave orbitar plate of the frontal bone, behind, for a small extent, by the lesser wing of the sphenoid. It presents behind forward, first, the transverse suture formed by the junction of the lesser wing of the sphenoid with the orbitar plate of the frontal. Secondly, quite in front and just behind the external angular process, the *lachrymal fossa*, which lodges a gland of the same name; and thirdly, behind the internal angular process, a little tubercle, or depression, for the insertion of a tendinous pulley.†

Lower or *Floor*. Nearly flat, much less extensive than the vault, directed upward, outward, and forward. Formed chiefly by the orbitar plate of the upper maxillary; assisted, in front, by the orbitar process of the malar bone, and behind by the orbitar process of the palate bone. It presents the two sutures formed by the junction of these three portions; and near its middle, the *infra-orbitar groove*,‡ which runs from behind, forward and downward, presently changing into the *infra-orbitar canal*. This surface at its anterior and internal part gives attachment to a muscle.§

Outer. Nearly flat, directed inward, forward, and a little upward. Formed by the orbitar plate of the sphenoid behind, by the upper part of the orbitar process of the malar bone in front. Presents the vertical denticulated suture of these two portions, and in front of the suture the inner orifices of the *malar canals*.‖ It also presents one or two *external orbitar foramina*.

Inner. This surface is the smallest of the four. It is directed outward, forward, and a little upward. It is formed chiefly by the orbitar plate of the ethmoid; assisted by the lachrymal in front, and by a small portion of the sphenoid behind (viz., that portion of the side of the body of the sphenoid which appears in front of the

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* The student is reminded that the *direction* or *aspect* of a surface is indicated by a line drawn perpendicular to its centre. See *Introduction*. (7)

† Through which the tendon of the superior oblique muscle turns.

‡ Transmits the infra-orbitar nerve and vessels.

§ Obliquus inferior oculi.

‖ Transmit small nerves and vessels; one of them gives passage to a branch of the malar nerve sent forward from the orbit to anastomose with the facial nerve.

sphenoidal fissure). It presents the two vertical sutures formed by the junction of these bones; the *vertical crest* of the lachrymal bone, and in front of that the *lachrymal groove;* which, however, being completed in front by the nasal process of the upper maxillary, is usually referred to the *circumference* of the orbit.

131. ANGLES. *Superior* and *external.* This angle is formed by the meeting of the upper and outer walls; and presents, from behind forward; 1st, the *sphenoidal fissure,* or *foramen lacerum anterius;** 2ndly, the junction of the orbitar plate of the sphenoid with the orbitar plate of the frontal bone (being part of the sphenoidal suture); and 3rdly, the articulation of the malar bone with the frontal, just behind the external angular process. *Superior* and *internal.* This angle is formed by the meeting of the upper and inner walls, and presents the *ethmoidal suture,* perforated by the *anterior*† and *posterior*‡ *internal orbitar holes;* and in front of that the little suture between the frontal and lachrymal bones. *Inferior* and *internal.* This is formed by the meeting of the inner wall and the floor, and it presents the sutures between the palate bone and ethmoid, upper maxillary and ethmoid, upper maxillary and lachrymal. *Inferior* and *external.* This angle, formed by the junction of the outer wall and floor, presents posteriorly the spheno-maxillary, or infra-orbitar fissure; a cleft, bounded externally by the orbitar plate of the sphenoid, internally by the orbitar plates of the upper maxillary and palate bones; and generally (but not always (85) completed in front by the orbitar plate of the malar. This fissure is wider at its extremities than in the middle, and gives passage to nerves§ and vessels.‖ (The relative position of the two fissures of the orbit may easily be remembered by bearing in mind, that the outer wall at its posterior part is bounded by a fissure above and below.)

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* Transmits the 3rd, 4th, and 6th nerves, the ophthalmic branch of the 5th, and a small vein.

† Transmits the internal nasal twig of the ophthalmic nerve.

‡ Transmits a small vessel.

§ The ascending branches of the spheno-palatine ganglion, and the posterior dental branches (three or four in number) of the infra-orbitar nerve (the infra-orbitar nerve itself runs across it, but does not pass through it).

‖ The infra-orbitar branch of the internal maxillary artery, with its accompanying vein.

132. Circumference or Base. Of a quadrilateral figure, with curved sides and rounded angles; somewhat larger externally than internally; formed *above* by the supra-orbitar arch; on the *outside* by the external angular process of the frontal, and part of the orbitar border of the malar; *within*, by the internal angular process of the frontal, and the nasal process of the upper maxillary; *below*, by the anterior border of the orbitar plate of the malar, and the corresponding border of the orbitar plate of the upper maxillary. The circumference thus formed is interrupted above by the supra-orbitar notch* (or hole†), and is traversed by three sutures; the *fronto-malar* externally; the *fronto-maxillary* internally, the *malo-maxillary* below. The inner border contributes to the *lachrymal groove*, which is traversed vertically by the suture between the lachrymal bone and the nasal process of the upper maxillary, perforated with numerous little foramina leading into the nose, and continuous below with the naso-lachrymal canal, which opens in the inferior meatus of the nose. The groove lodges a small sac‡ whose duct is transmitted by the canal.

133. Apex. Is represented by the optic foramen; a short round canal, situated quite at the back of the orbit, between the two roots of the lesser wing of the sphenoid. The direction of the two optic foramina is such that their axes, if prolonged backward, would intersect each other in the sella turcica. The slip of bone which separates the optic foramen from the sphenoidal fissure presents a little *tubercle* for the attachment of a tendon.§

The bones that enter into the composition of the orbit are, the frontal, sphenoid, ethmoid, upper maxillary, malar, lachrymal, and palate bones.

OF THE NASAL FOSSÆ.

134. These are two oblong cavities, separated from each other by a thin vertical septum; situated between the

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* For the transmission of the frontal nerve and vessels.

† Of thirty-eight male skulls, in Alexandre's collection, twenty-two had supraciliary *notches*, eight supraciliary *holes*, eight a hole on one side and a notch on the other.

‡ Lachrymal.

§ A tendon common to the internal, external, and inferior recti muscles of the eye.

base of the cranium and the roof of the mouth; flanked on each side by the cavities of the orbit and the antrum; and open before and behind. They open on each side into the antrum and the ethmoidal cells; behind, into the sinuses of the sphenoid bone; before, into those of the frontal. They communicate, by the naso-lachrymal canal, with the cavity of the orbit; by the anterior palatine canal, with that of the mouth; by the olfactory foramina, with that of the cranium; and sometimes, by a hole in the septum, with one another. Their shape is irregular; the roof or vault being long, narrow, and concave from before backward; while the floor is shorter, wider, and concave from side to side. The outer wall is uneven, and presents several appendages; and even the inner wall or septum, though vertical when regular, is often deflected considerably to one side, so as to render the two fossæ very dissimilar in size and shape. The anterior and posterior orifices of these fossæ having been already described (123, 124), the four walls only remain for examination,

135. Walls. *Upper* or *vault*. Formed in the *middle* by the cribriform plate of the ethmoid bone, which is horizontal; in *front*, by the nasal bones, which slope downward and forward; *behind*, by the under surface of the body of the sphenoid, which slopes downward and backward. Thus the vault has three aspects; it looks *directly* downward in the middle, downward and *backward* in front, downward and *forward* behind. The *middle* or *ethmoidal* portion is very narrow and cribriform; it is bounded in *front* by the suture between the ethmoid and frontal; *behind*, by the suture between the ethmoid and sphenoid; *internally*, by the vertical plate; *externally*, by the lateral mass of the ethmoid; it presents nothing of note but the olfactory foramina. The *anterior* portion is wider, and bounded *externally* by the suture between the nasal bone and the nasal process of the upper maxillary; *internally*, by the nasal crest of the nasal bone, and the nasal spine of the frontal. It presents a longitudinal furrow for a nerve,* and several small vascular apertures; it is surmounted by the transverse suture between the nasal and frontal bones. The *posterior* portion is the widest of the three; it is formed

* Internal nasal.

in *front* by the sphenoidal turbinated bone; *behind*, by the under surface of the body of the sphenoid, and of the wing of the vomer; it is concave from side to side, but somewhat convex from behind forward; it presents the rounded narrow orifice of the sphenoidal sinuses, the suture between the vomer and sphenoid, and the sphenoidal turbinated bones. *Lower* or *floor*. Formed in *front* by the palatine plate of the upper maxillary; *behind*, by that of the palate bone; level from before backward, concave from side to side, wider behind than before, widest of all in the middle; longer internally than externally, on account of the prominence of the anterior and posterior nasal spines. It presents *internally* the crest which articulates with the vomer; in *front*, one of the two upper orifices of the *anterior palatine canal;* and *behind*, the bevelled transverse suture between the maxillary and palate bones. *Inner* or *septum*. Formed by the vomer *behind;* by the perpendicular plate of the ethmoid* in the *middle;* by the nasal spine and crest of the nasal bones in *front;* by the crest of the upper maxillary and palate bones *below;* it is traversed by the sutures between these several bones and marked with numerous vascular and nervous furrows: it presents in *front* a triangular deficiency filled by one of the cartilages† of the nose; and at its *upper* part, the oblique lower orifices of several *olfactory canals.*‡ *Outer*. This wall is formed in *front* by the nasal process of the upper maxillary, and by the lachrymal bone; *behind*, by the vertical plate of the palate bone; *intermediately* by the inner surface of the upper maxillary, and by the inner surface of the lateral mass of the ethmoid. It is divided by three horizontal plates of bone which hang from it, into three channels, called the *inferior*, *middle*, and *superior meatus* of the nose. *Inferior meatus*. A horizontal channel, broader in front than behind, open at each end and below; formed externally by the maxillary and

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* The perpendicular plate of the ethmoid varies in size very much. I have seen a skull in which it extended forward a quarter of an inch beyond the nasal bones, articulated behind with the whole length of the vomer, and entered below into the groove formed between the upper maxillary bones.

† The triangular cartilage.

‡ Which open above in the cribriform plate, and transmit filaments of the olfactory nerves.

palate bones; internally and above, by the inferior turbinated bone. It presents in front the lower orifice of the *naso-lachrymal canal*.* This canal is formed chiefly by the upper maxillary bone, but is completed internally by the lachrymal bone, and by the lachrymal process of the inferior turbinated bone. It is nearly round, but slightly compressed from side to side; it is narrower in the middle than at its extremities; and it curves outwards a little as it ascends to join the lachrymal groove.† *Middle meatus*. A horizontal channel, broader in front than behind, and open at each end and below: formed above and internally, by the *middle* turbinated bone (a curved spongy plate of the ethmoid, that has been already described); bounded below by the *inferior* turbinated bone; and presenting externally, from before backward, the following objects:—1st, part of the inner surface of the nasal process of the upper maxillary; 2ndly, part of the inner surface of the anterior division of the lachrymal bone, the little holes by which it is perforated, and the sutures which it forms with the upper maxillary in front, and with the ethmoid between; 3rdly, behind the lachrymal, part of the inner wall of the ethmoid cells *above*, part of the inner wall of the maxillary sinus *below*, and intermediately the horizontal ethmoido-maxillary suture; 4thly, behind the maxillary bone, part of the inner surface of the nasal plate of the palate bone. This meatus presents two apertures; 1st, near its anterior extremity the lower orifice of the long funnel-shaped ethmoid cell, called the *infundibulum*, by which it communicates with the other *anterior ethmoid cells*, and through them with the *frontal sinuses;* 2ndly, at the middle of its outer wall, the *entrance of the antrum*, contracted by the ethmoid above, the palate bone behind, and the inferior turbinated bone below. This meatus is of much less extent than the inferior; it occupies little more than the middle two-fourths of the outer wall. *Superior meatus*. A horizontal channel occupying the posterior third of the outer wall, much shorter, and altogether smaller, than the others, open behind and below, and closed in front by the posterior wall of the anterior ethmoid cells. Its *inner* wall is formed by the upper turbinated bone (a little curved spongy plate of the ethmoid, which

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* Transmits the nasal duct. † Lodges the lachrymal sac.

has been before described); its *outer* wall is formed, *behind* by part of the inner surface of the *neck* of the orbitar process of the palate bone, in *front* by the inner surface of the lateral mass of the ethmoid; it is bounded *above* by the floor of the posterior ethmoid cells. This meatus presents two apertures; the *spheno-palatine foramen*,* at the posterior extremity of its *outer* wall; the *entrance of the posterior ethmoid cells* at the anterior extremity of its *upper* wall. Above and in front of this superior meatus, the outer wall of the nasal fossa is formed by the rough inner surface of the lateral mass of the ethmoid, which presents the oblique aperture of several *olfactory canals*.

136. The nasal fossæ are formed by the vomer, sphenoid, ethmoid, upper maxillary, palate, frontal, nasal, lachrymal, sphenoidal turbinated, and inferior turbinated, bones.

OF THE TEMPORAL FOSSÆ.

137. That part of each temporal fossa which belongs to the cranium has been already described (68). When the skull is entire this fossa is completed at its lower and external part by the *zygomatic arch*, a horizontal bony projection, formed by the temporal and malar bones. This arch, which is wider in front than behind, convex externally, concave internally, and traversed by the oblique suture between the *posterior angle* of the *malar* and the *zygomatic process* of the *temporal*, encloses an empty space, filled up in the recent subject by a muscle.† The temporal fossa is completed as its lower and anterior part by the upper portion of the malar bone, and is separated to a certain extent from the *zygomatic fossa* by a ridge which runs from the anterior root of the zygoma transversely across the temporal and greater wing of the sphenoid. In front of this ridge the two fossæ seem to run into each other, and cannot be very accurately defined; a difficulty, however, which is of no practical importance.

The temporal fossa is formed by the temporal, parietal, frontal, sphenoid, and malar bones. It is occupied by a large muscle,† to which it also gives origin.

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* Corresponds to Meckel's ganglion, and transmits the spheno-palatine vessels and nerves.

† Temporal.

OF THE ZYGOMATIC FOSSÆ.

138. Two irregularly shaped spaces, situated one on each side of the head, and bounded, *behind*, by the posterior border of the pterygoid process of the sphenoid; in *front*, by the ridge which descends from the malar process of the upper maxillary; *below*, by the aveolar border of the upper maxillary; and *above*, by the horizontal ridge described in the last section. The space thus circumscribed will be observed to consist of two portions; an *anterior* and larger, formed by the zygomatic surface of the upper maxillary bone; a *posterior*, formed above by part of the greater wing of the sphenoid, below by the pterygoid process, and by a narrow slip of the vertical plate of the palate bone which intervenes between the pterygoid process, and the upper maxillary bone. (89) The anterior portion is convex, and presents, near the middle, the upper orifices (two or three in number) of the *posterior dentar canals.* The posterior portion is concave, and gives attachment to a muscle.* (The spine of the sphenoid very often stretches forward and joins the outer plate of the pterygoid process, forming with it a large foramen. This is a mere accidental hole of no importance, and never mentioned by anatomists; nor should I notice it here, but that it is apt to perplex an inexperienced eye.) These two portions of the zygomatic fossa are separated by the *pterygo-maxillary fissure*, a triangular interval formed by the divergence of the maxillary bone from the pterygoid process. It opens a communication between the zygomatic and spheno-maxillary fossæ, unites at a right angle with the spheno-maxillary fissure, and transmits vessels.†

OF THE SPHENO-MAXILLARY FOSSÆ.

139. These are two small triangular fossæ, situated one on each side, beneath the apex of the orbit. Its *base* or upper wall, is formed by a small part of the under surface of the body of the sphenoid; its *posterior* wall is formed by the anterior aspect of the pterygoid process; its *anterior* wall by the posterior surface of the upper maxillary; its *inner* wall by the vertical plate of the palate bone. Its *outer* wall is deficient, being substituted by the pterygo-

* External pterygoid. † Internal maxillary.

maxillary fissure just described; its *apex* is formed by the approximation of the pterygoid process to the maxillary tuberosity. The *sphenoidal*, *spheno-maxillary*,* and *pterygo-maxillary* fissures terminate in this fossa; here seeming to run into each other like the fissures in a starred pane of glass. In its *posterior* wall there are three orifices; 1st, the anterior orifice of the *foramen rotundum*;† 2ndly, inferior and internal to that, the anterior orifice of the *vidian canal*;‡ 3rdly, internal and a little inferior to that, the anterior orifice of the *pterygo-palatine* canal.§ In its *internal* wall is seen the *spheno-palatine foramen*,‖ by which it communicates with the nasal fossæ, while its lower extremity or apex is perforated by the superior orifice of the *posterior palatine canal*¶ (as will be seen by passing a bristle up from below). Besides these larger openings this fossa presents, near its apex, the superior orifices of two or three little *accessory posterior palatine canals*** (which have already been described as opening below on the tuberosity of the palate bone.) (89)

140. This fossa, then, is formed by the sphenoid, upper maxillary, and palate bones; communicates with the orbitar, nasal, and zygomatic fossæ, and with the cavity of the cranium; presents five apertures, and is the meeting-point of three large fissures. The relative position of these openings, and the boundaries of the cavity itself, should be carefully studied; being essential to an accurate acquaintance with the distribution of several important vessels and nerves contained in this fossa.

OF THE CRANIO-FACIAL SUTURES.

141. These are not very numerous; nor have they received particular designations. Like the other sutures they are best distinguished by names, compounded of

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* This fissure opens a communication from the orbit into the temporal, zygomatic, and spheno-maxillary fossæ.

† Transmits the superior maxillary nerve, which is the second division of the 5th.

‡ Transmits a nerve and vessels of the same name.

§ Transmits vessels and nerves of the same name.

‖ Corresponds to the ganglion of Meckel, and transmits the spheno-palatine vessels and nerve.

¶ Transmits vessels and a nerve of the same name.

** Transmit small vessels and nerves of the same name those of the bones between which they are respectively formed.

In the centre appears a horizontal suture formed by the junction of the nasal bones, and the nasal processes of the upper maxillary bones, on the one hand, with the nasal notch of the frontal on the other. This suture surmounts the nose, and is continuous on each side with a very short horizontal suture formed between the lachrymal and the internal angular process of the frontal. This last is continuous with the vertical suture between the lachrymal and ethmoid; and this again meets at right angles the horizontal suture between the ethmoid and upper maxillary. These three last-mentioned sutures are within the orbit, and to its inner side. At its outer side is observed the meeting of the malar bone with the frontal above, and the sphenoid below. Still more externally appears the oblique bevelled suture, formed between the posterior inferior angle of the malar, and the zygomatic process of the temporal bone. Quite at the back of the face there is a vertical suture formed by the junction of the pterygoid process of the sphenoid with the nasal plate of the palate bone. Two articulations within the nasal fossæ, one a *schindylesis* (see Table, § 9) between the vomer and sphenoid, the other an *apposita* between the ethmoid and the ethmoidal process of the inferior turbinated bone, make up the list of sutures formed by the junction of cranial with facial bones.

FORM AND STRUCTURE OF THE FACE.

The face, like the cranium, presents considerable varieties of form and relative size, at different periods of life, and in different races of mankind. In the fœtus, the alveolar arches, still containing the germs of the teeth, are large and prominent; the non-development of the antrum contracts, in every direction, the middle region of the face: and the great size of the forehead and orbits, already advancing towards maturity, gives a disproportionate expansion to its upper part. In the adult, its middle region gains in every dimension by the development of the maxillary sinuses, while the growth of the teeth increases its vertical extent, and renders the angle of the jaw less obtuse. In old age, the fall of the teeth gives rise to a series of changes, well known in their effects on the features during life, and already recounted in the description of the lower jaw. On the national peculiarities of the face, we shall have to touch briefly in the general review of the skull. Its structure, and the arrangement of its parts, furnish a very good illustration of the mechanical principles on which the whole skeleton is framed. Examined from without, the face presents, in every direction, thick, bony arches, well adapted for the resistance of mechanical violence; while its interior is constructed of fragile laminæ, and slender processes, extremely irregular in form and disposition. The rationale of this arrangement scarcely requires explanation. Strength would be obviously superfluous in parts which derive from their position an adequate security; and their attenuation allows additional density and strength to be thrown into the surrounding arches, without increasing the mean weight of the whole structure. It is never indeed for its *absolute* strength that we admire the architecture of the "house in which we live." A blacksmith might forge a stronger skeleton. But there would be nothing admirable in its ponderous mechanism and redundant strength. The characteristics which distinguish the workmanship of Nature, and excite a discriminative and judicious admiration, are found in the rigid economy conspicuous in every part—the diversified application of each single contrivance—the effective employment of apparently insignificant advantages—the accurate adjustment of the capabilities of each organ to the special function which it is designed to perform, and the particular strain which it has to support—the elasticity of one, the rigidity of another, the tenuity of a third, the density of a fourth; and the wonderful combination of lightness and durability which results to the fabric, considered as a whole.

PROPORTIONS OF THE SKULL.

142. As the cranium contains the organs of intellect, and the face the apparatus of sense, the relative size of these two divisions of the skull serves to indicate the relative development of the mental and physical faculties, in different classes of animals, and different individuals of a class. This circumstance gives great interest to the comparative mensuration of the skull: and since Daubenton opened the subject,* in 1764, it has been

* Long before Daubenton wrote, Albert Dürer gave extremely laborious admeasurements of the head, in almost every possible

minutely studied by several eminent anatomists. I propose in this section to give a slight sketch of the different methods which have been adopted for determining the relative proportions of the skull, subjoining a short account of its peculiar character in the three great families of mankind, and concluding with a few observations on its development, structure, and use.

Direct Measurement. This, the most obvious method of ascertaining the proportions of the skull, has been employed by several anatomists. The table on the following page exhibits the dimensions of the cranium according to Bichat and Bourgery, together with the average size of three well-proportioned, moderately-developed European skulls, measured by me.

Daubenton's *Occipital Angle.* This angle is designed to show the position and inclination of the occipital foramen. A line is drawn from the posterior extremity of the margin of the occipital foramen to the lower border of the orbit; and another from the posterior extremity of the margin of the occipital foramen, over the convexity of the occipital condyle. The angle formed by these lines will obviously increase as the foramen magnum is placed further back, and deviates more and more from the horizontal position. It is stated by Daubenton to be 3 deg. in man, 34 deg. in the orang-otang, and somewhat more than 90 deg. in those quadrupeds which in this respect present the greatest contrast to the human species. In the most perfect form of the human skull the *plane* of the occipital foramen is horizontal; and its *position* is such that a line drawn tranversely across the base of the cranium, half-way between the occipital tuberosity and the upper incisors, passes through the anterior extremity of the foramen magnum.*

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view. He also invented a facial, a nasal, and a maxillary line (described in his great work "De Symmetriâ Partium in Rectis Formis Humanorum Corporum," published in 1553). But he studied the subject merely as a painter; its physiological bearings were first considered by Daubenton, as stated in the text. I mention this particularly, because Cruveilhier, and others, appear to attribute to Camper the merit of originating this inquiry.

* The purpose of Daubenton's angle has been frequently misunderstood. Cruveilhier says, "L'angle facial ne fournissant aucune donnée sur la capacité des régions postérieures du crâne, Daubenton a eu spécialement en vue cet objet dans la mesure qui porte le nom d'angle occipital de Daubenton; mais cette mesure, comme toutes les mesures lineaires appliquées à la détermination

	Bichat.		Bourgery.		Average of three European skulls.	
	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.
CRANIUM.						
Antero-posterior diameter, measured from the interior occipital tuberosity to the foramen cæcum	5	0	5	3	6	0
Transverse diameter, measured from the base of one petrous process to the same point on the opposite side	4	6	4	7	5	1
Vertical diameter, measured from the anterior border of the occipital foramen to the middle of the sagittal suture	4	Nearly 6	0	8	4	10
FACE						
Antero-posterior diameter, measured from the upper extremity of the posterior border of the vomer to the root of the nasal bones (including their thickness)	...		...		2	10
Transverse diameter, measured from the posterior border of the malar bone just above the zygomatic arch, to the corresponding point on the opposite side	...		...		4	3
Vertical diameter, measured from the root of the nose to the chin	...		...		4	6

Camper's *Facial Angle.* To form this angle, a facial line is drawn from the most prominent point of the forehead to the most prominent point of the upper jaw. This is intersected (according to Camper's original method) by a second line, drawn from the external aperture of the meatus auditorius to the base of the anterior opening of the nose. Other anatomists have drawn the second line from the aperture of the ear to the most prominent point of the lower jaw, *i.e.* to the inferior extremity of the facial line. (Camper's own figures do not, by any means, correspond as to the direction and point of junction of the two lines;* though the whole utility of the angle, as a comparative measurement, obviously depends upon uniformity in this respect.) The facial angle is stated to be about 70 deg. in the Ethiopian variety of mankind, about 75 deg. in the Mongolian, and from 80 to 85 deg. in the Caucasian division. In the orang-otang it is 30 deg. (Owen†), in the mastiff 41 deg., in the horse 23 deg. The

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de la capacité du crâne sont nécessairement inexactes." I have not found the design here attributed to Daubenton, either expressed or implied in his original paper; and the objection founded on this erroneous assumption is, of course, invalid. The real source of fallacy in Daubenton's angle appears to be, that it depends, in a great measure, on the prominence of the occipital condyles, instead of simply indicating the position and inclination of the foramen magnum. For instance, in the porpoise, the occipital condyles are very large, but project very little beyond the plane of the foramen; in the tiger they are much smaller, but extremely prominent; and though, in point of fact, there is a difference of full 20 degrees in the inclination of the occipital foramen in these two animals, yet Daubenton's angle is nearly alike in both. Blumenbach and Lawrence direct the second line to be drawn in the plane of the foramen itself, and this is doubtless a more certain method; but it reduces the angle considerably. However, in all the human skulls which I have measured by Daubenton's original method, I have found the angle nearer 10 or 12 deg. than 3 deg. Blumenbach considers the angles both of Camper and Daubenton useful for the distinction of animals, but insufficient to determine the varieties of the human species. The former angle he often found the same in skulls of different nations, while the latter as frequently varied in skulls of the same nation.

* See, for example, his first plate, figures 2 and 3, in which the basal line passes considerably below the meatus auditorius externus.

† Lawrence states it to be 58 deg., other naturalists as high as 64 deg. These errors have arisen from the examination of the skulls of young orang-otangs; as Mr. Owen has shown in his paper on the osteology of the chimpanzee and orang-otang. *Zool. Trans.* vol. i.

Grecian sculptors increased it to a right angle (90 deg.) in representing sages and heroes; and when they wished to convey an idea of super-human intellect, as in the statues of Apollo and Medusa, they extended it to 100 deg.*

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* The transcendental anatomists attach great importance to the angle at which the nasal bones join the cranium. They regard the coccygeal bones, the sacral and spinal vertebræ, the segments of the cranium, and the bones and cartilages of the nose, as forming one continuous hollow column, designed for the reception of the central organs of animal life. Each extremity of this column is rudimentary, the *coccygeal* bones being vestiges chiefly of the *bodies* of vertebræ, the nasal bones and cartilages being vestiges chiefly of the *laminæ* of vertebræ. The transcendentalists also trace an analogy between the ribs of the thorax, the lateral walls of the pelvis, and the upper maxillary bones (with several other portions) of the skull: all these bones belonging to a series destined for the protection of the organs of *vegetable* life. Each pair of ribs in the thorax, and each pair of bones analogous to ribs in the pelvis and face, is called a *proto-vertebra.* Each segment of the continuous column formed by the coccygeal bones, the sacral and spinal vertebræ, the cranial segments, and the bones and cartilages of the nose, is called (whether enormously developed, as in the cranium, or reduced to a mere vestige, as in the coccyx and nose) a *deuto-vertebra.* This explanation will suffice to render the terms employed, and the analogies assumed, in the following observations, intelligible to the reader: for fuller information he is referred to the transcendental writings of Carus. In the lower vertebrated animals the deuto-vertebral column is straight, or nearly so, from end to end. In the higher orders it is curved, and presents two angular changes of direction; one at the junction of the spinal vertebræ with the cranium, the other at the junction of the cranium with the nose. The variations of the former of these angles are shown by Daubenton's measurement; and they are found to indicate correctly the rank of different species in the animal kingdom; the species rising in the scale, as the angle becomes more abrupt. Analogy leads the transcendentalists to attach a similar importance. to the variations of the second angle; and a comparison of the heads of different races of men seems to corroborate this opinion. To the transcendental philosophers, moreover, the relative development of the proto-vertebral and deuto-vertebral series of bones, has an important signification; a superior development of the deuto-vertebral column indicating a predominance of the organs of animal life over those of the merely vegetable functions. For instance, a diminution in the size and prominence of the maxillary and inter-maxillary bones (or second and third facial proto-vertebræ), as compared with the lateral and alar cartilages of the nose (or second and third facial deuto-vertebræ), is an improvement in the shape of the head. To furnish a strong contrast, illustrative of these views, we may compare the Greek human skull with the head of the lamprey. In the former the axis of the vertebral canal forms nearly

BARCLAY'S *Basi-facial Angle.*—Dr. Barclay, observing that the apertures of the ear and nose differ considerably in position in different animals; and that even in man the aperture of the ear is lower during infancy than in the adult; and further observing that these variations are independent of the general proportions of the skull;* retained Camper's *facial* line, but drew the second or *basial* line along the under surface of the palate, continuing it forward to meet the facial line in front of the alveolar process. His reasoning, so far as it goes, is just;

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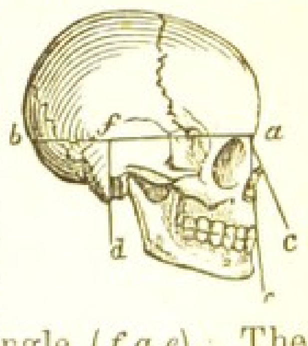
a right angle with that of the cranium, the direction of the nose approaches the vertical, the inter-maxillary bone (or third facial proto-vertebra) is rudimentary (some say altogether deficient), and the upper jaw (or second facial proto-vertebra) falls back considerably from the nose, so as to lie almost entirely beneath the cranium. In the lamprey these relations are exactly reversed; the spinal, cranial, and nasal axis form a right line: and the last proto-vertebra, instead of being rudimentary, is developed into a perfect ring, completely usurping the place of the last deuto-vertebra, of which not a vestige is to be found. Between these opposite extremes there are many intermediate degrees. In the negro head, for example, the vertebro-cranial angle is more obtuse than in the Greek; the nasal line slopes considerably forward, and the upper jaw projects so far that the lips are thrust out almost to a line with the extremity of the nose. In the simiæ all these characters are exaggerated; the vertebro-cranial and cranio-nasal angles are still more obtuse; and the upper jaw projects *beyond* the tip of the flattened ill-developed nose. Guided by these principles, I would suggest the following as an approximative method of estimating the proportions of the skull in different races of men. Carry a line (a b) from the occipital tuberosity to the root of the nose (*i.e.*, the centre of the naso-frontal suture): meet this, behind, by a prolongation of the axis of the vertebral foramen (d f); in front, by the line (a c) representing the profile of the nose. The angles d f a and f a c thus formed, indicate the sudden bends of the deuto-vertebral column in this region. Lastly, draw the facial line (a e) from the root of the nose to the prominence of the upper jaw, so as to form a third angle (f a e). The difference between the angles f a e and f a c indicates the relative position of the nose and upper jaw. As these three angles d f a, f a c, and f a e, become less obtuse, and as the difference between the second and third increases by the recession of the upper jaw, the proportions of the head improve, and its form approaches ideal perfection.



* This is shown by the fact, that the facial angle in the porpoise is about 90 deg., and in the dolphin still greater—almost equalling that of the Greek statues of the gods.

and his angle not only more accurate, but more easily measured than Camper's, especially with the craniogoniometer invented by Dr. Leach, which indicates the span of the angle on a graduated arc.

CUVIER'S *Method.* Cuvier disapproves of Camper's facial line, because it is liable to vary with the thickness of the walls of the cranium, the prominence of the frontal sinuses,* &c. He therefore makes a vertical section of the skull, and measures the areas of the cranium and face. In the European skull the area of the cranium is to that of the face as 4 to 1; in the negro the face is larger by one fifth.†

TIEDEMANN'S *Method.* Professor Tiedemann determines the capacity of the cranium by ascertaining the weight of millet seed it is capable of containing. The weight of the skull is taken, first while empty, afterwards when filled: and the difference represents its capacity in ozs. and drs. It is an extremely simple and accurate method. The only precaution necessary to render the results of different observers comparable, is to ascertain the weight of the millet seed employed; which I am informed is liable to vary as much as two ozs. in a quart.‡ I have already given a specimen of the results furnished by this plan (65); for further information the student may consult Tiedemann's original paper in the "Phil. Trans." for 1836.

BLUMENBACH'S *norma verticalis.* OWEN'S *norma basialis.*—These methods consist in ranging the skulls to be compared in an even line, and then contemplating them, in the *vertical* method from above, in the *basial* method from below. They are not intended to furnish definite numerical results, but they afford to the practised eye a collective view of the most characteristic national peculiarities of the cranium and face. Each method has its peculiar advantages; Prichard gives the preference to Owen's. The norma verticalis, adopted by Blumenbach in the classification of his extensive collection of skulls, developed those strong differential characters which led to

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* In a Scythian skull at King's College, the prominence of the frontal sinuses adds nearly 3 deg. to the facial angle.

† Soemmering and Bonn found the nasal fossæ and the sinuses connected with it remarkably large in the negro face, an observation quite in accordance with the well-known acuteness of the sense of smell in the negro tribes.

‡ Of the millet-seed I used, 3 quarts weighed exactly 5lbs.

the establishment of the three great divisions of mankind, known as the Caucasian or meso-bregmate, the Ethiopian or steno-bregmate, and the Mongolian or platy-bregmate varieties. I subjoin a short abstract of the most important of these characters.

CAUCASIAN, or *Meso-bregmate Skull.* This is the most perfect form of the skull; the standard form from which the two others are deviations in opposite directions. The meso-bregmate *cranium* is rounded and symmetrical, its posterior extremity bears to the anterior the proportion of about 3 to 2, and it has a capacity which may be represented (as compared with the other forms) by 40. (TIEDEMANN.) The *face* is oval, and in no part strikingly prominent; its area, as shown by a vertical section, bears to that of the cranium the proportion of 1 to 4.

ETHIOPIAN, or *Steno-bregmate Skull.* This form conveys the idea of lateral compression, and is called by Dr. Prichard the *prognathous.* The *cranium* is narrow, and elongated from before backward; and its capacity is equal to 37. The *face* is also narrow; its area, as shown by a vertical section, is 1-5th larger, in proportion to the cranium, than that of the Caucasian face; the cheek-bones, jaws, and incisor teeth, project considerably *forward,* while the nose is flat. The muscular impressions, both of the cranium and face, are deeply marked; the temporal fossa is large, and the temporal ridge prominent, indicating a considerable development of the muscle that moves the jaw; in correspondence with which appearances the jaw itself is large and strong, and the teeth are very perfect and durable.

MONGOLIAN, or *Platy-bregmate Skull.* This form conveys the idea of lateral expansion. The *cranium* is broad and square, and has an average capacity of 39. The *face* is square and flat; the cheek-bones and zygomatic arches project very much laterally; the nasal bones scarcely appear beyond the glabella,* which is broad; the jaws are wide, and the dental arches but slightly convex in front.

The first of these three forms is exemplified in the Europeans; the second in the Africans; the third in the native tribes of America. Each of these great classes

* The space between the eyebrows: so called because it is destitute of hair.

is subdivided into sections presenting particular modifications of the general form; and these groups are further liable to individual deviations.

In concluding this section on the proportions of the skull, I may perhaps be permitted to describe a modification of Tiedemann's method, by which I have obtained some interesting results as to the relative capacity of the anterior and posterior segments of the cranium in different races of men. The skull being held with the face downward, and the long axis of the cranium in a vertical position, millet seed is poured into it until that space which lies in front of the anterior extremity of the occipital foramen is exactly filled. It is then weighed. The difference between the weight thus obtained, and that of the empty skull, gives the capacity of the anterior segment of the cranium. Again, the difference between this weight, and that of the skull entirely filled with the seed, according to Tiedemann's method, gives the capacity of that segment of the cranium which lies behind the anterior border of the occipital foramen. The sphenoidal fissures, and the apertures in the base of the cranium, should be lightly stopped with tow or cotton during these experiments, a precaution which must also be observed in practising Tiedemann's method. The Table on the following page will show the nature of the results furnished by this method of research. The skulls marked B. H. belong to the museum of Bartholomew's Hospital, those marked G. H. to Guy's. The weight used is avoirdupois; and the three last columns are reduced into drs. to facilitate comparison.

An extensive series of these researches is required to neutralize casual errors, and furnish exact average conclusions: but we may safely infer, in general terms, from the few observations in this Table, that in the Esquimaux, Chinese, African, and Flat-head Indian, the anterior segment of the cranium is less capacious than the posterior; while in the German, Hindoo, and Grecian, these proportions are reversed; and further, that even when the greater capacity of the entire cranium seems at first sight to place the African, or even the Flat-head Indian, above the German or Hindoo skull, a comparison of the capacity of the anterior segments immediately re-establishes the superiority of the latter. (Compare, for instance, the eighth in the Table with the third; or the last with the second.)

Nation.	Museum.	Lower-jaw attached or wanting.	Weight of Skull.			Weight of millet-seed required to fill entire cranium.	Weight of millet-seed required to fill anterior segment of cranium.	Difference between the two preceding weights, giving weight of seed required to fill posterior segment of cranium.
			lbs.	oz.	drs.	Drs.	Drs.	Drs.
German,	B.H.	Attached.	1	7	9	660	391	269
	Do.	Ditto.	1	11	10½	584	358½	226
Hindoo,	Do.	Wanting.	1	5	13	482½	253½	229
	Do.	Ditto.	1	5	11	586½	349	237½
Grecian,	G.H.	Ditto.	1	1	11¼	621¼	328	293¼
Esquimaux,	Do.	Ditto.	1	8	8	643	306½	336½
Chinese,	B.H.	Ditto.	1	13	3	467	203½	263½
African,	Do.	Attached.	1	11	5½	513	214½	308½
	Do.	Ditto.	2	0	4	492	213	279
Flat-head Indian.	G.H.	Wanting.	1	5	5	590½	130½	460
		Ditto.	1	7	9½	634	176	458

Development. The fœtal skull is distinguished by the great relative size of the cranium, and by various indications of the as yet imperfect development of the bones. The centres of ossification are large and prominent; the radiating fibres can be traced on the surface; the nutrient foramina are numerous. Several parts are still separate epiphyses—as the styloid process; others are undeveloped—as the mastoid process, the sinuses, and the meatus auditorius externus. The frontal and sphenoid are each divided into two pieces, the occipital into four, and the temporal into five. The bones of the vault are thin, very slightly denticulated at the edges, and not in contact with each other, so that they can yield by a mutual overlapping to the temporary pressure of parturition. The angles of each parietal bone, being the furthest from the centres of ossification, remain for some time incomplete, and leave six spaces only closed by membrane. These are called the *fontanelles* of the cranium (from an old notion that the humours of the brain flowed out through them). The two largest are placed in the median line, one at each end of the sagittal suture; the anterior of these is called the *larger*, and the posterior the *lesser* fontanelle. The larger fontanelle has been already mentioned in the description of the parietal bone: it is of a lozenge shape, formed, posteriorly, between the two parietal bones, and anteriorly, between the two lateral halves of the frontal bone. This fontanelle, which is the last to close, finally disappears at about the age of four years. The remaining four are situated laterally, one at each end of each squamous suture. Towards adult age, all these deficiencies are supplied; the face gains in size by the expansion of the sinuses; and the progress of ossification converts many membranous and cartilaginous parts into bone, obliterates the temporary sutures, fixes the epiphyses, and fills up many of the nutrient holes, now no longer necessary. In old age the deposition of calcareous matter obliterates by degrees even the more permanent sutures, and renders the parietes of the cranium dense and brittle; the teeth are shed, and the lower jaw undergoes the gradual changes in shape and position consequent on their loss (110).

Structure and Uses. The skull is designed to contain and protect the delicate organization of the brain and its dependencies; a purpose for which it is very well adapted by several advantages of situation and structure. Thus, it is placed on the top of an elastic column, and within the range of two limbs which, on the approach of danger, rise instinctively for its defence. In shape it is an egg-like dome, with walls which are tough externally, spongy in the middle, and extremely dense and hard within; a triple structure, which enables them to deaden much of the force of concussion, and to oppose a considerable resistance to the residue. The floor of the cranium presents four strong wedges, diverging from a common centre; viz., the body of the sphenoid in front, the basilar process of the occipital behind, and the petrous process of the temporal on each side. The sides of these wedges are only connected by the interposition of plates of cartilage; so that they are not rigid, but capable of yielding a little to mechanical violence. The roof of the cranium consists of broad bones, alternately overlapping and overlapped at the borders, so as to afford each other a mutual support. They are united above by strong interlocking teeth, and prevented from starting outward below by the ascending processes of the temporal and sphenoid (which latter bone—well called the *key bone* of the skull—curves its greater wings upward, to bind together the vault of the cranium, and its pterygoid processes downward, to hold in apposition the two lateral divisions of the face). The roof of the cranium is further strengthened by tuberosities at all the exposed points, and by two strong ribs (analogous to the groinings of architecture), which run round it, one in the longitudinal, the other in the transverse direction, crossing each other behind at the occipital protuberance, and abutting below upon the wedges of the floor. These ribs correspond to clefts in the cerebral mass, and can therefore transmit considerable vibrations without affecting its substance; a provision of great importance, because concussions, or violent vibrations of the brain, are often more fatal than laceration, or even partial destruction of its substance.

With this brief analysis of its structure and mechanism we conclude the descriptive anatomy of the skull—the most strongly fortified part of the skeleton—the very citadel, as it were, of life. And in quitting the subject, we may take occasion to observe, with what an admirable economy Nature has collected around this stronghold the delicate organs of the principal senses—which are thus adequately protected without additional expense, and at the same time, like sentinels at the gates of a fortress, contribute to the security of which they partake.

OF THE BONY PARTS OF THE ORGAN OF HEARING.

143. Under this head we proceed to describe the auditory chambers of the petrous process of the temporal bone, and the *ossicula auditûs*, or little bones of hearing, therein contained.

The auditory chambers of the temporal bone, enumerated from without inward, are the following:—1st. The *external meatus;* 2ndly. The *tympanum,* or middle ear, which contains the ossicula auditûs; 3rdly. The *labyrinth,* or internal ear, consisting of three distinct portions, placed in a line one before the other, viz., the *vestibule* in the middle, the *cochlea* in front, the *semicircular canals* behind; 4thly. The *internal meatus.*

OF THE MEATUS AUDITORIUS EXTERNUS.

144. This canal leads from the exterior of the skull, into the tympanum. Its external orifice (which we have already described (61)), has the squamous portion of the temporal above it, the mastoid process behind, and the glenoid cavity in front. From this point it runs inward and a little forward, forming in its course a slight curve, the convexity of which is directed upward and backward, and terminating in the external orifice of the tympanum. Now this orifice, in the recent subject, is closed by a membrane (*membrana tympani*) stretched across it; and it is so inclined, that a line drawn perpendicular to the outer surface of that membrane, passes, not directly outward, but outward, downward, and forward; and, as the obliquity is at the expense of the upper and posterior walls of the meatus auditorius externus, it follows that this passage is longer at the lower than at the upper part, and also in front than behind. It is smaller at its inner than at its outer extremity, and slightly contracted, like an hour-glass, in the middle. Its vertical transverse section is of an oval form, with the greatest diameter from above downward. The length of its axis in the adult is about ten lines.* The anterior and inferior portions of this canal are formed by a curved osseous lamina which presents a rough edge externally, contributes in front to form the glenoid cavity and vaginal process, and blends above and behind with the rest of the

* A line is one-twelfth of an inch.

bone. In the fœtus this lamina is a mere detached ring of bone, incomplete at the upper part; so that at this period the external meatus is deficient. Its external orifice gives attachment to the cartilage of the auricle, or *ear*, commonly so called, and it is lined in the recent state by a cartilaginous tube prolonged from the auricle.

OF THE TYMPANUM OR MIDDLE EAR.*

145. The tympanum is a cavity of irregular form, situated just over the jugular fossa, with the carotid canal in front, the mastoid cells behind, the meatus externus to its outer side, and the labyrinth or internal ear bounding it within. Of its diameters, the antero-posterior, which is the most considerable, measures in the adult about five lines; the vertical, which is next in length, averages about three lines; and the transverse, which is the shortest, measures between two and three lines at the upper and back part of the cavity, and between one and two lines below and in front. This last diameter is subject in life to slight variations, from a cause which will be presently explained. The tympanum has six *walls*; an *external* and an *internal*, a *posterior* and an *anterior*, a *superior* and an *inferior*. The two first of these walls are flat, and their limits are indicated by distinct angles; but the four last being curved, run into each other, and are only to be distinguished by their relative positions.

WALLS. *External.* Perforated by the oval orifice, across which, in the recent subject, the *membrana tympani* is stretched; an orifice which is so large, that in the dry bone this wall seems almost deficient, only a small portion appearing above and below the aperture. The edge of this orifice is grooved, to receive the membrane. It is identical with that which has already been mentioned as forming the inner extremity of the external meatus; and its obliquity, which was shown to add length to the *lower wall* of the meatus at the expense of the *upper*, has of course exactly the opposite effect on the tympanum; in-

* The student will require a magnifying glass and some fine bristles, in studying the minute canals and foramina of the middle and internal ear. An old brush supplies the best bristles for this purpose, as their ends, rounded and polished by use, slip over little inequalities, in which recently-cut bristles are liable to catch.

creasing the extent of its *upper* wall at the expense of the *lower*. The outer wall presents three small apertures, one behind, the other two before the orifice of the membrana tympani. The first is the orifice of the *iter chordæ posterius;* the second is the *Glaserian* fissure; the third is the orifice of the *iter chordæ anterius.* The *iter chordæ posterius* is a minute canal which commences below in the aqueductus Fallopii, near the stylo-mastoid foramen, (61) ascends in front of the aqueduct, (164) and opens in the tympanum behind the aperture for the membrana tympani, close to its margin, and at the level of its centre. This canal transmits a nerve.* The *Glaserian fissure,* (59) which is said by H. Cloquet, Magendie, and others, to traverse the *floor* of the tympanum, does, in fact, open just above the orifice for the membrana tympani, near the point of junction between the anterior, superior, and external walls. This fissure, though it presents a length of half-an-inch on the exterior surface of the bone, appears within the tympanum merely as a little slit, about a line long; it gives passage to a muscle,† to several small blood-vessels, and to the *processus gracilis* of the *malleus.* (149) Just above this opening appears the tympanine orifice of the *iter chordæ anterius.* This is a minute canal, which runs obliquely forward, downward, and inward, parallel to the Glaserian fissure, to open in the retiring angle, formed between the squamous and petrous portions of the temporal bone. It lies on the outer side of the Eustachian tube (to which it is nearly parallel), and transmits a nerve.‡ The membrana tympani, which forms the principal part of the outer wall, belongs to the soft parts, and must not therefore be here described. We may observe, however, that it is supplied with muscles, by which it may be drawn either inward or outward, and that these changes in its position produce corresponding variations in the width of the tympanum. *Internal.*

* The chorda tympani; a reflected branch of the facial, given off by it just before it passes out of the aqueductus Fallopii.

† Laxator tympani.

‡ Chorda tympani.—This nerve is generally said by the English anatomical writers to leave the tympanum by the Glaserian fissure. M. Huguier first observed the separate canal described in the text. Several specimens, in my possession, prove his account to be correct. I have noticed, however, that the two passages sometimes open into the tympanum by a common orifice, from which circumstance the prevalent error has probably arisen.

This wall is vertical, and looks directly outward. It is perforated by the *fenestra ovalis*, an aperture which leads from the tympanum into the vestibule. (163) The *fenestra ovalis* is an irregular ovoid, curved above, but nearly straight below. Its long diameter is nearly horizontal, it is a little larger behind than before, and its rim is turned inward towards the vestibule. It is closed in the recent state by the base of the stapes, (150) which nearly fits it; a membrane, called the *membrana fenestræ ovalis*, extends from its rim to this bone. This membrane is exactly opposite to the membrana tympani;* and is connected with it by the *ossicula auditûs*, which stretch like a chain across the tympanum, from one membrane to the other. Below the fenestra ovalis is an eminence of a triangular form, with its apex directed backward. This is called the *promontory;* it is hollow, and its cavity belongs to the cochlea. (158) It is traversed by three *grooves*, which lead to three minute *canals*. These little passages will be described in the next section. The lower part of the promontory is perforated by a triangular hole, improperly called the *fenestra rotunda*. This hole is not seen unless the promontory is looked at from below; an imaginary axis drawn through its centre, would pass from below upward, forward, and inward; it leads from the tympanum into the cavity of the promontory, and as that cavity forms part of the cochlea, it leads from the *tympanum* to the *cochlea*.† It is closed in the recent state by a membrane, called the *membrana tympani secundaria*. A horizontal rounded eminence passes across the inner wall of the tympanum, just above the fenestra ovalis, and behind that opening makes a curve, descends nearly vertically on the posterior wall of the tympanum, and disappears. This curved eminence indicates the course of a canal called the *aqueductus Fallopii*, the description of which is deferred for the present. Just in front of the vertical portion of this eminence (and consequently behind and below the fenestra ovalis), there

* The tympanum, on account of these two opposite membranes, has been compared to a military drum—whence its name.

† This hole is usually described as being *below* the promontory; an expression calculated to convey the erroneous impression that it perforates the inner wall of the tympanum *beneath* that eminence —whereas, in fact, it is an aperture in the promontory itself.

is a little conical eminence called the *pyramid.** Its base is directed downward; its apex projects freely into the tympanum, being curved forward, so as to point to the posterior extremity of the fenestra ovalis. This eminence contains a cavity called the *fistula*, and its summit is perforated by a hole. In the recent state, the fistula lodges a minute muscle,† the tendon of which passes out through the hole. The cavity of the pyramid is usually said to terminate in a cul-de-sac. It is, in fact, prolonged downward as a canal, which at first descends vertically, parallel to the aqueductus Fallopii, and only separated from it by a thin osseous plate; and afterwards curves forward, and opens on the lower surface of the petrous portion, anterior and internal to the stylo-mastoid foramen. (61) This canal communicates with the aqueduct of Fallopius; it sometimes bifurcates below; it gives rise to a short horizontal canal, which loses itself in the diploë. (These two latter points I give on the authority of M. Huguier, the discoverer of the canal; but, of its existence, and communication with the aqueductus Fallopii, I have satisfied myself by observation.) Just in front of the pyramid there is a little depression, or nook, occasioned by the eminence of the promontory in front, and of the pyramid behind; it is sometimes called the *sinus* of the tympanum, and there are often several little bony threads, stretching across it from the apex of the pyramid to the promontory, and rendering the distinction of these parts rather difficult to an inexperienced eye. *Posterior.* This wall is wider above than below, and presents at its upper part one or more *orifices*, belonging to a *canal* or *canals*, leading downward, backward, and outward, into the *mastoid cells.* These are cavities in the mastoid process, which vary considerably in number, size, and form. There are generally three or four large ones in the centre, surrounded by others not much exceeding in size the common cellules of the diploë. They all communicate with each other; but are invested in the recent state by a prolongation of the lining membrane of the tympanum, which separates them from the

* The pyramid, together with the vertical portion of the eminence described just before it, belongs to the *posterior* wall. It is described here, in order that its relations with the objects on the inner wall may be more clearly understood.

† Stapedius.

common cells of the diploë. Beneath the opening of these cells appear the vertical portion of the eminence formed by the *aqueductus Fallopii*, and the *pyramid* (which were mentioned in the description of the internal wall). *Anterior.* This wall, like the posterior, is wider above than below. It presents at its upper part, just at the level of the fenestra ovalis, two *orifices*, situated one above the other, which are the posterior apertures of two *canals*. These canals run from the anterior wall of the tympanum forward, inward, and a little downward, to the retiring angle formed between the petrous and squamous portions of the temporal bone. Their anterior orifices occur in this angle, where they have already been pointed out, in the description of the temporal bone. (61) The two canals appear to result from the subdivision of a single canal, by an extremely delicate horizontal lamina, called the *processus cochleariformis.* They are quite parallel to each other. The *superior* and smaller is called the *canal of the tensor tympani.* It is rounded, and in the recent state occupied by the small muscle;* from which it takes its name. It lies immediately beneath the upper surface of the petrous portion; close to the *hiatus Fallopii.* (61) A minute passage, about a line in length, runs from the middle of this canal to the *groove* leading to the hiatus Fallopii; it transmits a minute nervous filament.† The posterior extremity of the canal of the tensor tympani is prolonged backward into the cavity of the tympanum, forming a little curved conical eminence, strongly resembling the pyramid, and like it perforated at the apex by a hole which transmits the tendon of the muscle lodged within its cavity. This *anterior pyramid*, as it may be called, is much more delicate and fragile than the *posterior pyramid;* insomuch that its upper half is frequently destroyed in the preparation of the bone, and nothing is left of it but a little curved lamina, which looks like a mere prolongation of the cochleariform process; and, in fact, is usually described as such. M. Huguier was the first who gave a correct account of the *anterior pyramid.* I have a bone in which this part is nearly perfect, quite sufficiently so to show its original size and form. The inferior and larger of the

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* Tensor tympani, or internus mallei.

† Sent from the otic ganglion to the internus mallei.

two canals under review is the bony portion of the *Eustachian tube.* This canal is seven or eight lines long, and runs from the tympanum downward, forward, and inward; its posterior, or tympanitic orifice, is wider than its anterior opening, which is joined in the recent subject to the *cartilaginous portion* of the Eustachian tube; the entire passage forming a communication between the tympanum and the pharynx. *Inferior.* This wall is very narrow, and presents nothing remarkable except the orifice of one of the minute canals of the tympanum. (146) *Superior.* Wider than the inferior, and perforated by some pores which transmit small blood-vessels.

OF THE GROOVES ON THE PROMONTORY, AND THE MINUTE CANALS TO WHICH THEY LEAD.

146. To enable the student to understand clearly the relative position of these little passages, it is necessary to premise that a small nerve, called the nerve of Jacobson, enters the tympanum by a hole in its floor near the inner wall, ascends a little way on the promontory, and just in front of the foramen rotundum divides into several branches. Three of these branches run in *grooves* on the surface of the promontory, diverging from each other, to three little orifices, by which they finally quit the tympanum. These orifices are the tympanine extremities of three little *canals* which traverse the substance of the petrous portion, and convey the nervous filaments to their respective destinations. We have, therefore, to examine, first, the passage by which the nerve of Jacobson enters the tympanum, called after its discoverer, the *canal of Jacobson;* secondly, the three *grooves* which diverge from the tympanine extremity of this canal; and, lastly, the three minute *canals*, to the tympanine extremities of which the grooves conduct. Before entering on their description, we must warn the student that sometimes the canal of Jacobson, instead of opening in the tympanum, ascends in the substance of its internal wall and splits into three diverging *canals*, which pursue the same course, and become continuous with the same canals as the *grooves* we shall presently describe. In these instances, instead of grooves diverging from a common orifice, and leading to three other orifices, we have canals concealed within the substance of the lamina which forms

the promontory; so that neither grooves nor orifices are to be seen on the walls of the tympanum. On the other hand, one or more of the grooves may be so superficial as to be scarcely perceptible, except in the immediate vicinity of the orifices; and I have examined some specimens in which, though the orifices were present, no traces of the grooves could be discovered, even with a lens.

The *canal of Jacobson* commences on the under surface of the petrous process by a fossula of variable size, situated on the crest which separates the lower orifice of the carotid canal from the jugular fossa. (61) From this point it ascends to the tympanum; sometimes perforating the floor of that cavity close to the internal wall, and just beneath the promontory; sometimes ascending a little way in the substance of the lamina which forms the promontory, to open just in front of the foramen rotundum. It is from this point that the three grooves of the promontory diverge. The *anterior groove* runs horizontally forward to an aperture situated in the line of junction of the anterior and internal walls, not far above the floor. The *middle groove* runs upward and forward to a little aperture, also situated in the angle formed by the junction of the anterior and internal walls, but much higher up: being on a level with, and just internal to, the tympanine orifice of the Eustachian tube. The *posterior groove*, which is the deepest and most distinct (and frequently traceable when the others are absent), runs vertically upward to an aperture in the internal wall, close under the *anterior pyramid* (commonly called the *processus cochleariformis*). Such are the *grooves*; and from them we pass naturally to the *canals*, the tympanine openings of which we have already noticed. The canal to which the *anterior* groove conducts, runs forward from the above-mentioned orifice "situated in the line of junction between the anterior and internal wall of the tympanum, not far above the floor," to open in the posterior wall of the carotid canal, just where it changes its direction. The canal to which the *middle* groove conducts, commences at the orifice, "just internal to the tympanine extremity of the Eustachian tube," and runs forward and inward, parallel to the vertical plane of that tube, but ascending instead of descending, to open upon the anterior surface of the petrous process at the point just internal to the anterior opening of the *canal of the tensor tympani* which lies immediately above the

Eustachian tube. The canal to which the *posterior* or *vertical* groove conducts, runs forward, upward, and inward, to open in the hiatus Fallopii, or in the groove leading to it.*

Of these three grooves and canals, the first and last described are sometimes double, on account of the subdivision of the filaments they respectively transmit.

OF THE BONES CONTAINED IN THE TYMPANUM, OR OSSICULA AUDITÛS.

147. These bones, three in number, and very small, are named after objects which they are thought to resemble, the *malleus* or hammer, the *incus* or anvil, and the *stapes* or stirrup. A fourth is sometimes described under the name of the *lenticular* bone. This is a minute rounded bone, interposed between the incus and stapes; but as it is almost always united to the incus, even in the fœtus, it is considered by the best anatomists as an epiphysis of that bone. The three remaining bones have this relative situation. The *incus* is placed between the other two; it projects forward from the posterior wall into the centre of the tympanum; and is articulated, externally to the *malleus*, which is connected with the *membrani tympani*, and internally to the *stapes*, which is connected with the *membrana fenestræ ovalis*.

148. INCUS. This bone bears a strong resemblance to a molar tooth. It is divided into a *body* (which may be compared to the crown of the tooth), and two *branches* (which represent the fangs). The *body* is of a somewhat square form, but compressed from side to side. Its *inner* surface is slightly concave, its *outer* surface is convex, and its *anterior* surface, or *summit*, which is directed forward

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* The nerve of Jacobson is a branch of the glosso-pharyngeal nerve. The filament transmitted by the first groove and the corresponding canal, enters the carotid canal, and joins the carotid-plexus, establishing a communication between the glosso-pharyngeal and the sympathetic. The filament transmitted by the second groove and canal passes out of the cranium by the middle lacerated foramen, and just beneath the foramen ovale joins the otic ganglion, of which it is regarded by Arnold as one of the origins or roots. This filament is called nervus petrosus superficialis *minor*, in contradistinction to the nervus petrosus superficialis *major*, or cranial branch of the Vidian. The filament transmitted by the third groove and canal joins the nervus petrosus superficialis major.

and a little upward, is concave from above downward, convex from side to side, and covered with cartilage for articulation with the head of the malleus. The *superior branch*, or *short process of the incus*, is shorter and thicker than its *inferior branch*, or *long process*. It arises from the back of the body, and runs backward, and a little downward and outward, to the posterior wall of the tympanum, where it terminates in a point which rests in the orifice of the mastoid cells. The *inferior branch*, more long and slender, arises from the lower end of the body, and descends obliquely forward and inward, till it is on a level with the fenestra ovalis. Its lower extremity (which is exactly opposite the centre of the fenestra ovalis, but separated from it by the lenticular bone and the stapes) is curved a little inward, and presents, sometimes the surface which articulates with the *os lenticulare*, more frequently that bone itself, united to it as an epiphysis.

149. MALLEUS. This bone is divided into a *head*, a *neck*, a *handle*, and two *processes*—viz., the *processus gracilis*, and the *processus brevis*. The *head* is the largest and uppermost part of the bone, and articulates with the incus: the *handle* is a vertical branch of bone, which rests against the membrana tympani; the *neck* is a short contracted portion which joins the head to the handle, running obliquely downward and outward from the former, so as to form an obtuse angle with the latter; the *short process* is a little conical projection, which rises from the angle formed by the junction of the handle and neck; and the *processus gracilis* is a long, curved, and delicate process, which rises from the anterior part of the neck itself.

The *head* is of an oval form; its *posterior* surface is convex from above downward, concave from side to side, and covered with cartilage for articulation with the anterior surface of the body of the incus; its other surfaces are free. The *neck* is somewhat thicker than the handle; its inclination downward and outward from the body has been already mentioned. The *handle* adheres firmly to the membrana tympani,* which it draws inward, so as to

* The membrana tympani consists of three laminæ; an external lamina, continuous with the delicate reflection of the cutis which lines the meatus externus; a middle fibrous lamina, or proper tympanine membrane; and an internal lamina continuous with the mucous lining of the middle ear. It is between these two latter laminæ that the handle of the malleus is interposed.

render its outer surface concave. The handle is curved forward at its lower extremity, which corresponds to the centre of the membrana tympani. A radius drawn from the centre of this membrane vertically upward to the circumference would nearly represent the position of the handle of the malleus. The *processus gracilis* runs from the front of the neck, first forward, and then outward, to enter the Glaserian fissure, where its summit gives attachment to a muscle.* The place of this process is sometimes supplied by a mere ligamentous cord. The *processus brevis* runs obliquely upward, outward, and backward,† from the junction of the neck and handle: it lies in contact with the membrana tympani, and gives attachment by its summit to a muscle.‡ With regard to the exact relative position of the malleus, its head is situated in front of the incus, but its other parts are external to that bone.

150. STAPES. This bone, which strongly resembles a stirrup, extends horizontally from the long process of the incus to the fenestra ovalis. It is divided into *head*, *base*, and two *branches*. The *head* (which corresponds with the top of the stirrup) is situated externally, and is supported by a short *neck*, which gives attachment posteriorly to a muscle.§ The summit of the head is directed outward, and presents an oval cartilaginous depression for articulation with the lenticular epiphysis of the incus. The *base* is the innermost part of the bone, and represents the footbar of the stirrup; it is a thin flat plate, corresponding in shape with the fenestra ovalis, which it loosely fits. Its lower edge is straight, its upper edge curved, and its posterior a little larger than its anterior extremity. Its internal surface is concave, and its circumference is connected with the rim of the fenestra ovalis by the membrana fenestra ovalis.‖ Of the two *branches*, the anterior is the shorter and less curved.

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* Laxator tympani, or anterior mallei.

† Cloquet says "backward." Quain "outward at right angles with the handle." Cruveilhier "a little outward." Possibly the direction of the process may be subject to variation; in all the specimens I have examined, it has taken the direction described in the text.

‡ Tensor tympani, or internus mallei.

§ Stapedius.

‖ The base of the stapes is enclosed between two laminæ of the membrana fenestræ ovalis, exactly as the handle of the malleus is enclosed between two laminæ of the membrana tympani.

They arise from the neck, and run inward, diverging from each other, to the opposite ends of the base. They circumscribe (with the base) a triangular space filled in the recent subject by a delicate membrane. A groove, which receives the border of this membrane, traverses the opposed edges of the anterior and posterior branches, and the outer surface of the base.

This bone is sometimes very small, as though atrophied. Cruveilhier mentions a case of this sort in which the two branches were joined together.

151. STRUCTURE. The ossicula auditûs consists chiefly of compact tissue, though a little cellular is found in their thickest parts.

152. DEVELOPMENT. By a single point of ossification for each. ARTICULATIONS. With each other, and with the walls of the tympanum, at the several points that have been described.

OF THE VESTIBULE.

153. This is a small ovoid cavity situated internal to the tympanum, external to the meatus auditorius internus, and above the jugular fossa. It is the middle of the three portions into which the labyrinth or internal ear is divided; the cochlea being in front of it, and the semicircular canals behind. It is wider above than below, and divided into two unequal fissulæ by a horizontal crest on its inner wall; the upper of these is the larger, and has a semi-elliptical form: the lower is smaller in size, and nearly hemispherical in shape. The vestibule presents eight orifices; five of which are the apertures of the semicircular canals. These latter are situated at the posterior part of the cavity. Their relative position cannot be understood till the semicircular canals themselves have been examined. Their description is therefore deferred. (156) Of the other three, one, situated in the outer wall, is the *fenestra ovalis* already described. In the dry bone the vestibule communicates with the tympanum by this aperture; but in the recent subject it is closed by the stapes, by its own proper membrane, and by the general lining membrane of the vestibule. The two remaining apertures are, the *apertura scalæ vestibuli cochleæ*, and the *osteum internum aqueductûs vestibuli.* The former is an oval hole, situated below and before the fenestra ovalis, and leading into the external scala of the

cochlea. (162) The latter is a minute orifice in the inner wall of the vestibule, situated just below and before the orifice common to the two vertical semicircular canals. (155) A short groove, called by Morgagni, the *recessus sulciformis*, runs downward and forward from this orifice, which is the vestibular opening of the AQUEDUCTUS VESTIBULI. This is a very narrow canal, about four lines long, which, commencing in the vestibule by the last-mentioned aperture, at the posterior extremity of the recessus sulciformis, runs for a little distance *upward*, inward, and backward; then, forming a curve, passes *downward*, inward, and backward, becomes much wider, and terminates near the middle of the posterior surface of the petrous process, in a narrow aperture or slit which has been already described. (61) Besides these principal apertures, the inner wall of the vestibule presents many small pores for the transmission of nervous filaments.* These pores are so numerous at the anterior and inferior part of the inner wall, as to give it a cribriform appearance. Hence the name *macula cribrosa*, which has been applied to this part of the wall of the vestibule.

OF THE PULVIS VESTIBULARIS.

154. This is a calcareous powder contained in the two membranous saccules which occupy, in the recent subject, the two fossæ of the vestibule. It appears to be the vestige, in mammalia, of certain concretions of considerable size and regular shape, found in the labyrinths of fishes. It is called *otoconia* (ὠτὸς κόνις, *auris pulvis*) by its discoverer, M. Breschet; who attributes to it the function of reinforcing the sonorous vibrations of the fluid, contained in the membranous sacs of the vestibule.

OF THE SEMICIRCULAR CANALS.

155. These are three curved tubes, situated behind the vestibule, into which they open by both extremities. One is horizontal, the other two are vertical. Of the two vertical, one is *superior*, and has its convexity directed upward; the other is *posterior*, and has its convexity directed backward. The inner leg of the superior-vertical, and the upper leg of the posterior-vertical, unite about two lines before their termination, to form a common

* Ramifications of the acoustic nerve.

canal which opens by a single aperture at the inner and back part of the roof of the vestibule. Each of the four remaining legs of the semicircular canals open into the vestibule by a separate aperture.

The *superior-vertical*, which stands erect, like a bridge, over the vestibule, in a plane parallel to its posterior wall, commences internally in the roof of the vestibule, at the common orifice just described, ascends a little, then curves transversely outward, and again descending perforates the roof of the vestibule at its posterior and external part. The summit of this canal forms an eminence on the anterior surface of the petrous process; as we have already observed in the description of the temporal bone. (61) The *posterior-vertical*, which projects from the back of the vestibule in a plane parallel to its inner wall, commences by the common canal before mentioned, first passes horizontally backward, then curves downward, and then, running forward and upward, re-enters the vestibule by an aperture in the posterior wall, situated vertically below the point from which it set out. The *horizontal*, which projects from the back of the vestibule in a plane parallel to its floor and roof, but nearer to the latter than to the former, commences internally by an orifice in the posterior wall, situated between the two apertures of the posterior-vertical canal (*i.e.* the common orifice above, and the proper orifice of the posterior-vertical below). From this point it runs backward a little way, curves horizontally outward, and then bending forward, opens again into the vestibule by an aperture in its posterior wall, situated just below the outer orifice of the superior-vertical canal.

156. Thus, of the five apertures by which the semicircular canals open into the back part of the vestibule, three are situated internally, one above the other; two externally, in a similar relative position. The three inner orifices, enumerated from above downward, are: 1st, the orifice common to the two vertical; 2ndly, the internal orifice of the horizontal; 3rdly, the inferior orifice of the posterior-vertical. The two outer orifices, enumerated from above downward, are: 1st, the outer orifice of the superior-vertical; 2ndly, the outer orifice of the horizontal.*

* The semicircular canals have not, strictly speaking, the precise directions here described. Thus the superior-vertical is not exactly

157. Each of these canals presents at one extremity a slight dilatation, called an *ampulla*. The inner extremity of the horizontal canal, and the short canal common to the two vertical, are not dilated; the other three extremities present ampullæ. In the order of length, beginning with the longest, they run thus: posterior-vertical, superior-vertical, horizontal. The great superiority in length of the posterior-vertical is occasioned by its describing in its course a larger portion of a circle than the others. Each of these canals is formed of a compact smooth lamina, embedded in the reticular tissue.

OF THE COCHLEA.

158. It is impossible to form a correct idea of the cochlea without actual inspection of the cavity itself. It is of a pyramidal form, and may be described in general terms to consist of a plate which forms the base of the pyramid; of an axis called the *modiolus*, which rises perpendicularly from the centre of that plate; of a conical tube spirally wound round that axis for two turns and a half; and of a delicate lamina, called the *lamina spiralis*, which is contained within that tube, follows its windings, and divides it into two unequal parts, called the two *scalæ of the cochlea*. In the adult bone, however, the outer surface of the conical tube is continuous with the surrounding osseous tissue, so that the cochlea has the appearance of a spiral *excavation* in the substance of the petrous process, rather than of a spiral *tube*. We shall conclude this rough outline of the cochlea with the observation, that the pyramid, or cone, which it forms, does not stand upright on its base within the petrous process, but has a position rather resembling that of a sugar-loaf laid on its side; so that the plate which forms the base of the

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transverse, nor perfectly upright, its outer leg being anterior, and a little superior, to its inner. Again, the posterior-vertical inclines downward and outward, and the horizontal downward and inward. The curve of the former is in a plane at right angles to the axis of the petrous process; the curves of the two latter are in planes parallel to that axis. Until, however, the purpose and meaning of the relative situation of these canals is ascertained, the student will perhaps be wise to spare his memory the burden of these minutiæ. An ultra-precision in *mere* details is not only useless and trifling in itself, but occupies time and thought which might have been more profitably employed.

cochlea is placed on its edge vertically; the modiolus projects horizontally outwards; and the scalæ, instead of leading, like winding staircases, from below upward, lead, in consequence of this horizontal position of the modiolus round which they turn, from within outward. We shall next describe, more minutely, these several parts.

159. Base of the Cochlea. Formed by a plate of bone standing nearly vertically within the petrous process, but so inclined that its inner surface looks inward, backward, and a little upward, its outer surface in the opposite direction. As the membrana tympani at the same time closes the inner extremity of the meatus auditorius externus, and forms the outer wall of the tympanum; so does this plate, interposed in a similar manner between the meatus auditorius externus and the labyrinth, close the former, and also constitute the inner wall of the latter; its inner surface being seen when we look into the meatus, and its outer surface appearing within the cochlea and vestibule. It is important that the student should clearly understand this relation, because branches of an important nerve pass through this plate, from the meatus auditorius internus into the cochlea and vestibule.

160. Modiolus. A bony axis, which arises, by a broad base, from the centre of the last described plate, runs outward, forward, a little downward, becoming narrower, and terminates at the apex of the cochlea, in an expanded summit, resembling a funnel, and called the *infundibulum*. Its base is hollow; and the cavity appears as a little depression at the bottom of the internal auditory canal. The modiolus is traversed by a number of minute canals, which open upon its surface by little pores, and transmit filaments of a nerve,* which enters the cavity of its base, from the meatus internus. The *infundibulum*, into which it expands, lodges the terminal branch of the same nerve. This little cavity is deficient at its upper part, so that it resembles the half of a funnel divided by a longitudinal section. It is covered by the rounded summit of the cochlea; a part which from its form and situation has been named the *cupola*. (The student must bear in mind that the summit of the pyramid formed by the cochlea, is directed, not upwards, but outwards.)

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* The cochlear branch of the acoustic nerve.

161. Lamina Spiralis. A thin plate of bone wound spirally round the modiolus for about two turns; it commences between the tympanine and vestibular openings of the cochlea, becomes gradually narrower as it pursues its winding course, and terminates in a little *hamular process* just where the expansion of the infudibulum commences. It contributes to form a septum which divides the spiral cavity of the cochlea into two unequal parts. This septum, however, is not perfect in the dry bone. That part which is attached to the wall of the cochlea, is membranous, and disappears during maceration. It is only the half which is connected with the axis, that is formed of bone. The membranous portion continues from the hamular process to the summit, or *cupola*, of the cochlea; so that the septum of the last half turn of the cochlea is entirely membranous. This membranous septum, in turning round the demi-infundibulum, adheres to its inferior convex aspect, but presents a free margin to its concavity. This free margin is curved, so that with the concavity of the infundibulum it forms a round aperture, through which the two scalæ communicate with each other. The lamina spiralis is formed of two lamellæ, between which are numerous fine canals for the transmission of nervous filaments.

162. Scalæ of the Cochlea. One is external and smaller, and opens freely into the vestibule by an oval aperture, situated just below the fenestra ovalis; the other is internal; it would communicate with the tympanum by the fenestra rotunda (or, as it ought rather to be called, the fenestra *triangularis*), were not that aperture closed in the recent state by its membrane. Hence the external is called the *scala vestibuli*, the internal the *scala tympani*. They communicate with each other, near the summit of the cochlea, by the aperture formed between the cavity of the demi-infundibulum and the membranous portion of the septum. The surface of the lamina spiralis which corresponds to the scala tympani, is rough; whereas the surface, which corresponds to the scala vestibuli, is smooth, and marked with slight transverse striæ.* The scalæ gradually contract from their commencement to their termination.

163. Aqueductus Cochleæ. A minute canal, which commences in the scala tympani, by a little aperture,

* These cannot be distinguished without a magnifying-glass.

situate anterior and internal to the fenestra rotunda, and from thence runs downward, forward, and inward, increasing in size as it descends, to terminate in an expanded triangular orifice, on the lower surface of the petrous portion, close to its posterior border, and just in front of the jugular fossa. This canal varies in size in different individuals, and is said to be sometimes altogether wanting. When present it transmits a minute vein.

OF THE MEATUS AUDITORIUS INTERNUS.

164. This is a straight canal, shorter and smaller than the external meatus, leading from the interior of the skull to the labyrinth. Its inner extremity, which is oval and somewhat expanded, opens nearly in the middle of the posterior surface of the petrous portion. The canal runs from this point directly outward, and, after a course of about four lines in the adult, reaches a vertical plate which closes its extremity. This plate is divided into two unequal portions by a horizontal crest; the *upper* and smaller portion is perforated posteriorly by small pores, which open on the inner wall of the vestibule, and transmit nervous filaments into that cavity; in front, it presents an orifice of considerable size, of which we shall presently speak. The *lower* portion corresponds, in front, to the cochlea, and presents the cavity of the modiolus; posteriorly it is cribriform, and corresponds to that portion of the inner wall of the vestibule which is called the *macula cribrosa.* (153) All the pores in this plate transmit filaments of the nerve of hearing.

The orifice just mentioned is the commencement of the *aqueductus Fallopii.* The course of this canal is not easily explained. To facilitate its description we shall trace it in a reverse direction, from its termination in the stylomastoid foramen, to its commencement in the meatus auditorius internus. From the stylomastoid foramen it passes vertically upward, forming an eminence on the posterior wall of the tympanum behind the fenestra ovalis; then, making a bend, it runs forward and a little upward, forming an eminence on the internal wall above the fenestra ovalis; and finally it disappears from the tympanum. After leaving the inner wall of the tympanum, it continues to run *forward* for about a line; and then, *turning at an acute angle,* runs inward and a little *backward* to terminate in the meatus auditorius internus. The exact situation of the sharp angle which it thus forms, may be readily pointed out, even in an undissected bone; it is immediately beneath the anterior surface of the petrous portion, and about two lines behind the aperture of the *hiatus* Fallopii, (61) which canal opens into the *aqueductus* Fallopii just at this angle. The aqueductus Fallopii, therefore, may be shortly described as a canal, which runs from the outer extremity of the meatus internus to the stylomastoid foramen, making in this course two remarkable bends; the first, which is very abrupt and angular, being in a horizontal plane, close under the anterior surface of the petrous process; the second, which is gradual and rounded, being in the vertical plane of the inner wall of the tympanum. It is at the first sharp angle, that the *hiatus* Fallopii joins the *aqueductus* Fallopii. Each of these canals transmits a nerve.*

165. Uses. Our knowledge of the uses of the curious apparatus that has just been described is very imperfect, and chiefly conjectural. The auricle, or external ear, collects, and the meatus auditorius externus transmits to the membrana tympani, the sonorous undulations of the air. The substance of the auricle itself likewise enters into sonorous vibrations, which are propagated along the cartilaginous lining of the meatus externus to the membrana tympani. The vibrations of this membrane travel, partly along the jointed lever formed by the ossicula auditûs, partly through the air in the tympanum, to the membranes of the oval and round foramina. From those membranes the undulations are communicated to the liquid that fills the labyrinth; and, through this medium, they reach the membranous saccules and tubes that float in the liquid of the vestibule and semicircular canals, and the membranous portion of the septum which separates the scalæ of the cochlea. These membranous parts receive the ramifications of the acoustic nerve; by which the impressions of sound are transmitted to the brain. The Eustachian tube admits fresh air from the pharynx

* The *aqueductus* Fallopii transmits the facial nerve, or portio dura of the seventh pair. The *hiatus* Fallopii transmits the cranial branch of the vidian, or nervous petrosus superficialis major. From the hiatus Fallopii this nerve passes into the aqueductus Fallopii, and mixes its fibres with those of the facial. It is from this compound nerve that the chorda tympani is reflected.

to the tympanum; equalizes, under every variation of temperature, the atmospheric pressure on the opposite surfaces of the membrana tympani; and, by permitting the ingress and egress of the air, enables that membrane to vibrate freely. In its latter function it resembles the sound-hole of a drum; and the deafness, which results from the obstruction, may sometimes be relieved by perforating the membrana tympani, or the mastoid process.

It is probable that the mastoid cells reinforce, by resonance, the sonorous undulations of the air in the tympanum; and that the series of ossicula, acted upon by their proper muscles, adapt the tension of the tympanine membranes to the varying intensity of sounds, as the iris adapts the eye to the varying intensity of light. A conjecture has been hazarded (among many others) that the semicircular canals may be designed to inform us of the direction of sounds, and the cochlea to ascertain their musical relations. With regard to the former, it is curious that they are trumpet-shaped tubes, whose smaller ends are all situated *opposite* the membrana fenestræ ovalis; and whose dilated extremities are most abundantly supplied with filaments of the acoustic nerve. With regard to the latter, it is remarkable that the membranous portion of the septum grows gradually wider as it approaches the infundibulum, and that the nervous filaments which supply it, pass across it at regular intervals, successively increasing in length as it increases in width; and presenting in this respect, a striking resemblance to the series of strings in a harp. Upon such analogies as these, however, little dependence is to be placed; they are useful as stimulants to curiosity, but often very fallacious guides of research.

CHAPTER III.

OF THE THORAX.

166. The thorax or chest is a sort of osseous cage, composed of bones and cartilages, and connected with the middle region of the spine. It is the largest of the three great cavities of the skeleton; and it is formed by the sternum in front, by the dorsal vertebræ behind, and by twelve ribs and twelve costal cartilages on each side.

The dorsal vertebræ having been already examined, it remains for us in this section to consider the sternum, ribs, and costal cartilages, and to take a general review of the entire cavity.

OF THE STERNUM.

167. The sternum is a flattened column, consisting of five bones, and an osseo-cartilaginous appendage. The uppermost of the five bones remains separate during the whole term of life; the other four unite with each other successively, and at the age of 25 form but a single piece; the osseo-cartilaginous appendix remains flexible at its joint with the bone to a late age; so that, in the adult, the sternum consists of three portions. Each of these, after a few preliminary observations, we shall describe separately; reserving for the sequel our review of the sternum in general. The sternal column is situated in the median line of the body, at the anterior part of the chest. In its form it reminds one of an ancient sword, the upper piece resembling the handle, and being consequently called the *manubrium;* the middle representing the principal portion of the blade, and hence called the *gladiolus;* while the osseo-cartilaginous portion (though it presents many variations of form in different individuals) frequently comes to a sharp point, like the tip of the sword, and consequently takes the name of the *ensiform,* or *xiphoid appendix.*

168. MANUBRIUM. This is a short, flat bone, of a somewhat triangular form, with its base, which is the thickest part, directed upward, and its apex, which is truncated, pointing downward. It presents for examination two *surfaces* and four *borders.*

169. SURFACES. *Anterior.* Directed forward and upward, concave from above downward, convex from side to side, and wider above than below. It gives origin to the aponeurosis of two muscles.* *Posterior.* Directed backward and downward, smooth, concave in the vertical, and plane in the transverse direction. It also attaches two muscles.†

* Sterno-cleido-mastoideus, and *portio deprimens* of the pectoralis major. (For an account of the physiological distinction implied in the latter name, see the author's "Physiological Observations on Several Muscles of the Upper Extremity." *Phil. Mag.* June, 1836.)

† Sterno-hyoid and sterno-thyoid.

170. Borders. *Upper.* The longest and much the thickest of the four. It presents on each side an oval articular surface, directed upward, backward, and outward, concave from side to side, convex from before backward, and designed for articulation with the clavicle. Between these two surfaces there is a curved non-articular depression, called the *interclavicular notch*. *Lower.* This border is thick but short, it presents an oval rough surface, which is connected to the upper border of the gladiolus by the kind of joint called *amphiarthrosis*, or mixed articulation. (See Table of the Joints, p. 8.) The anchylosis of this joint which frequently comes on in old age, results from the deposition of a thin osseous layer externally; the cartilage almost always remains fibrous and flexible in the middle. *Lateral.* These borders slope from above downward and inward; present, superiorly, a concave surface into which the fibres of the first costal cartilage are inserted; below this a thick curved edge; and below this again, just at the angle where the lateral joins the inferior border, a little concave articular facet, which, with another similar facet formed at the upper corner of the second sternal bone, forms a notch for the reception of the second costal cartilage. The manubrium therefore articulates, on each side, with the clavicle, with the *first* costal cartilage, and with the upper half of the *second*.

171. Gladiolus. This portion of the sternum is longer, narrower, and thinner than the manubrium, on which, in youth and middle age, it is slightly moveable. It is wider below than above, and presents for examination two *surfaces* and four *borders*.

172. Surfaces. *Anterior.* Directed forward and upward, and marked with three transverse ridges, which indicate the junction of the four bones of which this portion of the sternum originally consisted. The surface that lies between any two of these ridges is concave from above downward, and plane, or very slightly convex from side to side. At the junction of the third and fourth piece of the gladiolus, there sometimes appears the orifice of a hole called the *sternal foramen*, which passes through the bone from before backwards. This hole is very variable in size, sometimes open, but usually closed by a membraniform cartilage. The anterior surface is covered by the skin, and by a muscular aponeurosis to which it

gives insertion.* *Posterior.* Slightly concave both from side to side, and from above downward. It is marked by transverse ridges, corresponding in position to those of the anterior surface, but less prominent. It gives attachment to a pair of muscles,† and sometimes presents at its lower part the posterior orifice of the *sternal foramen.*

173. BORDERS. *Upper.* Short, thick, and connected by a fibro-cartilaginous or *amphiarthrodial* joint with the lower border of the manubrium. *Lower.* Short, and articulated by *amphiarthrosis* with the ensiform appendix. *Lateral.* These borders are by far the longest. Each presents, just where it joins the upper border, a little facet, which combines with the similar facet of the manubrium, to form a cavity for the cartilage of the second rib. This facet is succeeded by a series of shallow cavities for the third, fourth, fifth, and sixth costal cartilages; and quite at its lower end, where it joins the inferior border, this border presents a little facet which, with a corresponding one on the ensiform appendix, forms a notch for the reception of the seventh costal cartilage. So that the gladiolus articulates with the third, fourth. fifth, and sixth costal cartilages, and with part of the second and seventh. These cavities are separated by intervals, which diminish in length from above downward—the cavities for the second and third costal cartilages being an inch from each other; those for the fifth and sixth ribs about half an inch apart, while those for the sixth and seventh are a quarter, sometimes not more than an eighth of an inch apart, and in many instances quite contiguous. These intervals, which are curved, so as to present the appearances of semilunar notches, correspond to the intercostal spaces. It will be observed, that each horizontal transverse line corresponds to a pair of the articular depressions, extending from the middle of one to the corresponding point on the opposite side. Each articular depression is therefore formed between two of the pieces of which the sternal column originally consists. This is one of those points of analogy between the sternal and vertebral columns which we shall have occasion to notice more particularly in our general review of the skeleton.

174. ENSIFORM OR XIPHOID APPENDIX. This process is

* Belonging to the *portio deprimens* of the pectoralis major. (See note *, page 132.)

† The triangulares sterni.

cartilaginous in youth, but generally more or less ossified at its upper part in the adult. It is continuous *above* with the lower extremity of the gladiolus, *below* with a strong white aponeurotic ligament,* which descends along the middle of the anterior wall of the abdominal cavity, and is inserted below into the pubes. The ensiform appendix presents many varieties of size, form, and direction. It may be long or short, curved or straight, simple or bifurcated, situated vertically in the median plane, or deflected to one side. It sometimes presents a hole, and is occasionally altogether deficient. It gives attachment by its anterior surface to a ligament,† by its posterior surface to some muscular fibres,‡ and by its lateral borders to strong aponeuroses.§ On each side of the border by which it joins the gladiolus, it presents a facet that completes the notch for the seventh costal cartilage.

175. The sternal column, viewed as a whole, is a wide flat symmetrical bone, forming a sort of buckler to the organs contained in the chest. It has a slight general convexity in front, and concavity behind. In the natural position, its anterior surface looks forward and upward, and its posterior surface in the opposite direction. Its lateral borders are sinuous, each presenting seven articular and six inter-articular depressions. The surface of the first articular cavity is generally continuous with the fibres of the first costal cartilage: the other six cavities form diarthrodial joints with the cartilages which they respectively receive. The sternum is shorter, and more obliquely placed in the female than in the male.

176. Structure. Very spongy and cellular within, well supplied with blood-vessels, and covered externally with a layer of compact tissue.

Development. The number and position of the ossific points of this bone are exceedingly irregular. The manubrium is developed, sometimes by one central, sometimes by two lateral points; and in a few rare instances even by three or four points. The gladiolus is developed in four pieces, each having sometimes one central, sometimes two lateral ossific points. The appendix ossifies by one

* Linea alba. † Costo-xiphoid.
‡ Of the diaphragm and triangulares sterni.
§ Of the abdominal muscles.

or two points situated at its upper part. ARTICULATIONS. With the two clavicles, and with seven pairs of costal cartilages.

OF THE RIBS.

177. The ribs, with their cartilages, are elastic arcs, encompassing the cavity of the thorax, which they principally contribute to form. They are twenty-four in number, being situated in pairs, twelve on each side of the chest.* They are distinguished by numerical appellations; 1st, 2nd, 3rd, &c., counting from above downward. They are divided into three classes, which differ as to the connexions of their extremities, and are best distinguished by names expressive of this difference. The seven upper ribs on each side are articulated with the vertebral column behind, with the sternal column in front. These are, therefore, called the *vertebro-sternal* ribs. The three succeeding ribs on each side—viz., the 8th, 9th, and 10th, are articulated with the vertebral column behind; but falling short of the sternum in front, they attach their anterior extremities, each to the cartilage of the rib above. These are, consequently, denominated *vertebro-costal* ribs. The two remaining ribs on each side—viz., the 11th and 12th, are articulated to the vertebral column behind; but their anterior extremities float loose among the muscles. These, therefore, are simply *vertebral* ribs. The first class are commonly called the *true*, and the 3rd class the *false*, or *floating* ribs. But the term false is also applied to the 2nd class; which have hitherto had no particular appellation. To obviate the indistinctness arising from this circumstance, I have given them a name derived, like the denominations of the other classes, from the relations of their extremities. The several ribs in each of these three classes present further varieties of length, shape, direction, and articulation. But before entering upon these particulars, we shall describe certain characteristics which are liable to so few individual exceptions, that they may be considered as belonging to the ribs in general.

* A supernumerary rib is sometimes developed on each side, in connexion with the transverse process either of the last cervical, or of the first lumbar vertebra. More rarely, the first rib on each side is deficient in front, losing itself like the floating ribs, in the substance of the muscles.

COMMON CHARACTERS OF THE RIBS.

178. As an example in which to study these general characters, the student should take a rib from the middle of the series; for instance, the fifth or sixth, and place it on the table with its lower edge (which is distinguished by its sharpness) downward. Each rib presents for separate examination a *head*, a *neck*, and a *body* or *shaft*.

179. HEAD. This is a flattened articular tubercle, in which the rib terminates behind. It presents a horizontal *ridge*, separating two articular *facets*. These facets, of which the inferior is the larger, articulate with the costal cavity formed by the bodies of two dorsal vertebræ; the *ridge* corresponding to the intervertebral fibro-cartilage, and gives attachment to a ligament.* The head is joined to the body by the NECK.† This name is given to a portion of the bone, about an inch long, which rests upon the transverse process of the lower of the two vertebræ with which the head is articulated, and gives attachment below to a ligament.‡ BODY or SHAFT. This is the remaining portion of the rib. It is flat and thin, so as to present two surfaces and two borders; and curved, so as to be convex externally and concave within. Its *outer surface* presents, just where it joins the neck, an eminence called the *tuberosity of the rib*. This eminence is divided into two parts; an *articular* portion, which is internal and inferior to the others, looks downward, backward, and inward, and unites with the articular surface that occurs on the transverse process of the dorsal vertebra below it—*non-articular* portion, which is rough, and gives attachment to a ligament.§ At a little distance, in front of the tuberosity, the outer surface of the shaft presents a prominent line, which passes from the upper edge obliquely downward and forward to the bone. It is called

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* Inter-articular.

† Cruveilhier, Cloquet, and many other anatomists, describe the neck as a *contracted* portion of the rib. This statement requires some modification, I think, to render it correct as a general description. The neck, indeed, is almost always *thinner* than the shaft; but except in the two or three upper ribs, it usually exceeds the adjacent portion of the shaft in width, presenting a convex ridge, which has all the appearance of a buttress, and is doubtless intended to strengthen this portion of the bone in the vertical direction.

‡ Middle costo-transverse.

§ Posterior costo-transverse.

the *angle* of the rib, and gives attachment to muscular fibres.* The portion of the bone behind the angle is the thickest and strongest part of the rib; it is more abruptly curved than the anterior portion; so much so, indeed, as to give the articular surface of the head a direction *forward,* as well as inward. The rib is bent in two directions at its angle. Look at it from above downward, and you see that the posterior extremity is bent suddenly inward here, so as to form with the anterior portion an obtuse angle, apex *outward.* Again, press the lower edge of the rib upon the table, and you observe that it lies parallel with the surface from the anterior end to the angle, but that the part behind the angle is tilted up so as to form, with the anterior portion, an obtuse angle, apex *downward.* Between the angle and the tuberosity is an uneven surface for the attachment of muscular fibres.† The distance between the angles and the tuberosity gradually increases, and this surface consequently becomes more extensive from the first to the tenth rib. In front of the angle the outer surface is smooth; and here, also, it gives attachment to muscles. In addition to the changes of direction that have been already mentioned, the rib is twisted a little upon its own axis, so that behind the angle the outer surface looks a little downward; in front of the angle a little upward. The outer surface presents near the anterior extremity a slightly marked oblique line, sometimes called the *anterior angle.* Like the posterior angle, it gives attachment to muscular fibres. The *inner surface* of a rib presents the orifice of many little canals which transmit nutrient vessels ino the cancellous tissue.‡ It is smooth,

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* For the names of the muscles attached to the ribs see note *, page 140.

† See note *, page 140.

‡ I have observed the following curious circumstance with regard to the course of these canals. In the shaft they run, with scarcely a single exception, toward the posterior extremity of the rib. In the neighbourhood of the tuberosity, and from thence to the posterior extremity of the bone, no such uniformity of direction is observed. Some of the vessels plunge perpendicularly into the bone; some run obliquely forward; some backward; others in various intermediate directions. I have placed in the museum of King's College some preparations illustrative of this structure. Of its purpose and meaning I have no explanation to offer. Why do the nutrient arteries of the shaft run uniformly backward, while the intercostal artery, from which they are derived, proceeds in the

and looks a little upward at and behind the angle, a little downward in front of that point. The *upper edge* of a rib is rounded and blunt, and gives attachment to muscles. The *lower edge* is sharp and thin; it forms the outer lip of a *groove*, which commences at the tuberosity, and runs toward the anterior extremity of the rib. This groove is widest and deepest at the angle; it becomes shallower, and belongs more to the inner surface, as it advances beyond that point, and generally disappears at the junction of the anterior and middle thirds of the bone. It lodges vessels and nerves,* and by each of its lips gives attachment to a layer of muscular fibres.†

The *anterior extremity* of the shaft presents a porous, oval, concave surface, for the reception of the costal cartilage with which it is intimately connected. The *posterior extremity* of the shaft is continuous with the neck.

180. STRUCTURE. The ribs, which, as to their form come under the denomination of *mixed* bones, (3) in structure resemble the cuboid or short bones, consisting of a quantity of reticular tissue, enclosed in a thin compact layer. This outer layer generally presents a laminated appearance, as if it were composed of little scales overlapping each other. DEVELOPMENT. By three points; one for the body, one for the head, and three for the tuberosity. The two latter parts are developed as separate epiphyses, which remain detached up to the age of twenty, or even twenty-five years.

There are several ribs which present deviations from the general characteristics that have just been given. These, with certain gradations in size, curvature, and direction, come next to be described as

THE DIFFERENTIAL CHARACTERS OF THE RIBS.

181. The ribs increase in length, from the first to the seventh inclusive, and again diminish from the seventh to the last. The curvatures of the ribs become segments

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opposite direction? And again, what are the causes which give rise to so striking a contrast in this respect, between the shaft on the one hand, and the head, neck, and tuberosity, on the other; rendering unnecessary, in the latter, conditions which, from their constancy, we may infer to be essential to the former?

* Intercostal. † Intercostales interni and externi.

of larger circles, as we proceed from the first downward. This increase is most remarkable in the five or six upper ribs. The first is nearly horizontal; the others become successively more and more inclined on the vertebral column. The ribs differ also as to the muscles to which they give origin and insertion.* The first, second, tenth, eleventh, and twelfth are further distinguishable by the following peculiarities.

182. FIRST RIB. A short, stout rib, almost horizontal when in the natural position, and very abruptly curved. In this rib the *surfaces* look upward and downward, and are flat; while the *edges* look inward, outward, and are curved; in the other ribs it is just the reverse. The *head* of this rib is round, and presents only a single articular surface, to correspond with the entire articular surface on the body of the first dorsal vertebra. (19) Its *neck* is slender and rounded, its *tuberosity* very prominent, and placed on the outer border. It has no *angle*, and is not twisted on its axis; so that when laid on a table, it touches the level surface in its whole length. Its *anterior*

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* The following muscles are *inserted* into the ribs. Intercostales interni and externi into upper border of all except first. Levatores costarum into upper border of all between tubercle and angle. Sacro-lumbaris into exterior surface of all, near angle. Longissimus dorsi into exterior surface of all between angle and tuberosity. Scalenus anticus into tubercle and ridge which separate two shallow grooves on upper surface of first near the middle of its length. Scalenus posticus into that part of first which lies between subclavius groove and tuberosity, and also into upper border of second. Serratus posterius superior into upper border of second, third, fourth, and fifth, near angle. Serratus posticus inferior into lower border of four last ribs, near angle. Diaphragm transversalis abdominis into inner surfaces of seven lowest, close to cartilages. A few fibres of rectus, sometimes into fifth rib, close to cartilage.

The following muscles *take origin* from the ribs:—Intercostales interni and externi from the two lips of the groove of each rib, except the last. Longus colli from head of first serratus magnus from exterior surface of nine upper. Cervicalis ascendens from four or five upper between angle and tuberosity. Accessorius from upper edge of five or six upper. Pectoralis minor from exterior surface of third, fourth, and fifth. Obliquus internus abdominis from exterior surface of nine lowest near anterior extremity. A few fibres of subclavius sometimes from upper surface of first, near its cartilage. A few fibres of portio deprismus of pectoralis major sometimes from exterior surface of fifth or sixth near cartilage.

extremity is larger and thicker than that of any other rib, and often gives insertion above to a muscle.* The *outer border* is thick, rounded, and convex. Its *inner border* thin and concave. Its *lower surface* is smooth, slightly convex, and destitute of a groove. Its *upper surface* presents, close to the inner border, and at the junction of the anterior with the middle third of the bone, a *tubercle;* and running from this tubercle forward and outward to the anterior border of the bone, a slight *ridge.* The tubercle and ridge give attachment to a muscle,† and separate two shallow *grooves;* of which the anterior transmits a large *vein,*‡ the posterior a large artery.‡

183. SECOND RIB. Has a hardly perceptible *angle*, and no twist on its axis; so that, like the former, it touches, with both ends at once, any plane surface on which it may be laid. The *outer surface,* though not horizontal like that of the first rib, looks a good deal upward; and presents near the middle a rough eminence, which gives attachment to part of a large muscle.§ Its *inner surface,* which is directed more downward than that of the ribs in general, presents near the tuberosity that *groove* which is generally found on the lower edge of a rib. Besides this difference in position, the *groove* of the second rib is very short.

184. TENTH RIB. The *head* presents only a single articulating surface, to correspond with the single articular cavity on the body of the tenth dorsal.

185. ELEVENTH and TWELFTH RIBS. In these ribs the *head* is large, but has only a single articular surface, and the anterior extremity is attenuated. They are not connected with the transverse processes of their respective vertebræ, and are consequently destitute of *tuberosity* and *neck.* The eleventh has a very slight *angle* situated far forward, and a short indistinct *groove:* but in the twelfth, angle and groove are alike imperceptible. These points, with the superior length of the eleventh, are the only marks of distinction between the two vertebral or floating ribs. The ossification of these ribs proceeds from a single point: whereas the other ribs are developed by three.

186. OF THE COSTAL CARTILAGES. These are white elastic

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* The subclavius.
† The scalenus anticus.
‡ The subclavian.
§ The serratus magnus.

substances, corresponding in number,* general form, and situation to the ribs, of which they form the anterior prolongations. Their width, and the intervals by which they are separated, diminish gradually from the first to the last. Each cartilage, moreover, diminishes in width from its outer to its inner extremity; except the first and second, which are of equal width in their whole extent, and the sixth, seventh, and eighth, which are considerably enlarged where their edges come into contact. Their length increases from the first to the seventh; and diminishes from the seventh to the last. The seven upper cartilages are connected by their inner extremities with the sternum. The three succeeding cartilages are connected, each with the lower border of the cartilage immediately above it; while the two last, which are short and pointed, float, unconnected and free, in the muscular parietes of the abdomen. With regard to the direction of the costal cartilages, it may be observed that the first descends slightly from the rib to the sternum, while the second is nearly horizontal, and the third ascends a little to its sternal insertion. The four remaining cartilages of the vertebro-sternal ribs, and all those of the vertebro-costal ribs, follow for a few lines the direction of the ribs to which they respectively belong, and then forming a curve, ascend to their insertion in the sternum, or in the preceding cartilage. The abruptness of this ascent increases from above downwards. The two last cartilages, which are quite rudimentary, follow the direction of the vertebral ribs to which they are attached.

The *anterior surface* of each costal cartilage is directed forward, and a little upward and outward; and is slightly arched or convex. The *posterior surface* has an opposite direction, and is concave. Of the *borders*, which correspond to the intercostal spaces, the upper is concave, and the lower convex. The contiguous borders of the sixth, seventh, eighth, ninth, and tenth costal cartilages present smooth oblong surfaces at the places where they articulate; at which parts they are also somewhat enlarged. The *outer extremity* of each cartilage is continuous with

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* Sometimes there is a supernumerary cartilage projecting from the side of the sternum, not connected with any rib, but terminating gradually in the substance of the muscles. When this rudimentary cartilage occurs, it is usually formed between the third and fourth rib.

the osseous tissue of the rib to which it belongs. The *inner extremity* of the first is continuous with the osseous tissue of the sternum; but the inner extremities of the six next are furnished with convex articular surfaces, which play in the corresponding cavities on the borders of the sternum; in the vertebro-costal ribs, (the eighth, ninth, and tenth of the series,) this extremity is pointed, and lies in contact with the lower edge of the cartilage above; in the two vertebral or floating ribs (the eleventh and twelfth,) it is pointed and free. The costal cartilages (which are the largest and strongest cartilages in the body) give origin and insertion to numerous muscles.*

OF THE THORAX IN GENERAL.

187. The thorax in shape resembles a cone, truncated at the apex, which is situated above, flattened before and behind, and cut off somewhat obliquely at the base. The axis of the cone is not vertical, but inclined from above downward and a little forward. The thorax is of a symmetrical form, and presents for examination an exterior and an interior *surface*, an upper and a lower *aperture*, and a *cavity*.

188. SURFACES. *Exterior*. Divided into an *anterior*, a *posterior*, and two *lateral* aspects. The *anterior aspect* is *inclined* from above forward and downward, so that its *direction* is forward and upward. It presents in the middle the anterior surface of the sternum and ensiform appendix, and on each side of this the sterno-costal cartilages, increasing in length and curvature from above downward, and separated from each other by intervals, which diminish in width from above downward, and are closed in the recent state by a series of thin flat

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* The following muscles *take origin* from the costal cartilages: Subclavius from upper border of first. Sterno-hyoid from posterior surface of first. Sterno-thyroid from posterior surface of second. Intercostales interni from lower border of all except last. Portio deprimens of pectoralis major from anterior surface of second, third, fourth, fifth, and sixth. Rectus abdominis from fifth, sixth, and seventh. Diaphragm transversalis abdominis from inner surface of seventh border.

The following muscles are *inserted* into the costal cartilages:—Intercostales interni into the upper border of all but the first. Obliquus internus abdominis into interior border of seven lowest. Triangularis sterni into posterior surface of third, fourth, fifth, and sixth.

muscles.* Its *posterior aspect* is convex from above downward, alternately convex and concave from side to side. It presents in the middle the posterior surface of the dorsal region of the spine, with its *vertebral grooves*, separated by the row of imbricated *spinous processes*, limited externally by the series of strong clubbed *transverse processes*, and presenting intermediately the ranges of *articular processes*. Beyond the transverse processes appear the outer surfaces of the ribs, which are here very convex, presenting the row of *tuberosities*, and further outward the *angles* of the ribs. These latter form on each side an oblique line, interrupted by the intercostal spaces, and running from above downward and outward. The *lateral aspects* of the thorax are more convex than the others, and directed outward in the middle, outward and a little upward above, outward and a little downward below. Here are seen the smooth external surfaces of the ribs running from behind obliquely downward and forward, and separated by the intercostal spaces—a series of intervals which are shorter and broader above and below than in the middle of the thorax, broader also at its posterior than at its anterior part, and closed in the recent state by two layers of muscular fibres.† The lateral aspects present, moreover, at their lower part the cartilages of the vertebro-costal, and of the vertebral or floating ribs; the former united with each other, the latter free. The exterior surface gives attachment to numerous muscles. *Interior.* Divided like the exterior surface into four aspects. The *anterior aspect* is directed downward and backward, and presents the posterior surface of the sternum, of the ensiform appendix, and of the sterno-costal cartilages. The *posterior aspect* presents in the centre the bodies of the dorsal vertebræ, which project into the cavity of the thorax, forming a sort of curved ridge, concave from above downward, convex from side to side; on each side of these appear the heads of the ribs, directed and received into the cavities formed by the junction of the facets on the bodies of the dorsal vertebræ —then come the *necks* (the two or three uppermost contracted, the rest wider—more or less—than the shafts), and then the *bodies* of the ribs, each with its smooth and concave interior surface, and its grooved inferior margin.

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* Intercostales.

† Intercostales interni and externi.

The ribs, projecting backward on each side of the spine, and then curving rather suddenly forward, form two elongated cavities resembling large grooves, narrow above, wide below, deepest in the middle. The *lateral aspects* are concave, and present, like the last described, the smooth inner surface, and grooved lower borders, of the ribs, with the intercostal spaces between.

189. APERTURES. *Superior.* Smaller than the inferior, of an ovoid form, with the long diameter transverse, inclined from behind forward and downward, so that its axis is directed from below forward and upward. It is formed in front by the upper border of the sternum, on each side by the inner edge of the first rib, and behind by the body of the first dorsal vertebra, which projects forward so as to destroy the regularity of the oval, and render it somewhat heart-shaped. It is traversed by several important organs,* and its circumference gives attachment in front and behind to several muscles.† *Inferior.* Very large, and like the upper, transversely ovoid. Its circumference is irregular, presenting alternate notches and projections. It is bounded in front by the ensiform appendix, on each side of which is a convex margin, formed by the united lower borders of the cartilages of the vertebro-costal ribs. Next to these appear the tips of the floating ribs, with the interval between them; then the lower margin of the last rib, which runs backward, inward and upward; and lastly, the body of the lowest dorsal vertebra. We have, therefore, in *front,* a deep notch divided into two by the ensiform appendix, *laterally,* two curved eminences formed by the costal cartilages, and *behind,* two notches formed, one on each side, between the lower margin of the last rib and the spine. The axis of this aperture is directed downward and forward; it is closed, in the recent state, by a large muscle,‡ and transmits several important organs.§

190. CAVITY OF THE THORAX. The shape of this cavity may be inferred from the description of the frame-work by which it is enclosed. (187-8) It is chiefly occupied by the central organs of respiration and circulation; but

* Trachea and œsophagus; subclavian and carotid vessels; vagus, sympathetic, and other nerves.

† Sterno-hyoid, and sterno-thyroid in front; longi colli behind.

‡ Diaphragm.

§ Œsophagus, aorta, vena cava, sympathetic nerve, &c.

at its lower part it protects a portion of the abdominal viscera. This is permitted by the arched form of a horizontal muscular partition (called the *diaphragm*), which, in the recent subject, separates the thoracic from the abdominal cavity. The relative size of the supra and infra-diaphragmatic divisions of the thorax varies with the alternate rise and fall of the diaphragm in respiration. The form and dimensions of the thorax differ, moreover, in the opposite sexes, and in the same individual at different periods of life. It is wider and shorter in the female than in the male. In the adult its transverse diameters exceed those which are measured from the anterior to the posterior wall. In the fœtus, on the contrary, its antero-posterior exceed its transverse diameters. At birth, when respiration commences, it experiences a sudden increase of size; and its development undergoes a remarkable temporary acceleration at the period of adolescence. The capacity of the thorax indicates the volume of the lungs, which usually bears a direct proportion to the development of the muscular system, and the general vigour of the body. An expanded chest is the sign of sound health; a narrow contracted chest, with a prominent sternum, indicates an inherent weakness of constitution, and is frequently accompanied by a consumptive tendency. Besides these congenital diversities in the shape of the thorax, the student will meet, in the dissecting-room, with others which are produced by artificial means during life. For an example of these we may refer to the distortion which is caused by wearing a tight bandage round the middle region of the body. This practice, which reduces the expanded lower circumference of the chest to two-thirds of its natural size, and impairs, to a dangerous extent, the functions of digestion and respiration, prevails among the females of several European nations; who prefer an abrupt indentation of this part of the body to the flowing curve of its natural outline. So highly, indeed, is this unsightly deformity esteemed, that the thorax is often subjected to compression at an early age, before the bones are firmly knit, in order the more effectually to force in the lower ribs upon the abdominal viscera.

From birth to adult age the cavity of the thorax undergoes, during every respiration, an alternate increase and diminution of capacity, owing partly to the rise and fall of its muscular floor, partly to certain motions of its bones and cartilages, which we shall presently proceed to explain. In old age the cartilages of the thorax ossify, its joints grow rigid, its different pieces become gradually less and less movable on each other, and respiration is at last performed almost entirely by the action of the diaphragm.

191. Mechanism of the Thorax. The principal office of the thorax is to contain and protect the lungs, and to pump air alternately into and out of their cells; the middle region of its cavity is occupied by the heart; and by its outer surface it affords attachment, and a firm centre of action, to the arms, and to numerous muscles. Each of these three functions requires, for its due performance, the fulfilment of a different condition. The first involves the incessant motion of the walls of the thorax, and the alternate fall and reascent of its floor through a considerable space. The second, on the contrary, requires that the floor, so far as it serves to support the heart (the pulsation of which is disturbed by any considerable change of its relative position), should descend very little during inspiration. The third requires that the elastic, movable hoops of the thorax should be capable of suddenly assuming the qualities and condition of a rigid, jointless framework.

Without entering at length into the physiology of the diaphragm, which forms the floor of the chest, we may observe that its central part, which supports the heart, is a flat, tendinous expansion; while the lateral portions, which sustain the lungs, are composed of curved muscular fibres. By the contraction of the anterior and posterior portions of the muscle the central aponeurotic tendon is rendered tense, so as to become a fixed centre for the action of the lateral fibres; but being flat, and connected by short muscular fibres to the xiphoid appendix, it descends but little. The lateral muscular fibres, on the contrary, are very long, and arch upward into the cavity of the thorax, reaching at their highest point the level of the fifth rib. Each lateral muscular vault, in contracting, tends to bring the whole length of its curved fibres into the same plane; this can only happen by a considerable descent of its highest point; which descent involves the vertical dilatation of the lateral portion of the thoracic cavity. Such is the twofold structure, and function, of the musculo-aponeurotic floor of the thorax. We have next to consider the mechanism of its osseo-cartilaginous walls, and to ascertain, in the first place, by what manner of motions they alternately dilate and contract the cavity of the chest; and secondly, how this movable framework is enabled suddenly to assume a temporary rigidity, so as to furnish the upper extremities, and the muscles which are attached to its surface, with a fixed, unyielding centre of action.

If we examine, in a skeleton, the hoop formed by a pair of true ribs and costal cartilages, we shall find that it is inclined in two senses: 1st, the entire hoop is inclined downward and forward, from its spinal to its sternal attachment, so that its anterior is lower than its posterior portion; 2ndly, each lateral segment of the hoop is inclined downward and outward from the median plane of the body, so that the middle of the shaft of each rib is below the middle of a straight line connecting its extremities. To bring a rib, thus inclined, into a horizontal position, two things would be necessary; first, its anterior extremity must be raised to a level with its posterior extremity; and then its middle portion must be raised to a level with its ends. It is evident that the former of these actions would carry *forward* the anterior extremity of the rib and the sternum; thereby increasing the antero-posterior diameter of the chest; and that the latter would carry *outward* the middle of the rib, thereby increasing the transverse diameter of the chest; so that, performed together, they would dilate the cavity in both directions at once. Now, each rib is provided with muscles, by which its inclination with regard to the spine, and its inclination with regard to the median plane, are simultaneously diminished, all its parts being brought nearer to the horizontal plane in which its posterior extremity is situated. When we add that these muscles act during inspiration, and that their antagonists restore the ribs and sternum to their former position during expiration, the alternate dilatation and contraction of the walls of the thorax are sufficiently explained;* and we may proceed to consider, in the last

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* Of the numerous conflicting theories which have been proposed, in explanation of the respiratory motions of the thorax, several are at variance with plain facts, and may be satisfactorily refuted by direct observation. Such is the doctrine of the immobility of the first rib, originally advanced by Haller. It is only necessary to move the sternum up and down, in the dead subject, in order to be convinced, with Magendie, that the first rib is not less movable than any other of the series. But there are some

place, the conditions of rigidity, and the mechanical provisions by which it is attained.

And here we may observe that the condition of mobility, being in constant requisition day and night, is therefore the natural or spontaneous condition of the thorax; whereas the condition of rigidity, being only required when certain particular muscles are put into unusually strong action, is a temporary condition, produced

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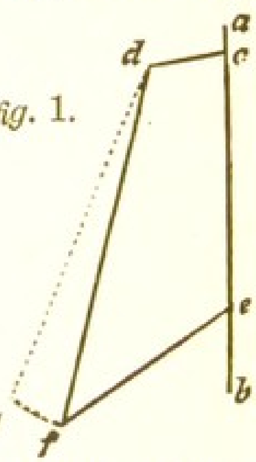
prevalent opinions which are not so easily brought to the test of experiment; as for instance, that which is maintained by Cruveilhier in the following passage:—

"Le sternum n'éprouve pas dans son ascension un mouvement de bascule, comme le pense Haller; mais il est porté en haut par un mouvement de totalité, en conservant sa direction primitive, ainsi que Borelli l'avait très-bien indiqué."

Now, I think that, whether with Haller we consider the first rib to be fixed, or with Cruveilhier admit its mobility, a few very simple considerations will be sufficient to prove that it is absolutely impossible for the sternum to "preserve its original direction" during the respiratory motion of the thorax, as Cruveilhier in this passage contends.

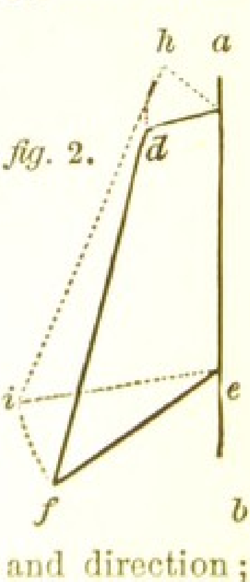
fig. 1.



Let $a\ b$ *fig.* 1 represent the spinal column, $d\ f$ the sternum, $c\ d$ the first vertebro-sternal rib (short and almost perpendicular to $a\ b$), and $e\ f$ the last vertebro-sternal rib (long and considerably inclined on $a\ b$).

If the first rib is fixed, it will prevent the sternum from ascending, but will allow it to advance at its lower extremity (to a distance depending on the extensibility of the costal arc $e\ f$), by turning above on d, as its centre, and describing below the segment $f\ g$ of a circle. Any two positions of the sternum, during an advance of this kind, would represent two radii of the same circle; and, therefore, could not be parallel to each other.

fig. 2.



If, on the other hand, the first rib turns during inspiration and its vertebral joint (as Cruveilhier admits, and as it really does), its anterior extremity will ascend in the arc $d\ h$, *fig.* 2; while the seventh rib, also turning at its vertebral articulation, will ascend in the arc $f\ i$, carrying the sternum forward and upward, into the position shown by the dotted line $h\ i$.

The arcs, $d\ h$ and $f\ i$, also represent the paths in which the ends of the sternum will respectively move. Now it is shown in the diagram, that these paths differ very considerably as to their curvature and direction; being in fact segments of unequal circles. But if the ends of the sternum advance unequally, the inclination of this bone must necessarily undergo a constant change during the motions of respiration.

by a voluntary effort, and maintainable only for a short time. To produce this temporary rigidity of the thorax, we first expand it by a deep inspiration, and then, closing the *glottis* (or aperture of the windpipe), put the muscles of expiration into action, so as forcibly to compress the air within. In this state of things, the elastic force of the condensed air, and the tension of the muscles of expiration, operate as antagonist forces, equally preventing the expansion and the contraction of the thorax. This explanation is confirmed by common experience. Every one has observed that in taking a leap, striking a blow, or any other violent exertion of the body, the breath is instinctively drawn in, and *held;* and that, just as the action is completed, the glottis opens, and the air escapes with an audible rush, which proves that it has been subjected to compression within the lungs.

CHAPTER IV.

OF THE PELVIS.

192. THE pelvis is an irregularly shaped, osseous girdle attached to the lower end of the spinal column, which it supports, and resting below on the thigh bones, to which it transmits the weight of the trunk. It is intermediate in size between the cranium and thorax; but it is stronger, and more massively framed, than either. It is composed, in the adult, of four bones, viz., the two *ossa innominata*, or *haunch-bones*, which bound it laterally and in front, and the *sacrum* and *coccyx*, which complete it behind. The two latter bones form a continuous line with the spinal column, of which they are universally admitted to be the degenerate termination. The haunch bears the same relation to the leg, that the shoulder does to the arm; each being considered by Cruveilhier, and many other descriptive anatomists, as the first division of the corresponding extremity; but, by the transcendental anatomist, as a portion of the costal series, analogous to the lateral arcs of the thorax.* We must again remind

* The transcendental anatomists regard the osseous girdle formed by the shoulder-blades and collar-bones, as a series of cervical ribs, coalesced, and otherwise modified, to adapt them for

the student, that the division of the skeleton, adopted in this treatise, is intended merely to furnish a simple and convenient order of description, not to indicate the true analogies of the bones, which would suggest an arrangement in the highest degree paradoxical and perplexing to the beginner. With this caution we may proceed, in the first place, to describe separately the four bones of the pelvis; and secondly, to review the cavity which they form by their conjunction.

OF THE SACRUM.

193. The sacrum is a large, pyramidal bone, inserted, like a wedge, between the two ossa innominata. It forms the upper and back part of the pelvis; its base articulates with the last lumbar vertebra; its apex, which is directed downward and forward, unites with the coccyx. It is originally formed in five separate pieces, analogous to the vertebræ of the spine—of which, in fact, the sacro-coccygeal column is the inferior prolongation. At the

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the support of the arms. The upper half of the manubrium is, in their view, a condensed cervical sternum, articulating with the cervical ribs. So again they trace in the ossa innominata, and the anterior portion of the lateral mass of the sacrum, a series of sacral ribs, consolidated into a mass, and coalescing with the transverse processes of the sacral vertebræ, in order to form a strong framework for articulation with the lower extremities. The sternum is here represented by the inter-pubic fibro-cartilage. In the abdomen these parts are reduced to mere vestiges; the linea alba representing the sternum, and the tendinous intersections of the rectus being indications of abdominal ribs. These views, supported as they are by the most comprehensive induction of facts from comparative anatomy, seem to me to deserve more attention than is bestowed on them by the medical students in this country; for which reason it is that the present, and several other notices, of the transcendental philosophy, have been introduced into this treatise. I take this opportunity of correcting an error which has escaped me in speaking of the transcendental relations of the teeth, note (*), page 80. The teeth are vestiges, not of the *dermoid* skeleton, as there stated, but of the *splanchnal* skeleton, as subsequently stated in note (*), page 83. The discrepancy is not so considerable as it appears at first sight, for the epidermis of the exterior cutaneous tegument (which, with its appendages, represents the dermoid skeleton), and the epithelium of the interior mucous tegument (which, with its appendages, represents the splanchnal skeleton), are continuous with each other at the orifice of the mouth: and when the front teeth grow upon the line of junction, as they do in many fishes, they may be referred to either skeleton indifferently.

age of 15, the sacral vertebræ (also called the *false* vertebræ, in contradistinction to the spinal or *true* vertebræ) begin to unite; the transverse processes are blended into a continuous mass on each side, and the joints of the bodies anchylose; so that, at 25 years of age, the whole series is consolidated into a single bone.

The sacrum is curved upon itself, so as to be convex behind, concave in front. In the natural position, it is directed obliquely from above downward and backward, so as to form with the lumbar vertebræ a prominent angle, of which we shall have occasion to speak in our general review of the pelvis. The sacrum presents four *surfaces*, a *base*, an *apex*, and a *canal*.

194. SURFACES. *Anterior.* More extensive, in general, than the posterior, wider above than below, slightly concave in the transverse, very concave in the longitudinal direction. It presents, in the median line, the *bodies* of the five sacral vertebræ, separated by four transverse *ridges.* External to these, on each side, appear four *holes*, leading into the sacral canal, and analogous to the inter-vertebral foramina. (26) External to these, again, is the anterior surface of the *lateral mass* formed by the conjoined transverse processes of the sacral vertebræ. Examining these objects more closely, we observe that the *bodies* diminish in size from above downward; that the uppermost is convex, the others nearly plain from side to side; and that each is concave in the longitudinal direction. The *holes*, which are called the *anterior sacral foramina*, correspond in position to the four transverse ridges (every ridge having a hole at each end). The two upper holes, on each side, are large and rounded; the two lower are smaller, and of a less regular form. They all give passage to nerves.* The anterior surface of the conjoined transverse process is smooth, and traversed by four wide, shallow *grooves*, leading horizontally outward from the anterior sacral foramina, and lodging the nerves which those foramina transmit. These grooves are separated by slight horizontal *ridges*, which give attachment to the digitations of a muscle.†

Posterior. This surface is convex, and uneven. It presents, in the median line, the rudimentary *spinous processes* of the sacral vertebræ. Immediately external

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* Anterior branches of sacral nerves. † Pyriformis.

to these, on each side, are the *laminæ:* beyond these appears a series of indistinct tubercles, representing the *articular processes;* close on the outside of these are the *posterior sacral foramina;* and just beyond these is another row of tubercles, which represent the extremities of the *transverse processes,** and separate the posterior from the lateral surface. Of the *spinous processes,* the uppermost is usually very prominent, and separate from the others. The second, the third, and the upper half of the fourth, unite to form a tubercular ridge, which becomes less prominent as it descends, and disappears opposite the middle of the fourth sacral vertebra. The lower half of the fourth sacral vertebra, and the whole of the fifth, are deficient in spinous process and laminæ; so that the sacral canal is here laid open, and appears as a wide vertical *groove,* bounded on each side by a tubercular *ridge.* These ridges are formed by the articular processes of the fourth and fifth sacral vertebræ; they project downward, under the name of *cornua sacralia,* or *horns of the sacrum,* to meet corresponding processes of the coccyx, with which they ultimately coalesce. Beneath each sacral horn is a notch, which transmits a nerve.† The *laminæ* present nothing remarkable; they are long and thick in the first sacral vertebra, and deficient in the fifth, and in the lower half of the fourth, as we have already had occasion to observe. Of the *articular* processes, the uppermost pair are well developed, but as they belong to the base of the sacrum, their description is deferred. (195) The second and third pair are represented by small indistinct tubercles; the fourth pair are more distinct, and contribute to form the ridges that bound the ter-

* Cloquet regards these eminences as the representatives of the articular processes of the spine, and makes no mention of the tubercles which we (with Cruveilhier and others) describe as rudimentary articular processes. But the relative position of the two rows of tubercles, clearly indicates, I think, their true analogies. The two processes by which the sacrum articulates with the last lumbar vertebra above, and the *cornua sacralia,* by which it articulates with the first coccygeal bone below, are admitted on all hands to be analogous to articular processes. Now the tubercles described in the text as articular, extend in a direct line between these processes. On the contrary, the tubercles, which Cloquet describes as articular, are in a line with the *transverse* processes of the lumbar vertebræ, and half an inch external to the range of articulating processes.

† Fifth sacral.

minal groove of the sacral canal; the fifth pair also contribute to those ridges, and are prolonged downwards to form the sacral horns. The *posterior sacral foramina*, four on each side, lie just external to the tubercles representing the articular processes. They are exactly opposite to the anterior sacral foramina, but smaller, and less regular in form. Like the anterior, they communicate with the sacral canal, and serve for the transmission of nerves.* The tubercles which represent the *transverse* processes, are large, and give attachment to strong ligaments.† The uppermost pair are particularly distinct; appearing, one on each side, as a horizontal tubercular eminence on the boundary line between the posterior surface and the base of the sacrum. The space between the transverse and spinous processes is concave from side to side, and forms a channel, continuous with the vertebral groove of the spine, and called the *vertebral groove of the sacrum*, or, more shortly, the *sacral groove.* The posterior surface gives attachment to several muscles.‡ *Lateral.* This aspect is broad above, but it narrows into a mere edge below. It presents, superiorly, a rough, semilunar surface, directed outward, backward, and a little downward, for articulation with a corresponding surface on the os innominatum. This surface of the sacrum is sometimes called the *auricular*, or *ear-shaped surface.* It is bounded, posteriorly, by some rough depressions, for the attachment of strong ligaments.§ Beneath the auricular surface is an uneven edge, which gives attachment to ligaments,‖ and presents, at its lowest part, a deep *notch* converted, either by a ligament, or by the transverse process of the first coccygeal vertebra (202), into a *hole*, which transmits a nerve.¶

195. BASE. This aspect is directed upward and forward. It is widest transversely, and presents, in the median line, an oval surface exactly resembling the articular surface of the body of the last lumbar vertebra, to which it is joined by the intervention of the last intervertebral fibro-cartilage. Behind this articular surface

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* Posterior branches of sacral. † Sacro-sciatic.

‡ The spinous processes give attachment to the aponeurosis of the latissimus dorsi; and the sacral grooves, to the fleshy mass by which the sacro-lumbalis and longissimus dorsi commence, and to the glutæus maximus. § Sacro-iliac.

‖ Sacro-sciatic. ¶ Anterior branch of fifth sacral.

appears the upper orifice of the *sacral canal*, large and triangular, bounded, in front by the body, and behind by the laminæ, of the first sacral vertebra. *Behind* this orifice is seen the upper border of the *spinous process* of the first sacral vertebra; *beside* it appear the upper *articular processes* of the first sacral vertebra. Each of these processes presents an oval, cartilaginous surface, concave from side to side, plane from above downward, and directed backward, inward, and a little upward, to articulate with the inferior articular process of the last lumbar vertebra. In front of each articular process is a *notch*, which, with the inferior notch of the last lumbar vertebra, forms the last *intervertebral foramen*. The only remaining objects presented by this aspect are two smooth, triangular surfaces, concave transversely, convex from before backward, extending outward, one on each side, from the central articular surface of the base, to become continuous, in the united pelvis, with the internal iliac fossa of the os innominatum. These surfaces are sometimes called the *alæ* of the sacrum; the rounded angle, formed by their junction with the anterior surface, is continuous with the *linea ileopectinea* of the os innominatum (209), and forms part of the brim of the true pelvis (218).

196. APEX. Is directed downward and a little forward, and presents only a concave, oval surface, for articulation with the coccyx.

197. SACRAL CANAL. Large and triangular above, small, and flattened from before backward below. It follows the curve of the sacrum, is continuous above with the vertebral canal, and is reduced below to a groove, by the deficiency of its posterior wall between the sacral horns. In the recent subject, however, this groove is converted into a canal by ligamentous fibres, which extend between the cornua. The sacral canal lodges nerves,* and its walls are perforated by the anterior and posterior sacral foramina, through which those nerves pass out.

198. STRUCTURE. Light and spongy within, invested by a thin layer of compact tissue externally. DEVELOPMENT. Each of the three upper sacral vertebræ is developed by five ossific points, one for the body, two for the laminæ, two for the lateral masses which represent

* Sacral.

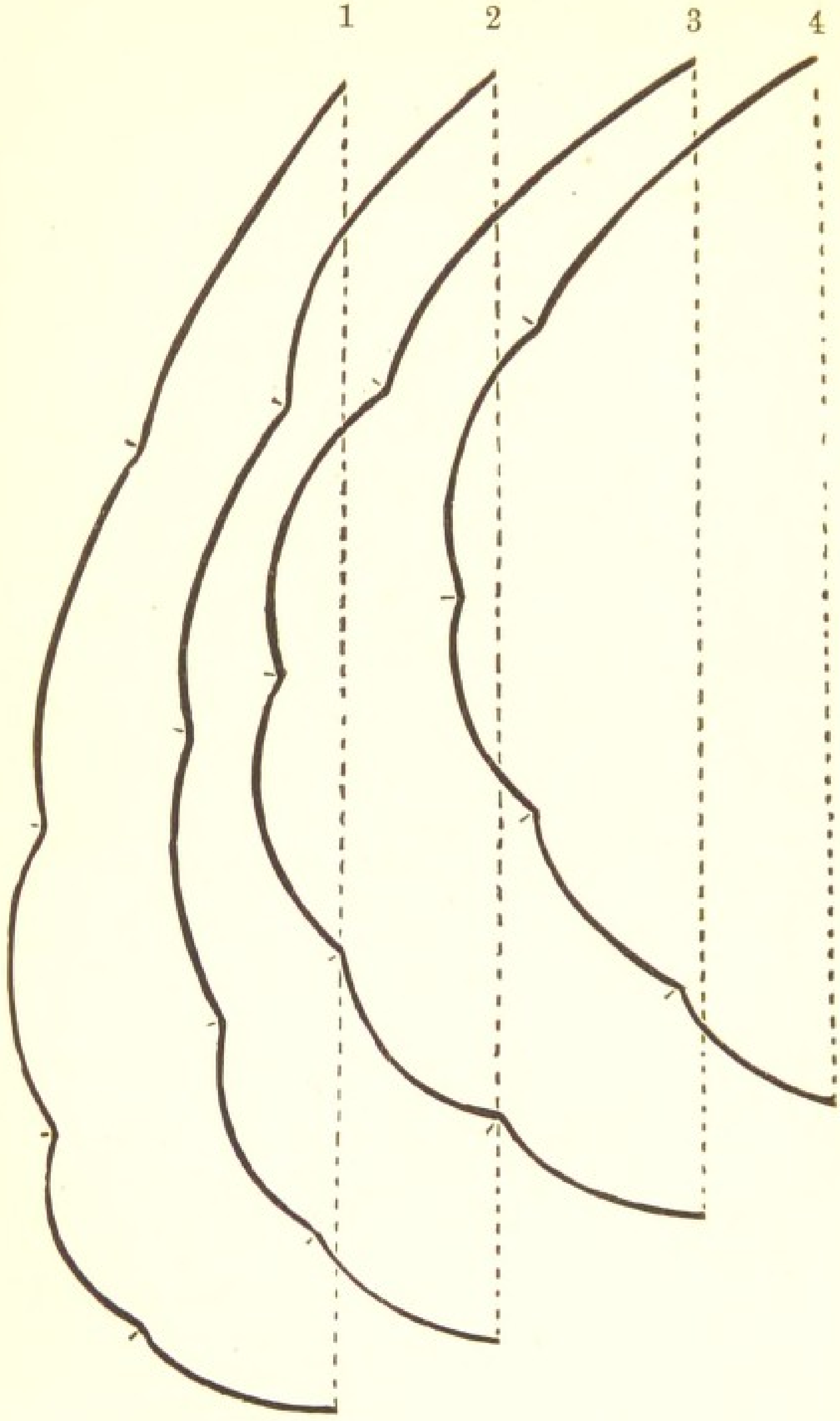
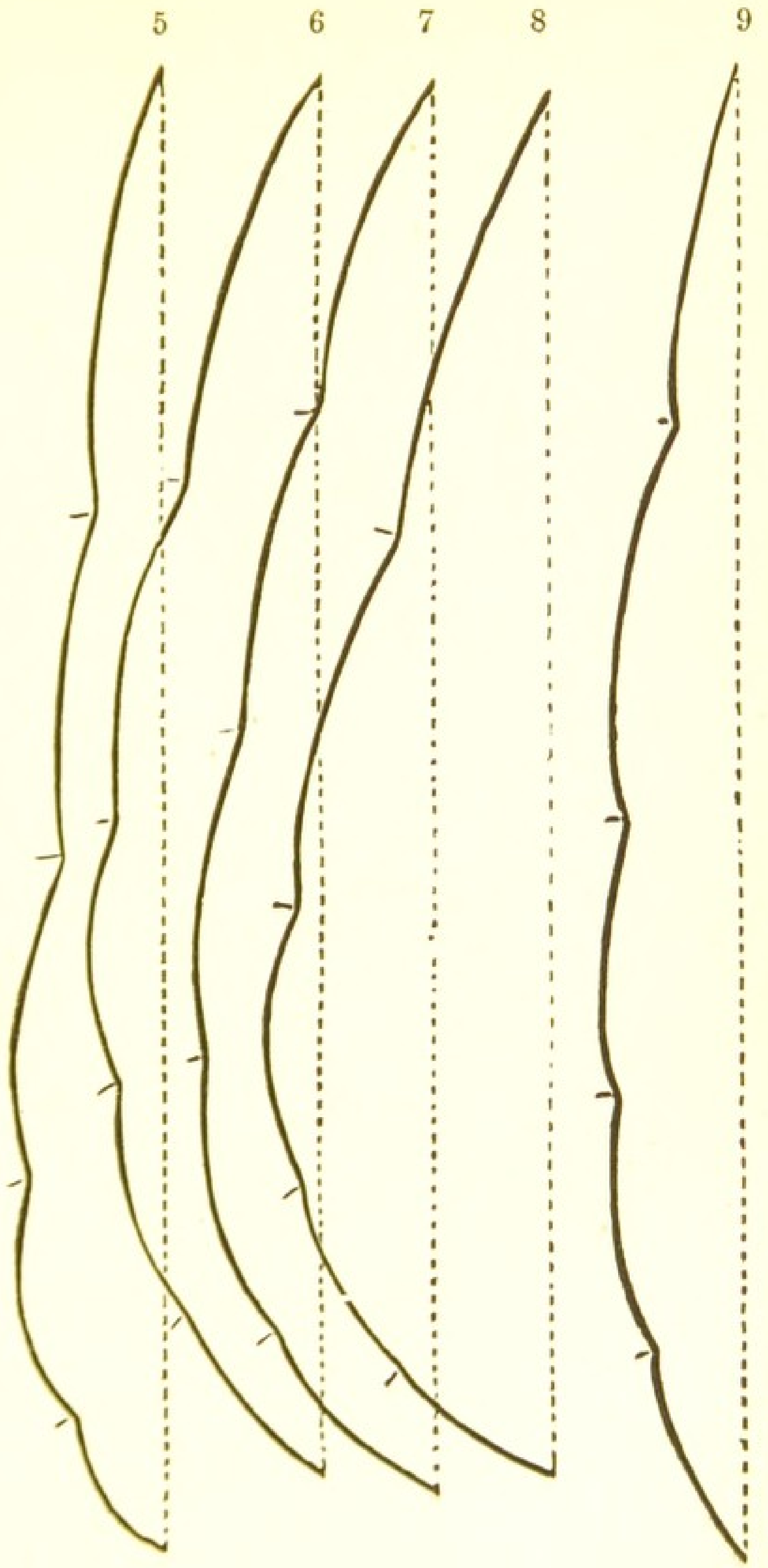


Fig. 1, 2, 3, 4 . . . . Male
5, 6, 7, 8 . . . . Female.
9 . . . . Male.


5
6
7
8
9

the transverse processes. The two lowest sacral vertebræ are developed by three points each, one for the body, two for the lateral masses. The articular surfaces of the body of every sacral vertebra, and the two auricular surfaces of the sacrum, are developed separately, each as a thin plate, which subsequently unites with the rest of the bone. Each of these twelve epiphyses is developed by a separate point, which, with the twenty-one before-mentioned, make up the number of *thirty-three* ossific points for the sacrum. ARTICULATIONS. With the last lumbar vertebra, the ossa innominata, and the coccyx.

CURVATURE OF THE SACRUM.

199. The sacrum is somewhat wider in the female than in the male. Its relative curvature in the two sexes is a subject upon which contradictory opinions have been delivered by anatomists of high authority. Cloquet says that the female sacrum is more curved than that of the male. Others maintain a directly opposite opinion. Cruveilhier states that he has examined the sacrum in many male and female subjects, without finding any difference sufficiently pronounced and constant, to be taken as characteristic of the sexes.

As this is a question of considerable interest to the practitioners of midwifery, I have endeavoured, by employing an exact mode of measurement, to arrive at a correct decision on this point, and shall here state briefly the method and the results of my observations. A narrow strip of sheet-lead was pressed against the anterior surface of the bone, so as to receive its exact curvature in the median line. The lead was then laid edgeways on a sheet of paper, and its curve was traced with a pencil. The foregoing diagram exhibits curved lines obtained in this manner, from the sacra of four male and four female pelves, belonging to the museum of King's College. An extensive series of similar observations gave the following general conclusions:—

1. The curvature of the female sacrum belongs chiefly to the lower half of the bone. The upper half is nearly straight. 2. The male sacrum is, on an average, more curved than that of the female, and its curvature is more equally distributed over its whole length. 3. The male sacrum, in many instances, approximates in its form to that of the female, but the female sacrum rarely presents

the characters proper to the male. Thus, it is much more common to find a very straight sacrum in a male subject, than one that is very much curved in a female. (Fig. 9 in the diagram, represents the curvature of the straightest male sacrum I have ever met with.)

The curvature of the sacrum is liable to be changed after birth by pressure. A dealer in bones, who obtains his supplies from a French military hospital, informs me that the skeleton of a horse-soldier may generally be distinguished from that of a foot-soldier, by the more sudden curvature of the sacrum.

OF THE COCCYX.

200. A series of four, sometimes five, small vertebræ, resembling those of the sacrum, but still more degenerate and rudimentary. Uniting successively with each other, these coccygeal vertebræ form, in the adult, a single bone, of a triangular form, articulated by its base to the apex of the sacrum, with which it ultimately contracts an osseous union; so that, at a late age, the entire sacro-coccygeal column forms but one bone. The coccyx is a vestige, in the human race, of the tail of quadrupeds. It presents for examination two *surfaces*, two lateral *borders*, a *base*, and an *apex*.

201. SURFACES. *Anterior*. Smooth, slightly concave, forming a curve continuous with that of the sacrum, marked with three transverse *grooves*, indicating the junction of the cocygeal vertebræ. It is covered by a ligament,* and supports a portion of the alimentary canal.† *Posterior*. Convex, marked with tranverse *grooves* like those of the anterior surface, and also with two rows of *tubercles*, which represent the articular processes of the coccygeal vertebræ. The uppermost pair of these tubercles are prolonged upward, to meet the descending articular processes of the last sacral vetebræ; and as the latter processes are called the *cornua of the sacrum*, so are these denominated the *cornua of the coccyx*. The cornua of the sacrum and coccyx, together with the bodies of the false vertebræ, to which they respectively belong, complete a pair of foramina, which transmit each a nerve.‡ The coccygeal vertebræ are destitute of laminæ and spinous

* Anterior sacro-coccygeal. † Rectum.
‡ Fifth sacral.

processes, and consequently also of vertebral canal, and intervertebral foramina. This surface of the coccyx is covered by a ligament,* and affords insertion to part of two large muscles.†

202. Lateral Borders. Thin and uneven, presenting, alternately, *eminences*, which correspond to the transverse processes of the spine, and *notches*, which indicate the original separation of the coccygeal vertebræ. The transverse processes of the first coccygeal vertebræ are long, and flattened from before backward. They frequently curve upward, and join the lateral masses of the sacrum, so as to enclose on each side a foramen, which transmits a nerve.‡ The transverse processes of the second coccygeal vertebra are much smaller, and those of the third and fourth are often quite deficient. Indeed, the last two pieces of the coccyx are, in general, mere rudimentary nodules of bone, without distinct processes or markings of any kind. The lateral borders of the coccyx give attachment to ligaments§ and muscles.‖

203. Base. Presents an oval surface, which articulates, by amphiarthrosis, with the extremity of the sacrum. Normally, the coccyx forms a continuous line with the sacrum, prolonging its curvature forward; but it is sometimes turned upward by the pressure of sitting, so as to form a right or even an acute angle, with the sacrum.

204. Apex. Sometimes tubercular, sometimes bifid, sometimes deflected to the right or left of the median line. It gives attachment to a tendon,¶ and to some muscular fibres.**

205. Structure. Of spongy tissue, enveloped in a very thin layer of compact. Development. By four points, one for each piece. The upper pieces are sometimes developed, each by two lateral points, which unite in the median line. Articulation. With the sacrum only.

OF THE OS INNOMINATUM, OR HAUNCH BONE.

206. An irregularly shaped, unsymmetrical bone, articulated behind with the sacrum, in front with its fellow of

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* Posterior sacro-coccygeal. † Glutæi maximi.

‡ Anterior branch of fifth sacral.

§ Sacro-sciatic. ‖ Ischio-coccygei.

¶ Central tendon of sphincter ani externus.

** Posterior fibres of levatores ani.

the opposite side, and forming the anterior and lateral boundary of the pelvis. It is the largest of the flat bones, and serves as a fulcrum to the lower extremity.

The haunch bone presents, near the middle of its outer aspect, a large cup-like socket, for articulation with the head of the thigh bone. From this socket, as from a centre, diverge three strong branches of bone—viz., the *ilium*, the *ischium*, and the *pubes*. The *ilium* runs from the socket upward and backward, expanding into a wide, fan-like plate. The *pubis* runs from the socket horizontally inward, for about two inches, and then, making a sudden turn, called the *angle of the pubes*, runs downward for about the same distance. The *ischium* passes from the socket downward, for about an inch and a half, expands into a large *tuberosity*, and then, curving upward, joins the descending portion of the pubes, so as to enclose with it a large space called the *obturator foramen*. These three portions of the os innominatum are originally developed as separate bones; and the socket, from which they diverge, is itself formed by their union. That part of each bone which contributes to the socket (together with the portion immediately adjacent), is called its *body*. The expanded portion of the ilium is called its *ala*. The descending portion of the pubes is called its *ramus*: and the same name is applied to the ascending portion of the ischium. The point of junction between the ramus of the pubes, and the ramus of the ischium, is indicated, in the adult, by a rough eminence. The lines of junction between the three bones in the acetabulum, are frequently not distinguishable in the adult; but we shall subsequently state the proportion which each bone contributes to that cavity. The student should further observe, before commencing the minute examination of the haunch bone, that its middle portion, which supports the socket, is narrow, and twisted in such a manner that the inner surface of the bone looks *forward* upward and inward, above, where it belongs to the ilium; *backward* upward and inward, below, where it belongs to the pubes and ischium.

207. The os innominatum, considered as a whole, presents for examination two *borders* and four *surfaces*.

208. BORDERS. *Superior.* This border is called the *crest of the ilium*. It is curved so as to apper convex when looked at sideways; alternately convex and concave, like an italic *f*, when surveyed from above. It is thick,

especially towards the extremities, so that it may be described as having an internal and an external *lip*, separated by a narrow *interval*. Each of these three divisions gives attachment to muscles.* The crest of the ilium terminates at each end in a prominent angle. The anterior of these angles is called the *anterior superior spinous process of the ilium*; it may be felt distinctly under the integuments during life; it gives attachment to two muscles† and a ligament.‡ The posterior angle, which is larger and thicker than the anterior, is called the *posterior superior spinous process of the ilium*: it gives attachment internally to strong ligaments.§ *Anterior*. This border is irregularly concave; its outer half, which belongs to the ilium, is inclined from above downward and inward; its inner half, which is formed by the body of the pubes, is horizontal. It forms, by its junction with the crest, the angle that has just been described as the *anterior superior spinous process of the ilium*. It presents, just below this process, a *notch*, which gives attachment to a muscle,|| and transmits a nerve.¶ Below the notch there is another prominence, called the *anterior inferior spinous process of the ilium*, to which a tendon** is attached. Below, and internal to this notch, appears a wide shallow *groove*, over which a tendon†† slides. This groove is bounded internally by a rough eminence, called the *ilio-pectineal eminence*, which indicates the junction of the pubes and the ilium, and gives insertion to a muscle.‡‡ Further inward is the smooth, triangular, upper surface of the body of the pubes, wider externally than internally, and limited behind by a sharp edge, which forms the pubic portion of the *linea ilio-pectinea*. (209) At the inner end of this surface is seen a short horizontal ridge, which attaches several muscles,§§ and is called the *crest of the pubes*. This ridge terminates

* *Outer lip*. Obliquus externus abdominis in front, latissimus dorsi behind, fascia lata in its whole length. *Inner lip*. Transversalis abdominis in front, quadratus lumborum behind. *Interval between the lips*. Obliquus internus in front, erector spinæ behind.

† Tensor vaginæ femoris, and part of sartorius. ‡ Poupart's.

§ Long and short sacro-iliac. || Sartorius. ¶ External cutaneous.

** Straight tendon of rectus (the external tendon of which is attached to some irregularities just above the acetabulum).

†† United tendon of iliacus internus, and psoas magnus.

‡‡ Psoas parvus.

§§ Rectus abdominis, and pyramidalis, also part of obliquus internus, and transversalis.

internally at the *angle of the pubes* (formed by the junction of the body and the ramus), and externally at a tubercle, called the *spine of the pubes*, which projects forward, and gives attachment to a ligament.* *Inferior.* Extends from the angle of the pubes to the tuberosity of the ischium. Its upper third is vertical, and presents an oval, uneven surface, which is united to the similar surface of the opposite bone, by the intervention of a fibro-cartilage, forming the articulation called the *symphysis pubis.* This articular surface often presents eight or nine transverse ridges, separated by grooves. In a few specimens I have observed, instead of ridges, a series of nipple-shaped eminences, regularly arranged in horizontal rows, of three or four each. This curious structure, which anatomical writers have not hitherto described, is doubtless intended to enable the interpubic fibro-cartilage, by sending in its fibres between those mastoid tubercles, to take a firmer hold of the bone. The remainder of the inferior margin slopes downward and outward, and forms with the corresponding margin of the opposite bone, the *pubic arch.* This margin is nearly straight in the male; in the female it is concave, more obliquely placed, and turned somewhat forward, so as to present a smooth surface, rather than a sharp edge towards the pubic interval. This border attaches, superiorly a muscle,† inferiorly a part of the organs of generation.‡ *Posterior.* This border extends from the posterior superior spinous process of the ilium to the tuberosity of the ischium. It is exceedingly uneven. It presents, immediately below the *posterior superior spinous process of the ilium*, a small *notch;* and below this again, a small thin eminence, called the *posterior inferior spinous process of the ilium.* Below this is a very large deep notch, called the *great sciatic notch*, which transmits a muscle,§ nerves,‖ and vessels,‖ and contributes to form what the student will hereafter know as the *great sciatic hole.* This notch is bounded below by a sharp triangular eminence, called the *spinous process of the ischium.* It is directed downward, backward, and inward, and gives attachment to muscles¶ and ligaments.** Beneath this process is ob-

* Poupart's. † Gracilis.
‡ Crus and erector, *penis* in the male, *clitoridis* in the female.
§ Pyriformis. ‖ Glutæal, sciatic, and internal pudic.
¶ Gemellus superior, levator ani, and ischio-coccygeus.
** Lesser sacro-sciatic.

served the *lesser sciatic notch*, a smooth depression, over which a tendon* turns; it is covered, in the recent state, with cartilage, and contributes to form the lesser sciatic foramen. Below this notch there is a broad rough eminence, situated at the junction of the posterior and inferior borders, and called the *tuberosity of the ischium.* This tuberosity, like the crest of the ilium, has two lips, and an intermediate rough surface, each giving attachment to muscles.† The inner lip of the tuberosity, and the corresponding edge of the ascending ramus of the ischium, project backward a little into the cavity of the pelvis, so as to form a slight groove, which is deepened in the recent subject by a ligament,‡ and lodges important vessels and nerves.§ The tuberosity of the ischium forms the lowest angle of the os innominatum, and is the part upon which we rest in sitting.

209. SURFACES. *Interior* or *Pelvic.* Presents, posteriorly, some rough depressions for the insertion of ligaments,‖ and, in front of these, a semilunar surface, which articulates with the auricular surface of the sacrum. The remainder of this aspect is divided into two portions by a curved line, which runs forward from the articular surface just mentioned to the spine of the pubes. This is the *linea ilio-pectinea.* That part of it which belongs to the ilium is rounded, but the pubic portion is very sharp, and gives attachment to two muscles¶ and a ligament.** Above this line there is a smooth, concave surface, directed forward, upward, and inward, perforated near the middle by the foramen for the medullary artery, and filled in the recent state by a large muscle.†† It is called the *internal iliac fossa*, or *venter of the ilium*, and, as we shall afterwards see, belongs to the false pelvis. Below the linea ilio-pectinea we find, posteriorly, a smooth concave surface, covered, in the recent subject, by two muscles;‡‡ and, in front of this, the *obturator foramen.* This hole is large, and of an oval shape, in the male;

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* That of the obturator internus.

† *Outer lip.* Quadratus, and adductor magnus. *Inner lip.* Inferior gemellus, and transversalis perinæi muscles, and great sacro-sciatic ligament. *Intermediate surface.* Long head of biceps, semitendinosus, and semimembranosus.

‡ A process of the greater sacro-sciatic ligament.

§ Pudic.

‖ Sacro-sciatic.

¶ Pectineus, and part of psoas parvus.

** Gimbernat's.

†† Iliacus internus.

‡‡ Obturator internus, and levator ani.

smaller, and triangular, with rounded angles, in the female. It has a thin, uneven circumference, interrupted at the upper and outer part by a groove, called the *groove of the obturator foramen*, which passes from the interior of the pelvis, forward, inward, and a little downward, and serves to transmit vessels and a nerve.* The greatest diameter of the obturator hole is directed downward and outward. In the recent subject it is closed by a fibrous membrane, except at the groove. Each surface of the membrane gives attachment to a muscle.† The obturator foramen is bounded, above, by the body of the pubes; below and externally, by the body of the ischium; internally, by the united rami of the ischium and pubes. *Exterior.* The posterior and upper part of this surface looks *backward*, downward, and outward: while its anterior and inferior portion is directed *forward*, downward, and outward. Posteriorly, it presents the smooth, external surface of the ilium, which undulates, so as to be concave behind, and slightly convex in front. This surface, which is called the *dorsum of the ilium*, or the *external iliac fossa*, is traversed by three curved lines, called the *superior*, *middle*, and *inferior*, *semicircular lines of the ilium*. The *superior semicircular line* commences at the crest of the ilium, two inches in front of its posterior extremity, and runs downward, to terminate at the back part of the great sciatic notch, just in front of the posterior inferior spinous process. Its upper extremity is well marked, but it becomes indistinct, often quite imperceptible, below. Between this line and the outer lip of the crest, lies a narrow rough surface, which gives attachment to part of a large muscle.‡ The *middle semicircular line* is the longest and most distinctly marked of the three. It commences at the crest of the ilium, two inches behind the anterior superior spinous process, and runs from thence backward and downward, to terminate at the posterior part of the great sciatic notch. The *inferior semicircular line* commences at the anterior inferior spinous process, or at the notch just above it, and runs from thence backward and downward to the anterior part of the great sciatic notch. These

* Obturator vessels and nerve.

† The posterior surface to the obturator internus. The anterior surface to the obturator externus.

‡ Glutæus maximus.

lines give origin to the aponeurotic fibres of three muscles, and the intervening surfaces give origin to their fleshy fibres.*

Proceeding downward and forward from the iliac fossa, we come to the *cotyloid cavity*, or *acetabulum*, a hemispherical, articular excavation, about two inches and a half in diameter, directed downward, outward, and forward, covered with cartilage, except at a large rough depression at the bottom, and circumscribed by a prominent uneven margin, which is interrupted internally by a deep notch, called the *cotyloid notch*. This cavity is articulated with the head of the femur. Its circumference supports a fibro-cartilaginous brim, which deepens the cavity, and contracts its orifice. The *cotyloid notch* gives attachment, by its borders, to the inter-articular ligament:† it is converted into a hole by the fibro-cartilage of the brim, which stretches across it like a bridge. The hole thus formed transmits nutrient vessels into the joint. The non-articular depression extends from the cotyloid notch to the centre of the cavity. It presents several nutrient foramina, and lodges a fatty substance,‡ the use of which is unknown. The acetabulum is formed in front by the pubes, below by the ischium, and above by the

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* The glutæus maximus is attached to the upper curved line, and to the small surface between it and the crest of the ilium. The glutæus medius is attached to the middle curved line, and to the surface between it and the upper curved line. The glutæus minimus arises from the inferior curved line, and from the surface between it and the middle curved line. The surface between the lower curved line and the acetabulum, is covered by the glutæus minimus, but does not give origin to its fibres. Of these three curved lines, the French anatomists in general recognise only the two upper; while the English anatomists, on the contrary, usually describe only the two lower. What we have here described as the *middle* line, is called the *lower* by Cloquet and Cruveilhier, and the *upper* by Quain. To increase the ambiguity thus created, the upper and middle lines have sometimes both been described as superior, in different parts of the same work (compare, for instance, pages 230 and 232 of the *Dublin Dissector*). These discrepancies are of no great importance in themselves, but they are likely to mislead the student as to the attachment of the glutæal muscles; for which reason it is that they are here pointed out.

† Ligamentum teres.

‡ One of the so-called glands of Havers. (The nature of these fatty bodies is still a matter of dispute. Their glandular structure, which is denied by Béclard, and by most other modern physiologists, has been lately reasserted by Heyligers.)

ilium; the pubes contributing one-fifth, the ischium a little more than two-fifths, the ilium a little less than two-fifths, to the entire dimensions of the cavity. Above the acetabulum is a rough impression, indicating the attachment of a tendon.* To its inner side is the obturator foramen, already described. Below the obturator foramen appear the *outer surface*, and the *tuberosity*, of the ischium; and between the tuberosity and the margin of the acetabulum, there is a smooth horizontal groove, in which a tendon† glides. To the inner side of the obturator foramen, is the anterior surface of the united rami of the ischium and pubes, wider above and below than in the middle, where it presents a rough, horizontal ridge, indicating the junction of these originally separate portions of bone.

This surface gives attachment to muscles.‡ Above the obturator foramen is the triangular anterior surface of the body of the pubes, limited *internally* by the *spine* and *crest* of the pubes; *externally* by the ilio-pectineal eminence; *behind* by the posterior border of the pubes (which forms the pubic portion of the linea ilio-pectinea); *in front* by the anterior border of the pubes, which extends from the spine of the pubes to the upper border of the cotyloid notch, and forms the anterior lip of the groove of the obtuator foramen.

210. STRUCTURE. Of loose reticular tissue, enclosed between two compact layers. At the centre of the iliac fossa, and at the bottom of the acetabulum, the bone is thin, semi-transparent, and composed entirely of compact tissue. In the neighbourhood of the acetabulum, at the tuberosity of the ischium, and indeed at all the thicker parts, the bone is perforated with many large nutrient foramina. DEVELOPMENT. The ilium, ischium, and pubes, are each developed by a separate point. The crest of the ilium, the tuberosity of the ischium, the anterior inferior spinous process of the ilium, and sometimes the angle of the pubes, are developed as epiphyses, each by a separate centre of ossification. (The epiphysis of the tuberosity of the ischium extends also along the inner border of its ascending ramus.)

Besides these seven ossific points, M. Serres has

* The external curved tendon of the rectus femoris.

† That of the obturator externus.

‡ Adductor longus above, adductor brevis in the middle, adductor magnus below.

described one for a portion of bone which fills up the Y-shaped interval between the ilium, ischium, and pubes, at the bottom of the acetabulum. The ilium, ischium, and pubes, unite about 14 or 15 years after birth. The epiphyses, up to that age cartilaginous, then begin to ossify, and successively unite with the bone; generally at 22, but sometimes not till 25 years after birth, the consolidation of the innominatum is complete. ARTICULATIONS. With the sacrum, the femur, and its fellow of the opposite side.

OF THE PELVIS IN GENERAL.

211. The four bones which we have just described form, by their union, a large, bason-like cavity, open above and below, situated in an inclined position between the spine and lower extremities, and divided by the linea innominata into a superior, expanded portion, called the *false pelvis*, and an inferior, narrow, deep cavity, called the *true pelvis.**

OF THE FALSE PELVIS.

212. The false pelvis has no anterior wall, but presents in front a wide gap, extending from the anterior superior spinous process of one os innominatum to the corresponding point on the opposite side. Its posterior wall is also deficient in the middle, opposite the sacro-vertebral angle. Its lateral walls are formed by the alæ of the ossa innominata. It presents for examination an interior and exterior *surface*, an upper and a lower *circumference*, and a *cavity*.

213. SURFACES. *Interior*. Presents, on each side, the *internal iliac fossa*, and posteriorly, in continuity with that fossa, the smooth, upper aspect of the *lateral mass* of the sacrum. These two parts together form a wide concave surface, traversed by the *sacro-iliac symphysis*, and directed inward, upward, and forward; by which obliquity it is adapted, partly to support the intestines, partly to throw their weight forward against the anterior

* In examining the pelvis detached from the skeleton, one is apt to place it in a horizontal position, resting on the coccyx and the tuberosities of the ischia. It is better to retain it as nearly as possibly in its natural oblique position; so that the true inclination and aspect of its surfaces, &c., may be constantly present to the eye.

wall of the abdomen. This surface gives origin to a pair of large muscles.* *Exterior.* Presents on each side the *dorsum of the ilium,* alternately convex and concave, marked with the three *semicircular lines,* and affording attachment to several muscles.†

214. CIRCUMFERENCES. *Superior.* Formed chiefly by the *crest of the ilium,* which terminates in front at the *anterior superior spinous process.* Below this appears the *anterior inferior spinous process,* separated by a *notch* from the superior, and by a wide shallow *groove* from the *ileo-pectineal eminence.* This circumference attaches numerous muscles.‡ *Inferior.* Identical with the *brim* of the true pelvis, under which designation it will be described. (218)

215. CAVITY. When the false pelvis is completed in front by the abdominal muscles and fasciæ, it presents a wide shallow cavity, with its longest diameter transverse, and its axis directed obliquely from above downward and backward. In the skeleton this cavity is very imperfect; indeed it may be doubted whether a space lying between two lateral plates of bone, but having no definite boundaries before and behind, deserves the name of a *cavity*—still more, whether it has any ascertainable *axis.* Each iliac fossa supports a part of the alimentary tube,§ and the intervening space is filled with the convolutions of another portion of the same canal.‖

OF THE TRUE PELVIS.

216. The true pelvis is a smaller cavity than the false, but its osseous boundaries are more perfect. Its posterior

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* Iliaci interni; which arise from the internal iliac fossæ.

† Glutæus maximus, medius, and minimus, and curved tendon of rectus femoris. (For a particular account of the attachment of these muscles, see note *, page 166.)

‡ The crest gives attachment to the latissimus dorsi, the obliquus externus and internus, the transversalis, the quadratus lumborum, and the common commencement of sacro-lumbalis, longissimus dorsi, and spinalis dorsi, the anterior superior spinous process to the tensor vaginæ femoris, Poupart's ligament, and a few fibres of the sartorius; the notch beneath it to the sartorius; the anterior inferior spinous process to the straight tendon of the rectus; the ileo-pectineal eminence to the psoas parvus. The groove between the two last-mentioned eminences transmits the united tendon of the iliacus internus and psoas magnus.

§ The right iliac fossa supports the cæcum, the left the sigmoid flexure of the colon.

‖ The ileum.

wall is formed by the sacrum and coccyx, and is about five inches in depth. Its anterior wall in the median line corresponds to the symphysis pubis, and is not more than an inch and a half deep; it widens, however, on each side, where it is formed by the ischium and pubes, and presents the obturator foramen. Each lateral wall is formed by that portion of the ilium which lies below the linea ilio-pectinea, and has its extent diminished by a large and deep notch, called the *sacro-sciatic notch.* This notch belongs, in the skeleton, to the inferior outlet of the pelvis; but in the recent subject, it is separated from that aperture by a strong ligament, which stretches across from the sacrum to the tuberosity of the ischium, converting the notch into a hole, and considerably diminishing the extent of the outlet. The true pelvis presents for consideration two *surfaces,* two *circumferences* and a *cavity.*

217. SURFACES. *Interior.* Presents posteriorly the concave anterior surface of the sacrum and coccyx; on which are observed, in the median line, the *bodies* of the sacral and coccygeal vertebræ; external to these on each side the *anterior sacral foramina,* for the transmission of nerves;* and beyond these the anterior surface of the *lateral mass* of the sacrum, marked with shallow horizontal *grooves* for the reception of nerves,* and with slight *eminences* which separate the grooves, and give origin to the digitations of a muscle.† Immediately external to the sacrum is the *sacro-iliac symphysis.* Proceeding forward, we come to the lateral wall, scarcely an inch deep above the sacro-sciatic notch, where it belongs to the ilium, gradually widening in front of that notch, where it presents the roughened line of junction between the ilium and ischium. Passing to the anterior wall, we observe, in the median line, the *symphysis pubis:* external to this, the posterior surface of the united *rami* of the ischium and pubes, marked in the middle with the transverse *ridge* that indicates their union; and beyond these the *obturator foramen,* with its thin uneven circumference, interrupted above by a *groove* for the transmission of vessels and a nerve.‡ Above the obturator foramen is the posterior surface of the body of the pubes, wide at its inner extremity, gradually narrowing as it passes outward. External to the obturator foramen is a wide smooth surface,

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* Anterior sacral. † Pyriformis. ‡ Obturator.

belonging chiefly to the ischium, but completed above by the body of the pubes, and of the ilium. This surface corresponds to the back of the acetabulum, and often presents three roughened lines which indicate the union of the three portions of the os innominatum. It is covered in the recent subject by two muscles.*. Beneath the obturator foramen is a smooth surface belonging to the body of the ischium, and bounded below by the inner lip of the tuberosity. This lip, and the margin of the ramus with which it is continuous, project a little into the cavity of the pelvis, so as to form a slight groove, which, when deepened by a ligament† lodges important vessels and nerves.‡ The surface which surrounds the obturator foramen, and the membrane which closes that hole, give attachment to a muscle.§ *Exterior.* Presents, posteriorly, the convex uneven surface of the sacrum and coccyx, on which are observed, in the median line, the row of sacral spinous processes; below these, the *terminal groove* of the sacral canal, and the *posterior surface* of the coccyx. External to the spinous processes on each side is the *sacral groove*, continuous with the vertebral groove of the spinal column, and bounded externally by the tubercles, which represent the *transverse processes* of the sacral vertebræ. This groove is perforated by the *posterior sacral foramina* (for the transmission of nerves‖) and presents the coalesced *laminæ* of the sacral vertebræ, and the row of *articular processes;* the two uppermost well developed, and articulated to the last lumbar vertebra; the two lowermost (called the *horns of the sacrum*) prolonged downward to meet the ascending *horns of the coccyx;* the others mere rudimentary tubercles. On each side of the sacrum appears the posterior extremity of the *ala* of the ilium, projecting backward so as to form, with the lateral surface of the sacrum, a deep groove, filled in the recent subject with short strong ligaments¶ which hold the two bones together. Proceeding forward we observe, 1st, the *dorsum of the ilium*, of which only a small portion belongs to the true pelvis; 2ndly, the exterior surface of the *body of the ischium;* and thirdly, the *acetabulum*, with its prominent *circumference*, its *cotyloid notch*, and its central non-articular *depression.* Internal to the acetabulum is the *ob-*

* Levator ani, and obturator internus.

† A process of the great sacro-sciatic ligament.

‡ Internal pudic.

§ Obturator internus.

‖ Posterior branches of sacral.

¶ Posterior sacro-iliac.

turator foramen, bounded by the *bodies*, and *rami*, of the *ischium* and *pubes*. Below the acetabulum, and lying between its border and the tuberosity of the ischium, is a *groove* for the tendon of a muscle.* The exterior surface of the true pelvis gives attachment to several muscles.†

218. CIRCUMFERENCES. *Superior*. This circumference is usually called the *brim* of the true pelvis. It is formed by the ileo-pectineal line of the os innominatum, completed posteriorly by the rounded anterior border of the base of the sacrum, and by the sacro-vertebral angle; anteriorly by the *spine* and *crest* of the pubes. This circumference is traversed by the *pubic*, and *sacro-iliac symphyses*, and presents on each side the posterior extremity of the *ilio-pectineal eminence*. It affords attachment to several muscles and ligaments,‡ and circumscribes a space called the *abdominal strait*, or *inlet* of the true pelvis. This aperture would be oval, but for the sacro-vertebral angle, which projects forward posteriorly, so as to render it kidney-shaped. It has four principal diameters; an *antero-posterior*, measured from the sacro-vertebral angle to the symphysis pubis; a *transverse*, carried across so as to indicate its greatest width; and two *oblique*, each passing from one ileo-pectineal eminence to the sacro-iliac symphysis on the opposite side. Of these diameters the transverse is the most considerable, the oblique the next in length, and the antero-posterior the shortest. *Inferior*. This circumference presents three eminences, separated by three deep notches. Of the eminences, one is posterior, and formed by the sacrum and coccyx; the other two are lateral, and formed by the two ischia. At the summit of the first eminence is seen the extremity of the coccyx; at the summits of the two latter are the broad, rough tuberosities of the ischia. Of the notches, one is anterior and angular, bounded on each side by the rami of the ischium and pubes, and above by the symphysis pubis. This is called the *pubic arch*. The other two are lateral and curved, formed by the sacrum and

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* Obturator externus.

† By the sacrum it gives attachment to the sacro-lumbalis, latissimus and longissimus dorsi, and glutæus maximus; by the ilium to the glutæus maximus, medius, and minimus; by the anterior surface of pubes and ischium, to the obturator externus, gracilis, adductor brevis, longus, and magnus.

‡ By the linea ileo-pectinea to the levator ani, psoas parvus, and pectineus muscles, and to Gimbernat's ligament. By the spine of the pubes to Poupart's ligament, and by the crest of the pubes to the rectus, and pyramidalis abdominis.

coccyx behind, by the ichium in front, and by the ilium above. They are called the *sacro-sciatic notches.* Each is subdivided by the spine of the ischium into two parts: a superior, larger, called the *greater sacro-sciatic notch;* an inferior, comparatively inconsiderable, called the *lesser sacro-sciatic notch.* The margins of these sacro-sciatic notches are thin; the margin of the pubic arch is thicker, and deflected a little outward. This irregular circumference gives attachment to several muscles and ligaments,* and encompasses a space called the *perinæal strait*, or *outlet*, of the true pelvis. This space is measured, in the skeleton, by only two diameters, an *antero-posterior*, drawn from the tip of the coccyx to the symphysis pubis; a *transverse*, carried from one ischiatic tuberosity to the other. In the recent subject, the perinæal strait is considerably altered in shape and dimensions, by the presence of the sacro-sciatic ligaments, which, extending from the sacrum and coccyx to the tuberosity of each ischium, furnish two straight margins for its posterior boundaries, instead of the deep, sacro-sciatic notches. The lozenge-shaped aperture thus formed is measured by four diameters; an *antero-posterior*, and a *transverse*, the same as those described above; and two *oblique*, each carried from the tuberosity of the ischium on one side, to the centre of the great sacro-sciatic ligament on the other. Of these diameters, the oblique and the transverse are about equal. The antero-posterior varies with the length and direction of the coccyx, which differ considerably in different individuals; it is also susceptible of increase and diminution, on account of the mobility of the coccyx. In the recent subject, the perinæal is smaller than the abdominal strait.

219. CAVITY. The cavity of the true pelvis, or the *pelvic excavation*, is deep posteriorly, where it is bounded by the sacro-coccygeal column, but very shallow in front,

* The sphincter and levatores ani are attached to the tip of the coccyx; the ischio-coccygei to the spine of each ischium, and to the lateral borders of the coccyx; the gemellus superior and levator ani to the spine of the ischium; the gemellus inferior, semi-tendinosus, semi-membranosus, long head of biceps, quadratus femoris, and lower fibres of adductor magnus, to the tuberosity of the ischium; the crus and erector, *penis* in the male, *clitoridis*, in the female, to the ramus of the ischium and pubes. The sacro-sciatic ligaments are attached, posteriorly, to the lateral border of the sacrum and coccyx; the greater taking hold, in front, of the *tuberosity*, the lesser of the *spine*, of the ischium.

where it corresponds to the symphysis pubis. The sacro-coccygeal column, bending forward at its extremities, contracts the apertures of the true pelvis, and renders its cavity less capacious above and below than in the middle. The lower part of the excavation is still further diminished by the inclination of the walls of the pelvis, which slope towards each other from above downward. The two apertures, or *straits*, of the true pelvis are inclined in different directions. The axis of the upper, or abdominal strait (*i.e.* a line passing at right angles through the centre of its plane), if continued downward, would fall upon the lower third of the sacrum; the axis of the lower, or perinæal strait, if prolonged upward, would fall on the sacro-vertebral angle, intersecting the former in the middle of the cavity. To convey the same fact otherwise, —if the planes of the two straits were continued forward till they met, they would form an acute angle, with the apex directed forward. A brief description of this cavity might run thus;—the pelvic excavation is a short canal, more capacious above than below, and in the middle than at its extremities, curved, so as to present a convexity backward, and cut off very obliquely above and below, so that its posterior boundary is many times longer than the wall by which it is limited in front.

The true pelvis is occupied, in the recent subject, by the urinary bladder, by the rectum, and by a portion of the organs of generation. The rectum corresponds to the anterior surface of the sacro-coccygeal column, the curvature of which it follows. The bladder lies in the anterior part of the cavity, close behind the symphysis pubis. In the female the womb intervenes, being suspended in the midst of the pelvis, in contact with the bladder anteriorly, and with the rectum behind. The passage which leads to the womb, and through which alone its contents can be discharged, passes through the lower strait of the pelvis; through which strait, therefore, the fœtus must necessarily descend, in parturition. The female pelvis is adapted to the performance of this important function, by certain peculiarities of form and size, an account of which will be found in the following section.

DIFFERENTIAL CHARACTERS OF THE MALE AND FEMALE PELVIS.

220. The male pelvis presents a narrow, deep excavation, with small apertures. Its bones are thick, its mus-

cular impressions are well marked, its angles are abrupt and prominent, and its general appearance is that of a strong framework, adapted to afford leverage to powerful muscles.

The female pelvis is not so deep as that of the male, but exceeds it considerably in the transverse, and antero-posterior dimensions. Its cavity is more capacious, its apertures are larger, its walls, are less massive and rough, its general contour is less angular and abrupt. The alæ of the ossa innominata spread further outward; the anterior superior spinous processes are removed to a greater distance from the median line, as also are the tuberosities of the ischium, and the acetabula; (whence the prominence of the hip in the female.) The sacrum is wider and less curved, and, consequently, the sacro-vertebral angle less prominent, than in the male. The obturator foramen is somewhat triangular in form, and of a smaller size than in the male; the ischiatic spines project less into the pelvic excavation; the coccyx is more movable;* the symphysis pubis not so deep. The upper aperture is more nearly circular, and its margin smoother, and more rounded. The pubic arch is wider and more curved; and its rami are everted, so as to present shelving surfaces, rather than angular edges, to any object descending through the perineal strait. By these several peculiarities of form and structure, the female pelvis is adapted to permit the expansion of the uterus during pregnancy, and the passage of the child in parturition. The following table of the average comparative dimensions of the male and female pelvis, according to the various estimates of Meckel, Cloquet, and Burns, is taken from Quain's Anatomy.

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* The joints of the female pelvis acquire an increased mobility during the last months of gestation; the symphysis pubis, and the articulations of the coccyx, are especially relaxed. This change is at first temporary, but after frequent childbearing it becomes permanent. The same cause is said to induce occasionally an actual alteration of structure. Of this a very remarkable example has been noticed by Cruveilhier, in the pelvis of an aged female, who had borne nineteen children. In this instance the articular surfaces of the symphysis pubis had come into contact, and the inferior ligament had disappeared; while a fibrous capsule of great strength surrounded the joint on all sides, except behind, and permitted a very considerable motion.

DIMENSIONS OF THE PELVIS.

		MECKEL.				CLOQUET.		BURNS.	
		MALE.		FEMALE.		FEMALE.		FEMALE.	
		Inch.	Lines.	Inch.	Lines.	Inch.	Lines.	Inch.	Lines.
Between the anterior superior spinous processes of the ilia		7	8	8	6	10	0	10	0
Between the middle points of the cristæ of the ilia		8	3	9	4	11	1	11	1
The transverse diameter	of the abdominal strait of the true pelvis.	4	6	5	0	5	6	5	6
The oblique	of the abdominal strait of the true pelvis.	4	5	4	5	4	7	5	5
The antero-posterior	of the abdominal strait of the true pelvis.	4	0	4	4	4	4	4	0
The transverse diameter	of the cavity of the true pelvis.	4	0	4	8				
The oblique	of the cavity of the true pelvis.	5	0	5	4				
The antero-posterior	of the cavity of the true pelvis.	5	0	4	8				
The transverse	of the perineal strait of the true pelvis.	3	0	4	5	4	4	4	0
The antero-posterior	of the perineal strait of the true pelvis.	3	3	4	4	4	4	4	0

The last may be increased to 5 inches, in consequence of the mobility of the coccyx.

221. DEVELOPMENT. The fœtal pelvis is smaller in proportion than that of the adult. Its lesser basin is especially diminutive, in accordance with the rudimentary condition of the organs of generation which it contains. The alæ of the ossa innominata are quite flat. The sacrum, and the pubic region, are very narrow; so that the transverse diameters are shorter, in proportion, than the antero-posterior.

INCLINATION OF THE PELVIS.

		In the adult male.	In the adult female.	In the "not full-grown" *unausgewachsen* (sex and precise age not specified).
A vertical line passing through both ends of the column of true vertebræ forms,	With the antero-posterior diameter of the upper strait (measured from the promontory to the upper border of the symphysis pubis) an angle of	155°	150°	154° 66
	With the antero-posterior diameter of the lower strait (measured from the tip of the coccyx to the lower border of the symphysis pubis) an angle of . .	106°51	101°	

N.B. The inclined line of each strait, falling upon the vertical line of the spine, of course forms with it *two* angles—an upper and a lower. It is the former which Naegele and Weber always mean when they speak of the "neigungswinkel" (angle of inclination) of the strait, and to which the measurements in the above Table apply.

Lastly, the fœtal pelvis is inclined more obliquely on the vertebral column, than that of the adult. During the interval between birth and puberty, these peculiarities gradually disappear, and the pelvis acquires the shape, size, and position proper to adult age. The preceding Table exhibits the inclination of the pelvis, in the opposite sexes, and at different periods of life. The second column (gathered from Naegele's work, *Ueber das Weibliche Becken*, Carlsruhe, 1825) is the average of numerous and accurate measurements. The first and last columns are taken from a treatise entitled, *Mechanik der Menschlichen Gehwerkzeuge*, recently published by the brothers Weber.

One of the methods employed by these anatomists (described at page 128 of their work), appears to me objectionable; and their recorded observations are too few to furnish correct averages. Nevertheless, from their experiments, and from those of Naegele, we may safely draw this general conclusion; that the deviation of 35° from the horizontal plane, assigned by Cloquet, and others, to the pelvis, is too little by at least 30°.

222. MECHANISM AND USES. The uses of the pelvis, as a cavity for the reception of certain viscera, a fulcrum for the spine and lower extremities, and a centre of action to many powerful muscles, have been noticed incidentally in the course of the foregoing description. It may be further observed that the inclined position of this bony girdle adapts it to reduce the force of concussions transmitted upward from the feet, and that the oblique direction of the sacrum, which runs downward and backward from the base of the vertebral column, causes the inertia of the trunk, when the body is carried forward by a sudden spring, to tell upon the surfaces of the sacrolumbar articulation, instead of straining its ligaments, as would certainly happen if the joint were horizontal.*

* A further distribution of the resistance of inertia in the action of springing forward, results from the curvature of the lower part of the vertebral column, which instead of rising vertically from the sacrum, inclines obliquely forward and upward; so that the strain of the leap, which would otherwise fall almost exclusively on the last joint of the column, is divided between, at least, four of its lower articulations. This point has been well elucidated by Mayo, in the 11th chapter of his "Outlines of Physiology;" which chapter I take this opportunity of recommending to the student, as a most admirably written and instructive sketch of the mechanism of the skeleton. It is one of that author's ablest performances, and, in my opinion, a model of philosophical composition; in which character alone it would well repay a frequent perusal.

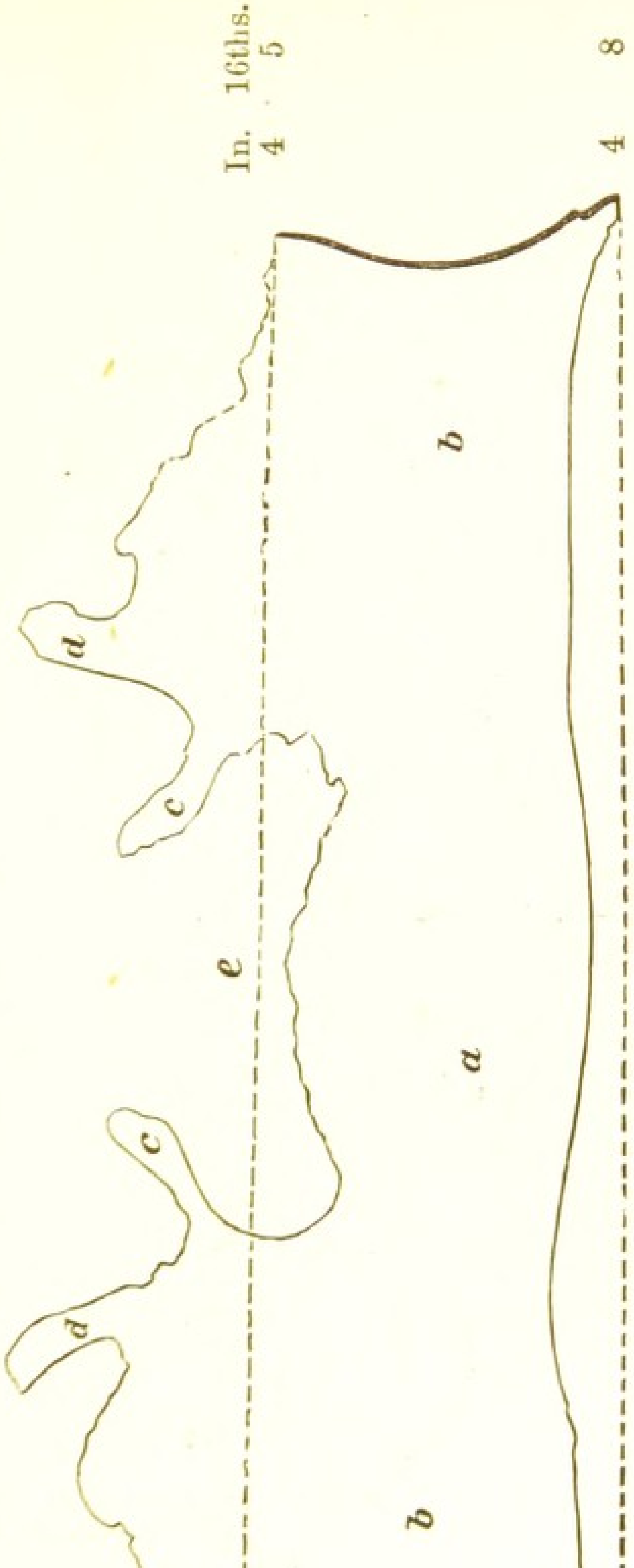
The student should also particularly notice the strong, prismatic thickening in the substance of the os innominatum, which extends, on each side, from the sacro-iliac symphysis to the top of the acetabulum. These two bony columns are the immediate supporters of the sacrum, which divides equally between them the weight of the superincumbent trunk. This pressure they transmit to the vaulted roof of either acetabulum, from which again it is transferred to the heads of the thigh-bones. The purpose of these two ribs, which are the thickest and strongest parts of the ossa innominata, is rendered the more obvious by the striking contrast which exists between their thickness and that of the bone in their immediate neighbourhood. While they are prisms of nearly an inch in diameter, the ilium, within half an inch above them, becomes as thin as paper, and semi-transparent.

These groinings, and inclined articulations, which occur in the pelvis, along the line of transmission of force, furnish a good illustration of the two principal laws which prevail throughout the structure of the skeleton—viz., first, That accumulation of osseous matter indicates, and is proportionate to, *pressure to be sustained*. Secondly, That frequency and obliquity of joints indicate, and are proportionate to, *concussion to be distributed*.

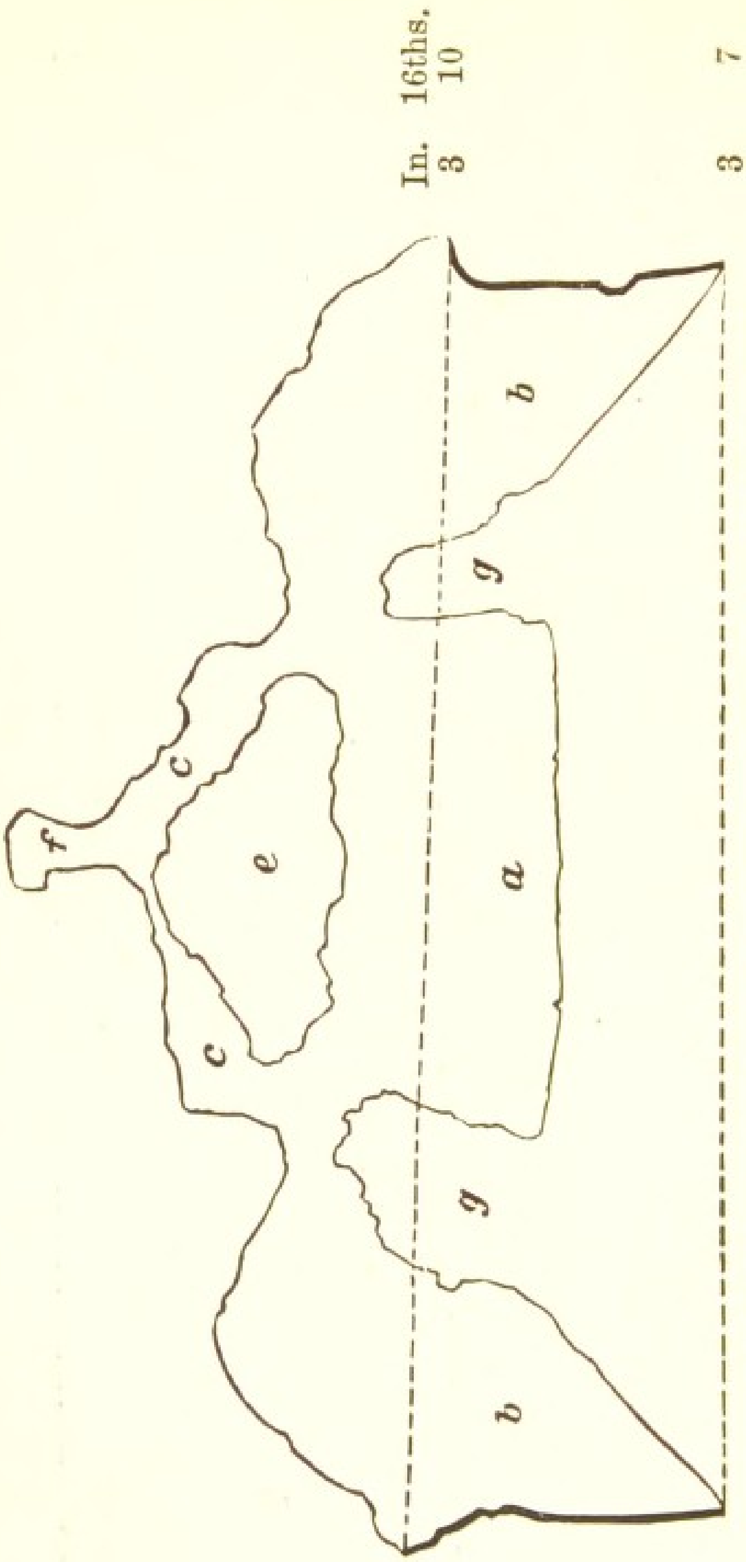
The double wedge-like shape of the sacrum is a feature in the mechanism of the pelvis which has been noticed by several anatomists. Cruveilhier has pointed out, with his usual accuracy and clearness, the effect of that form in preventing the displacement of the bone by any force acting, either from above downward, or from before backward. For the bone is larger above than below, and is also (with certain exceptions, which will presently be stated) wider before than behind. But Cruveilhier appears to me to have fallen into error, when he goes on to state, that the provisions for preventing this bone from being driven forward, are but slight; that the powerful apparatus of posterior-sacro-iliac ligamentous fibres can only tend to resist the backward dislocation, and that the space between the ilia is, in its whole length, larger before than behind; "*double disposition*" (as he states, in conclusion) "*évidemment propre à favoriser le déplacement du sacrum à la partie antérieure.*" ("Anatomie Descriptive," vol. i. p. 454.) The facts, and the conclusion, here advanced, are not in accordance with my own observations; which have satisfied me, on the contrary, that both the form of the sacrum, and the disposition of its posterior ligaments, are calculated very strongly to resist the anterior dislocation—against which the bone is further defended by the shape and position of the alæ of the ilia. I shall offer a few remarks on each of these points in succession.

And first, with regard to the form of the sacrum. Although it is true that, at the upper extremity of the bone, the anterior surface is usually two or three-eighths of an inch wider than the posterior, yet, upon dividing the bone by a section, parallel with the plane of the upper strait of the pelvis, and at about an inch and a half below its superior extremity (in other words, opposite to about the middle of the auricular surface), I have generally found these proportions reversed, the posterior surface being here wider than the anterior, sometimes as much as half an inch, or even five-eighths,* seldom less than one-eighth. Half an inch lower down, the anterior surface resumes the superiority in width. These changes of proportion are illustrated in the annexed diagram, which represents three sections of the same sacrum: the first taken just below its upper extremity, the second three-fourths of an inch lower down, and the third half an inch below the second. In the first and third, the base of the wedge is turned forward; in the second, it is obviously directed backward. The figures are of the natural size; and the exact points from which the measurements have been taken, are indicated by transverse lines, against each of which its length, in inches and sixteenths of an inch, has been set. The letters, which are the same in all the figures, refer to the explanation appended to the diagram. In examining a large number of sacra, with a view to this particular point, I have found the form above described to be a general rule, liable to many individual exceptions. Thus, in some instances, the back and front of the sacrum have been nearly equal in width, in the whole length of the auricular surface. In other specimens the anterior surface has been wider, for the same distance, than the posterior; or, *vice versâ*, the posterior has, more or less, exceeded the anterior in width. But these exceptions, so far from throwing doubt on the rule here laid down, have rather afforded it an indirect

* I have seen but one specimen (in the collection of Professor Partridge) in which the difference amounted to five-eighths. The average difference is between an eighth and a quarter of an inch.

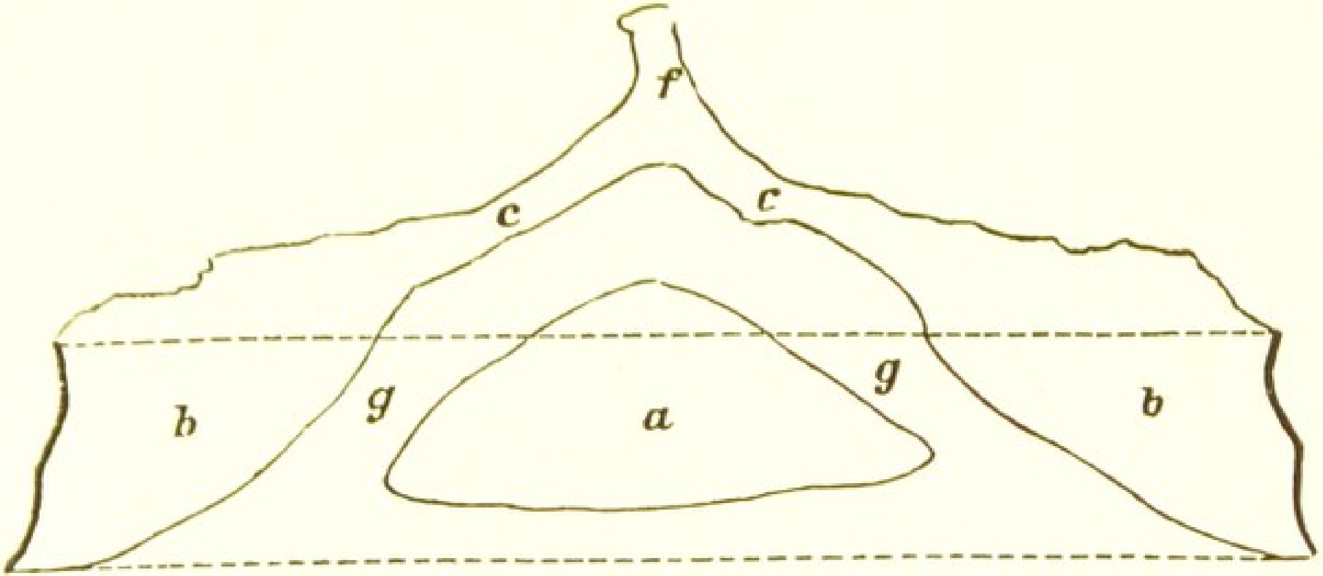


FIRST SECTION.



SECOND SECTION.

THIRD SECTION.



In.	16ths:
3	5
3	9

a Body.
b b lateral masses.
c c laminæ.
d d articular processes.

e sacral canal.
f spinous process.
g g anterior sacral foramina.

N.B.—The extent of the auricular surface is indicated in each figure by the lateral thickened lines.

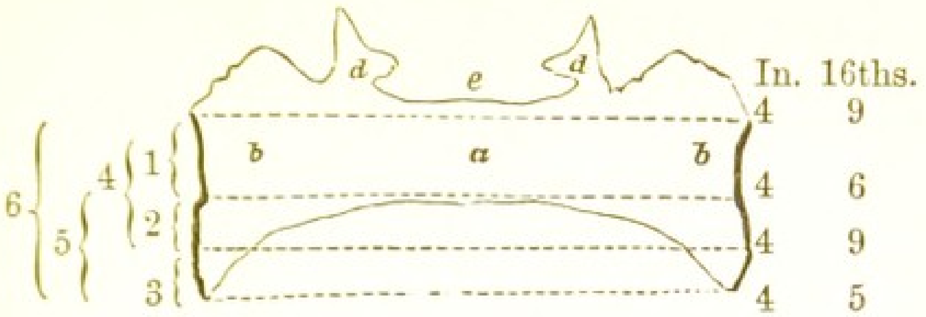
corroboration. For those sacra which have not presented the ordinary changes of proportion, have invariably possessed some compensating peculiarity of form, calculated to produce a similar result. Some, for instance, have presented a strong angle, projecting from each auricular surface, and fitting into a corresponding depression on the articular surface of the ilium; or, on the contrary, a depression in the auricular surface, adapted to an eminence of the os innominatum. Not unfrequently the sacrum has presented, opposite the middle of its auricular surface, a general contraction in the transverse dimension, obviously tending to resist dislocation in every sense—whether upward, downward, forward, backward, or in any intermediate direction. In other specimens, the auricular surface has exhibited, on a transverse section, a series of undulations, all at the same horizontal level, and disposed in such a manner as to resist, alternately, the anterior and posterior dislocation. I have not space for sketches of all these varieties: but I will take the last mentioned, as one of the most remarkable, for illustration.

The annexed diagram (to which the explanation of the former is applicable) represents, on a reduced scale, three horizontal sections of a sacrum, wider behind than before in the whole length of the auricular surface (as may be deduced from a comparison of the measurements annexed to each figure). The form of this specimen, taken as a whole, is only calculated to oppose the advance of the bone, and has no tendency to resist the posterior dislocation. But on comparing the four measurements of the first section, the bone will be found to consist, in this part, of three wedges, of which the anterior and posterior have their bases behind, and their narrow ends directed forward, while the intervening one presents a contrary disposition. The two former tend to resist the anterior, and the latter, the posterior dislocation. This arrangement sufficiently exemplifies the nature of the compensation allude l to above.

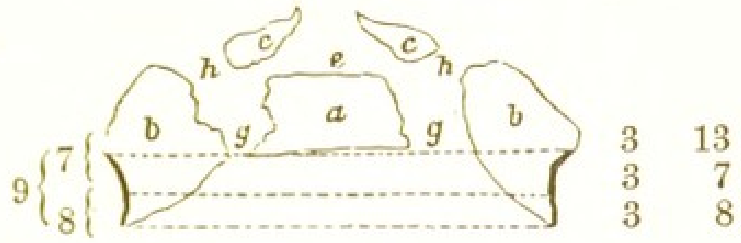
These facts compel me to dissent from Cruveilhier's opinion, so far as it relates to the *form* of the bone.

With regard to the posterior sacro-iliac ligaments, it is to be observed, that many of their fibres run obliquely forward and inward, from the ilium to the sacrum. These fibres must necessarily be stretched by the advance of the bone towards the cavity of the pelvis, and therefore can-

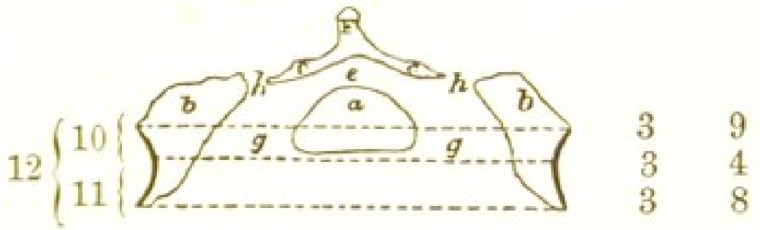
FIRST SECTION.



SECOND SECTION.



THIRD SECTION.



The numbered brackets indicate portions of the sacrum lying between the lines of measurement: and the annexed Table exhibits the respective tendencies of the portions so comprised. By adding the two last columns, we find that the total amount of resistance presented by these three sections is, to the anterior dislocation $=18$, to the posterior dislocation $=8$. N.B. The portions marked with an asterisk consist of two or more smaller portions; and their effect is, of course, only the sum, or the difference, of the effect of those smaller portions; for which reason it is not taken separately into the account.

No. 1	resists	anterior dislocation	by	3	
2	,,	posterior ,,	,,		3
3	,,	anterior ,,	,,	4	
*4	,,	*is neutral* ,,	,,		
*5	,,	anterior ,,	,,		
*6	,,	anterior ,,	,,		
7	,,	anterior ,,	,,	6	
8	,,	posterior ,,	,,		1
*9	,,	anterior ,,	,,		
10	,,	anterior ,,	,,	5	
11	,,	posterior ,,	,,		4
*12	,,	anterior ,,	,,		
				18	8

not fail to oppose its dislocation in that direction. In order to satisfy myself on this point, I tried the following experiment. I divided, in a recent pelvis, all the connexions between the sacrum and ossa innominata, except the posterior sacro-iliac ligaments; and then, having fixed the ossa innominata, endeavoured to draw the sacrum forward; but it resisted my strongest efforts. I then cut away part of the bone opposite the lower half of the sacro-iliac joint, in order that the wedge-like form of the sacrum might have no influence, either in promoting or preventing its advance; but it still resisted my entire force applied from behind, though now retained in its position solely by the posterior sacro-iliac ligaments. This experiment may be easily repeated, and it appears to me to afford conclusive evidence that these ligaments are not favourable to the anterior dislocation.

Looking, in the last place, to the form and position of these alæ of the ilia, we shall find them calculated to furnish the upper half of the sacrum with an additional protection against the anterior dislocation. Their posterior extremities, which are very strong and massive, extend backward nearly two inches from the sacro-iliac articulation, and project on each side, so as to sustain the force of many shocks, which would otherwise tell upon the posterior surface of the sacrum.

These several considerations lead me to think, that the anterior dislocation of the sacrum, so far from having been favoured by Nature, is quite as effectually guarded against as any other displacement to which the bone is liable. It is true, indeed, as Cruveilhier observes, in explanation of his opinion on this point, that the force which the sacrum habitually sustains (namely, the constant pressure of the trunk) tends always to thrust it downward and backward, and never, in any degree, towards the cavity of the pelvis. But, on the other hand, the external violence to which the sacrum is occasionally exposed, can operate only from behind, or from below, in no case from above or from before. And, if this bone, so well fortified against the constant strain to which it is exposed, had been left unprotected against dislocation by sudden shocks from without, it would present a strange exception to the watchful providence of Nature against accidental violence, which is exemplified in the structure of every part of the skeleton. It is indeed a remarkable reflection,—and one with which these observations may be not inappropriately concluded,—that contingencies which may occur but once in fifty years,—which may *never* happen to some individuals,—are yet as elaborately provided against by Nature, as those internal strains, and tendencies to displacement or rupture, which are in incessant operation throughout the whole period of life.

CHAPTER V.

OF THE EXTREMITIES.

223. THE extremities are long, jointed appendages of the body, attached by one end to the trunk, and free in the rest of their extent. They are four in number; an upper pair, depending from the thorax, chiefly subservient to tact and prehension; a lower pair, connected with the pelvis, the principal agents in support and locomotion. To these the transcendental anatomists add the lower jaw, which they regard as a pair of limbs, joined together at their distal ends, and otherwise considerably modified for the function of mastication: but, nevertheless, bearing precisely the same relation to the *cranial* division of the vertebral column, that the arms do to its *thoracic*, and the legs to its *pelvic* region. These analogies will be considered more in detail in our general review of the skeleton. In the present chapter we have only to describe the bones of each limb in succession; subjoining some brief observations on their mechanism and uses.

OF THE UPPER EXTREMITY.

224. The upper extremity is divided, by descriptive anatomists, into four parts: the *shoulder*, the *upper arm*, the *fore-arm*, and the *hand*. Of these parts only the three last are recognised, by the transcendental anatomists, as constituents of the upper extremity; the bones of the shoulder being referred by them to the costal series. (See note *, page 150). This latter appears to me to be the legitimate arrangement, the former being at variance with the obvious analogies of the bones. But I shall here, as elsewhere in this work, follow the ordinary system, for the sake of its practical convenience, having previously set the student on his guard against its theoretical errors.

OF THE SHOULDER.

225. The shoulder consists of two bones, the *scapula*, and the *clavicle*. The scapula is a flat bone, resting on the exterior surface of the thorax. The clavicle is a long bone, situated horizontally at the anterior part of the thorax, just above the first rib.

OF THE SCAPULA.

226. The scapula is a large, flat, thin bone, of triangular form, lying on the posterior and lateral wall of the thorax, between the first and seventh ribs. Taking a general survey of the scapula, the student will observe that it presents two surfaces, three borders, and three angles. Of the angles one is truncated, thickened, and hollowed, by a concave, articular surface, designed to receive the rounded head of the arm-bone. This surface is named the *glenoid cavity*, and the thickened angle on which it occurs, may be called the *head* of the scapula. This head is supported by a slightly contracted portion called the *neck;* and from the neck the thin, wide *ala* of the scapula expands. The ala is strengthened by its three thickened borders, which present the appearance of stout bony ribs, and are hence called the *costæ* of the scapula. The anterior surface is concave, lies upon the surface of the thorax, and is called the *venter* of the scapula. The posterior surface is convex, and derives from its backward aspect the name of *dorsum*. The dorsum is traversed by a strong horizontal process of bone, called the *spine* of the scapula. This eminence curves upward externally, and expands into a flattened extremity, named the *acromion process*, which projects forward so as to overarch the glenoid cavity. The spine and the acromion are the two principal processes of the scapula; there is a third, of smaller size, called the *coracoid process*, which arises from the upper border of the neck, and stretches forward, like the acromion, over the glenoid cavity.

From this rapid sketch of the principal objects presented by the scapula, and of their general relations to each other, we may proceed, in the next place, to examine more minutely, first, its *head* and *neck*, with the *coracoid process* which the neck supports; then its *borders* and *angles;* and lastly, its *surfaces*, ventral and dorsal, with the *spine*, and its *acromion process*, arising from the latter.

227. HEAD. The *head* is an expanded portion of bone, which occupies the external angle of the scapula, and supports the glenoid cavity.* The *glenoid cavity* is a wide, shallow, articular depression; of an ovoid shape, with its longest diameter directed from above downward and backward. It is wider below than above; and its outline presents a close resemblance to that of the longitudinal section of a pear. Its direction, or aspect, is outward, forward, and a little downward. Its margin gives attachment to a ligament,† and supports, in the recent subject, a fibro-cartilaginous brim, by which the cavity is deepened. A strong tendon‡ takes origin from its summit. The NECK is that contracted portion of bone which immediately supports the head. It is not separated by any definite boundary from the ala, into which it appears, as it were, to expand. Its contraction is more distinct behind than before, and below than at its upper part, where it supports the CORACOID PROCESS. This process has somewhat the appearance of a finger, half-bent, pointing forward and outward. It arises, by a strong wide root, from the upper border of the neck; extends, for a little way, upward and inward; and then, suddenly changing its direction, runs forward and outward, and passes, as we shall hereafter find, beneath the clavicle. The first, or ascending portion of the coracoid process, is

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* What we have here called the *head*, is usually described among the angles of the scapula, under the name of the *external* or *articular* angle. Such an association appears to me to be highly objectionable. For while the two other angles are entirely insignificant, being the mere incidental results of the junction of the borders, this articular expansion is, on the contrary, the essential element of the scapula, to which every other portion of the bone is obviously subordinate and accessory. It is to the muscles by which the *head* is moved, or maintained in its position, that the *costæ* afford leverage, and the *ala* an expanded insertion. The *acromion* and *coracoid* processes overarch and protect the *head;* the *spine* strengthens the scapula precisely opposite to its centre; and even in the depth and disposition of the *fossæ*, we shall presently discover a distinct adaptation to the functions of this portion of the bone. For these reasons we have placed it alone, and made it the starting point of our description; at the same time *enumerating* it among the angles, that the student may bear in mind the arrangement generally adopted.

† Capsular ligament of shoulder-joint.

‡ Long head of biceps.

flattened from before backward; it is smooth, and presents nothing remarkable for examination. The horizontal portion is much narrower, and flattened in a different direction;—viz., from above downward. Its upper surface is rough, and gives attachment to ligaments;* its inferior surface is smooth, and directed downward and backward towards the glenoid cavity, which it overhangs. The anterior margin of the process is rough, and gives insertion to a muscle.† Its posterior margin, likewise rough, attaches a ligament.‡ Its summit, rounded and tubercular, affords origin to two muscles.§ The *angle* which the two portions of the coracoid form by their junction, gives attachment to a ligament,|| to which we shall have occasion to revert, in describing the superior border of the scapula.

228. BORDERS OR COSTÆ. *External* or *axillary*, sometimes also called *inferior*. This is a stout, bony rib, extending from the head to the inferior angle of the bone. It is by far the thickest of the three costæ, but it gradually diminishes in thickness towards its lower extremity. Its upper third is full half an inch wide, and presents a shallow, oblong depression or groove, which attaches a large muscle.¶ Its middle third is also slightly grooved, in the longitudinal sense, and gives origin to part of a smaller muscle.** The lowest third presents an edge which attaches some fibres of another muscle.†† *Superior*. This is the shortest, and thinnest, of the three costæ. It extends from the coracoid process to the posterior-superior angle of the bone, attaches a muscle,‡‡ and presents, externally, a semicircular depression, called the *supra-scapular notch*. This notch is bounded on the outer side by the coracoid process; and the ligament which we have mentioned as being attached to the angle of that process, stretches across the notch, and converts it into a hole. Sometimes a slip of bone performs the office of this ligament; in which case there is a complete *supra-scapular foramen*, even in the dry bone. This hole gives passage to a nerve,§§ and occasionally also to vessels.§§ *Internal*, or *vertebral*. This border is often called

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* The conoid posteriorly, the trapezoid in front.

† Pectoralis minor. ‡ Coraco-acromion.

§ Coraco-brachialis internally, short head of biceps externally.

|| Supra-scapular.

¶ Long head of triceps. ** Teres minor. †† Teres major.

‡‡ Omo-hyoideus. §§ Supra-scapular.

the *base* of the scapula. It extends from the uppermost to the lowest angle of the bone. It is the longest of the borders, but, in thickness, intermediate between the other two. It is not straight, but presents, at the junction of its upper one-fourth with its lower three-fourths, an *obtuse angle*, the position of which should be borne in mind, as indicating the commencement of the spine of the scapula, and the limits of several muscular insertions. The base affords attachment to six muscles, of which one is attached to (what would be called, if this border were thicker) its *anterior* lip,* two to its *posterior* lip,† and three to the *interval*.‡

229. ANGLES. *Inferior.* Formed by the junction of the axillary and vertebral borders. It is thick and rough, constitutes the lowest point of the bone, and gives origin to a few fibres of two muscles.§ *Superior-anterior.* This angle is truncated, and occupied by that thickened eminence, which bears the glenoid cavity, and has already been described as the *head* of the bone. The grounds upon which we have distinguished this angle, by giving it a separate paragraph, and selecting it for the opening of our description, are stated in note *, page 189. *Superior-posterior.* Formed by the junction of the upper and vertebral borders. It is thin, rounded, and smooth, forms the highest point of the bone, and gives insertion to some fibres of a muscle.||

230. SURFACES. *Posterior* or *dorsum.* Convex from above downward, alternately convex and concave in the transverse direction. Divided into two unequal portions by the *spine of the scapula*, which projects backward and upward from it, at the line of junction between its upper fourth and its lower three-fourths. The surface above the spine belongs to the *fossa supra-spinata*; the surface below it, to the *fossa infra-spinata*. The *fossa supra-spinata* is smooth and concave, wider internally than externally, and filled in the recent state by a muscle,¶ the fibres of which are attached to its two internal thirds.

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* Serratus magnus.

† Some fibres of supra-spinatus, above the *obtuse angle*; of infra-spinatus, below that point.

‡ Levator anguli scapulæ, above the angle; rhomboideus minor, opposite the angle; rhomboideus major, below the angle.

§ Of the teres major, and (occasionally) of the latissimus dorsi.

|| Levator anguli scapulæ. ¶ Supra-spinatus.

The *infra-spinous fossa* is more than three times as large as the supra-spinous fossa; it presents, externally, a long, wide groove, which runs parallel to the axillary border; internal to that a convexity, running parallel to the groove, of which it forms the inner boundary; and again, internal and superior to this convexity, another, but less extensive concavity. This fossa is perforated by several nutrient foramina; it lodges a large muscle,* which is attached to its inner three-fourths, but only covers, without taking origin from, its outer fourth. The infra-spinous fossa does not extend quite to the axillary border, but is bounded externally by a rough line, which commences above, at the lower part of the head, and passes downward and backward to the vertebral border, which it joins about an inch above the inferior angle of the bone. This line attaches an intermuscular aponeurosis;† it cuts off a long surface, of which the upper two-thirds are narrow, and give attachment to a small muscle,‡ while the lower third is much wider, and roughened for the insertion of a larger muscle.§ The wide and the narrow portions of this surface are separated by a line which runs obliquely downward and backward from the axillary border, and attaches an intermuscular aponeurosis.|| This is sometimes called the *oblique line* of the scapula.

From the description of these fossæ we pass naturally to that of the *spine*, which serves as a sort of party-wall to separate them from each other.

THE SPINE OF THE SCAPULA is a strong, triangular plate of bone, whose apex is situated at the vertebral border of the scapula, just opposite its *obtuse angle* (228); whose base is placed externally, near the head of the bone; while of its sides, one is joined to the ala, the other, thick and free, gives attachment to muscles, and is called the *crest*. The spine does not extend quite across the dorsum, but stops short about half-an-inch from the head, leaving an interval through which the supra and infra-spinata fossæ communicate with each other. Its surfaces are not horizontal; the superior looks forward and inward, as well as upward, and the inferior has the contrary direction.

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* Infra-spinatus.

† Which separates the infra-spinatus muscle from the teres major and minor. ‡ Teres minor. § Teres major.

|| Which separates the teres major from the teres minor.

Both surfaces are slightly concave, perforated by one or two large nutrient foramina, wide near the head of the scapula, gradually narrowing as they approach the vertebral border. The *superior* surface contributes to the *fossa supra-spinata*, and attaches part of the muscle which that fossa receives.* The *inferior* surface contributes in like manner to the *fossa infra-spinata*, and gives origin to the upper fibres of the muscle therein contained.† The spine, being of a triangular shape, has necessarily *three borders*. Of these, one is anterior, one external, and the third posterior. We have already noticed them slightly, and with regard to the two former have little to add. The *anterior* border is attached to the dorsum, and forms the root of the process. The *external* border, short, thick, and rounded, is continuous, below with the neck, and above with the under surface of the acromion process; intermediately it is smooth and free. The *posterior* border, or *crest*, is wide, and presents two *lips*, separated by a rough *interval*. Each *lip* of the crest gives attachment to a muscle,‡ but the *interval* is subcutaneous. The lips approach each other, and the interval is narrow, in the middle of the crest, but they diverge from each other at its extremity, *externally*, to become continuous with the borders of the acromion; *internally*, to join the base of the scapula, with which they enclose a small, triangular, smooth surface, on which a tendon§ glides. It is from the angle formed by the junction of the *crest*, with the *external border* of the spine, that the *acromion process* springs. The ACROMION PROCESS is large and strong; it runs outward a little way, and then, forming an angle, directs itself forward and upward. It is flattened, like the spine, but in the opposite direction. If a plane were drawn parallel to the two surfaces of the acromion, and another parallel to the two surfaces of the spine, the two planes would cut each other nearly at right angles. Hence the upper surface of the acromion is continuous, not with the upper surface of the spine, but with the interval between the lips of the crest. The acromion is slightly curved, and overarches the glenoid cavity. Its upper surface is convex and uneven; it is directed upward, outward, and

* Supra-spinatus. † Infra-spinatus.

‡ The upper lip to the trapezius, the lower lip to the deltoid.

§ Of the trapezius.

backward, and lies immediately beneath the skin of the shoulder, of which it forms the summit. Its lower surface, which is smooth and concave, has an opposite direction. The external margin of the acromion is thick and tubercular, and attaches some fibres of a large muscle.* Its internal (or anterior) margin is concave, attaches part of a muscle,† and presents, near the summit of the process, an oval, concave, articular surface, directed inward, forward, and a little upward, for articulation with the extremity of the clavicle. (236) The tip of the acromion process is thin, and attaches a ligament.‡

Anterior surface, or *venter* of the scapula. This surface is chiefly occupied by a wide concavity, called the *fossa subscapularis*. This fossa, however, is separated from the posterior border by a long, plane surface, from a quarter to half an inch wide above, narrower below, still narrower, often altogether deficient, in the middle, and serving for the attachment of a large muscle.§ The *subscapular fossa* is traversed, in its two posterior thirds, by several rough lines, which pass from behind obliquely forward and upward. Its anterior third is quite smooth. The rough lines give origin to the tendinous intersections, and the intervening surfaces to the fleshy fibres of a large muscle, which is lodged in this fossa.|| The smooth anterior third of the fossa is covered by the muscle, but does not give origin to any of its fibres. (The extremity of the muscle passes beneath the coracoid process, which presents a smooth, concave surface, to permit its passage.)

The subscapular fossa presents, just at the level of the spine, a retiring angle, which may be called, from its position, the *subscapular angle*. As this angle has been hitherto overlooked by anatomists, or only noticed as a slight depression in the subscapular fossa,¶ I shall, in this place, endeavour to show that its depth is by no means inconsiderable, and that it serves an important purpose in the economy of the shoulder.

Fig. 1, in the annexed diagram, represents a sectional view of a human scapula, divided longitudinally, about midway between the vertebral and axillary borders. *a c*

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* Deltoid. † Trapezius. ‡ Coraco-acromion.
§ Serratus magnus. || Subscapularis.

¶ See, for instance, Meckel's Manuel d'Anatomie, tom. i. p. 704. "Elle offre seulement une légère dépression qui correspond à l'épine," &c.

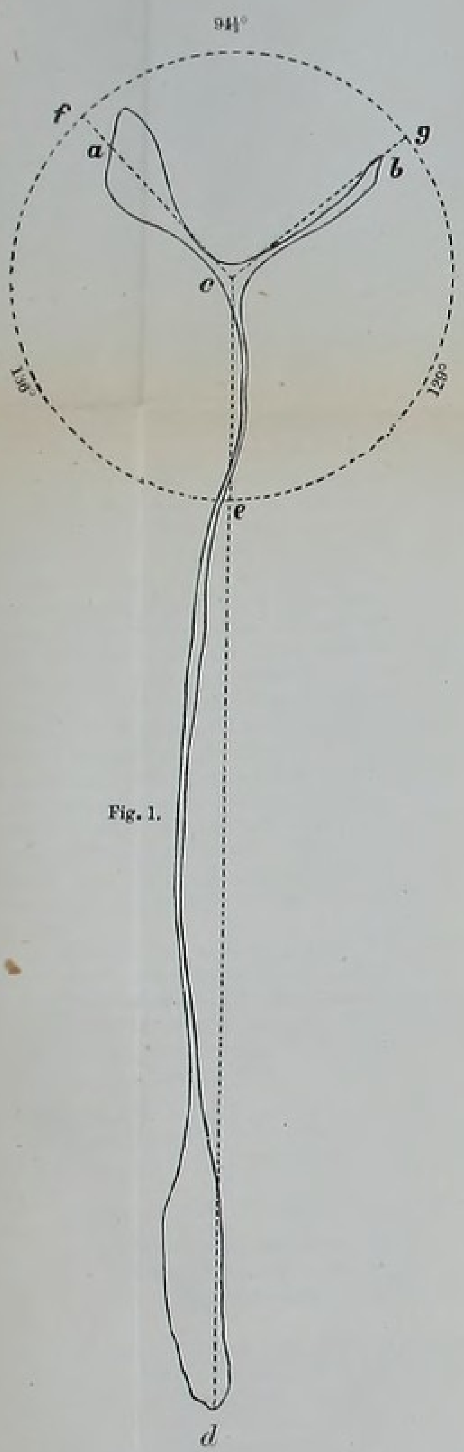


Fig. 1.

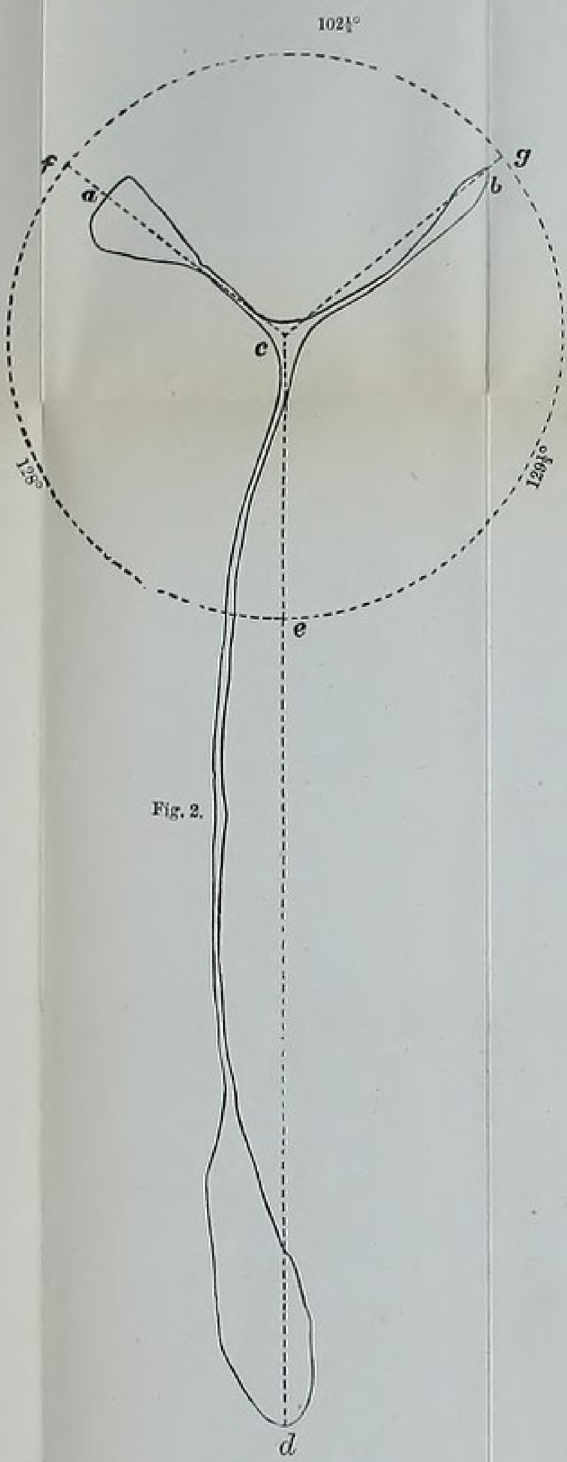


Fig. 2.

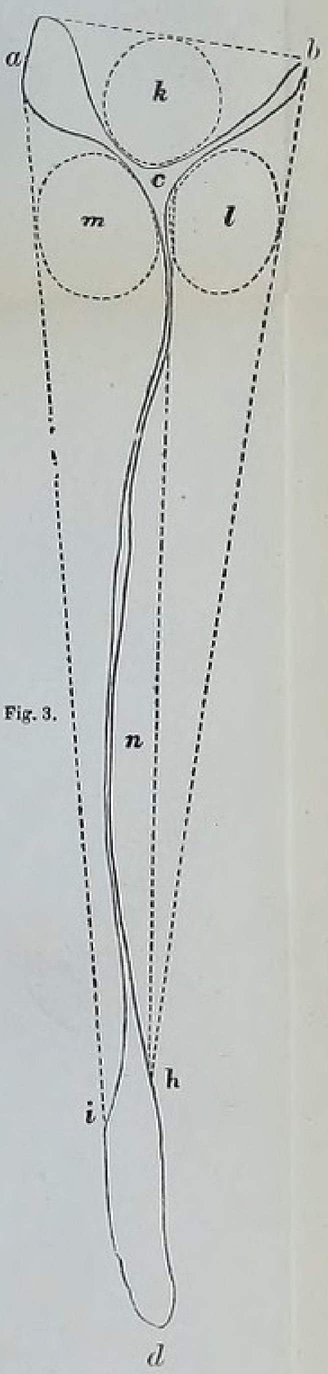


Fig. 3.

(To face page 194.)

is the spine, *b c* the supra-spinous portion of the ala, *c d* the infra-spinous portion of the ala. The spine, projecting backwards from the ala forms with it two angles; one above, *a c b*, which may be called the *supra-spinous angle;* and one below, *a c d*, which may be denominated the *infra-spinous angle*. The remaining angle *b c d* is the *subscapular angle*. The straight line *c e d* passing through both ends of the infra-spinous portion of the ala, may be taken to represent its general direction; and the straight lines *c b g* and *c a f* indicate, in like manner, the respective directions of the supra-spinous portion of the ala, and of the spine. As these three lines meet in the point *c*, around which, as a centre, is described the circle *e f g*, the three angles under consideration may be readily compared, by ascertaining how many degrees of the circle they respectively subtend. This has been carefully measured, and the numbers obtained are seen in the diagram, each opposite to the angle which it numerically represents.

In Fig. 2, which is a similar section of another scapula, the same letters are employed to indicate corresponding parts; and the circle, with the numbers attached to it, has the same meaning and purpose as in fig. 1.

To facilitate the comparison of the angles, the results are subjoined in a tabular form.

Subscapular angle in fig. 1 = $129°$ ... in fig. 2 = $129\frac{1}{2}°$.
Infra-spinous angle in fig. 1 = $136\frac{1}{2}°$ ... in fig. 2 = $128°$.
Supra-spinous angle in fig. 1 = $94\frac{1}{2}°$ ... in fig. 2 = $102\frac{1}{2}°$.

MEAN OF THE TWO MEASUREMENTS.

Subscapular angle = $129\frac{1}{4}°$.
Infra-spinous angle = $132\frac{3}{4}°$.
Supra-spinous angle = $98\frac{1}{2}°$.

Hence it appears that, in the first scapula, the subscapular angle is more abrupt, or nearer to a right angle, by $7\frac{1}{2}°$ than the infra-spinous angle; and that, in the second scapula, though it is more obtuse than the infra-spinous angle, the difference is only $1\frac{1}{2}°$ in favour of the latter. The mean of the two measurements gives a difference of only $3\frac{1}{2}°$ between the infra-spinous and the subscapular angles. Without laying too much stress upon the results obtained by these few observations, I think they will justify us in inferring, generally, that the subscapular angle is a very considerable bend in the ala—much too considerable to be without a purpose; which it is our business, in the next place, to ascertain.*

Now, I think that the use of this angle becomes obvious, when we consider, first, the position of the point *c* (figs. 1, 2, and 3) with respect to the glenoid cavity; secondly, the function of the muscles contained in the three fossæ of the scapula, and the position of their most effective fibres; and lastly, the manner in which the subscapular angle affects the shape of the subscapular fossa, and the position of its deepest part.

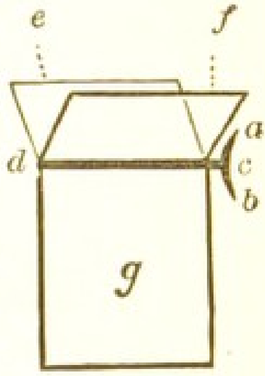
The point (*c*) *is precisely opposite to the centre of the glenoid cavity.* It will be seen, by reference to the diagram, to occupy the centre of a triangular space, which represents the section of a horizontal, prismatic thickening, or rib, in the scapula. This rib commences at the base of the bone, and runs across the ala, increasing in strength as it proceeds to reach the centre of the glenoid cavity. It presents a strong analogy in its form and position to the prismatic rib which runs, in the os innominatum, from the acetabulum to the sacro-iliac joint. Of this we shall speak further hereafter.

The function of the muscles contained in the scapular fossæ, is to draw the head of the humerus towards the scapula, and to maintain it in close contact with the surface of the glenoid cavity. The fibres most efficient to this end are those which lie in immediate vicinity of the prismatic rib *c* (and which are represented in section by the dotted circles, *k*, *l*, and *m*, fig. 3); because these fibres, and these only, act upon the humerus in a direction parallel to the line of motion required. Hence for the most advantageous disposition of the muscles in question, it is requisite that each fossa should have considerable depth in this part. The straight lines *b a*, *b h*, and *a i*, in fig. 3 (which, I should observe, represents the same section as fig. 1) enable the eye to estimate the general capacity of each fossa, and the relative depth of its different parts. The straight line *c h* shows the depth

* The reason why this angle has hitherto escaped notice appears to be, that it is filled up, and in a great measure obliterated, as it approaches the borders of the scapula, by the thickening of the bone towards the head, on one hand, and at the vertebral costa, on the other. This sort of shelving away on each side deceives the eye as to the real abruptness of the bend in the middle of the fossa.

which the subscapular fossa would have if there were no subscapular angle. In that case it would be deepest at *n*, and extremely shallow, if not wholly deficient, opposite the point *c*; so that the bulk of the subscapular muscle would be lodged in a disadvantageous position. *In the present form of the scapula, each fossa has its greatest depth opposite the point* (*c*), *and, consequently, the thickest part of each muscle lies in that precise position in which it can operate most effectively on the head of the humerus.*

The annexed diagram will, perhaps, enable the student to form a clear conception of the essential elements of the scapula, and of their relative position, independently of special form and dimensions.



The curved line *a b* represents a section of the glenoid cavity; *c d* is the prismatic axis already alluded to, projecting from the back of the glenoid cavity, exactly opposite its centre; *e*, *f*, and *g*, are three plates, springing from the angles of the prismatic axis; one forming the spine, the other two constituting the supra and infra-spinous portions of the ala. Each plate is strengthened by a stout bony rib running round its margin. In the human scapula the lower plate is four times as large as either of the two upper, which are about equal in extent, and support each a process.

231. Structure. Cellular in the head, processes, and other thickened parts, composed of a dense compact tissue in the rest of its extent. The ala is attenuated to semitransparency opposite the centres of the supra and infra-spinous fossæ; and, in some instances, the bone is absolutely deficient at these points, presenting natural perforations, through which the muscles of the venter and dorsum may come into contact with each other. Development. Anatomists are not agreed as to the number and position of the points, by which the ossification of the scapula takes place. Cruveilhier, who has given particular attention to this branch of anatomical inquiry, describes six ossific points in the scapula, one for the ala and spine, one for the coracoid process, two for the acromion, one for the vertebral border of the bone, and one for its inferior angle. The first enumerated, is the principal ossific centre; it appears as a flat plate in

the second month of fœtal life; and the spine, which is a true *apophysis* (as contradistinguished from an *epiphysis*), begins, in the third month, to protrude from its posterior surface. The other points are complementary, and appear successively at various ages, from birth up to fifteen years. Each remains a detached epiphysis for several years after its appearance; and it is not till the period of growth is fully accomplished, that the scapula is consolidated into a single piece. ARTICULATIONS. With the clavicle, by arthrodia, or gliding-joint, with the humerus, by enarthrosis, or ball-and-socket joint. The scapula derives a considerable support from the ribs, though cut off from direct contact with them by several intervening muscles.

OF THE CLAVICLE.

nearly *

232. The clavicle, or collar-bone, is situated nearly horizontally at the upper and lateral part of the thorax, immediately above the first rib, the direction of which it crosses obliquely. The clavicle rests, internally, against the upper border of the sternum, which serves it as a fulcrum; and it articulates, at its outer extremity, with the acromion process of the scapula, which bone it follows in all its movements, preventing it from falling inward upon the thorax, and sustaining it firmly in the various positions which it assumes.

The clavicle is nearly straight, with regard to the horizontal plane; but in the opposite sense it presents a double curvature, being convex in front, internally, concave in the same direction, at the opposite end. The clavicle is, moreover, twisted on its long axis, so that a surface looking directly upward externally, is turned *forward*, as well as upward, towards its sternal extremity. Or, to convey the same fact otherwise, the lines by which the clavicle is traversed, pass somewhat spirally along the bone, so that the surfaces which lie between them necessarily vary in direction in different portions of their length.

The clavicle, in the inner three-fourths of its extent, has the form of a triangular prism; but its outer fourth is flattened, so as to present a wide superior and inferior surface, separated by an anterior and posterior margin. In the natural position of the bone, the prismatic portion extends from the sternum to the coracoid process of the scapula, and the flat portion from the coracoid process to

Acromial end is a little higher than sternal.

the acromion. The prismatic portion is subject to considerable variations of form. In ill-developed specimens it presents indistinct angles, and a smooth rounded contour, so that its surfaces merge into each other, and cannot be exactly defined. All its edges, on the contrary, are strongly pronounced in individuals of great muscular force, or who have exercised a trade requiring hard and continuous manual labour. In these instances it often resembles a quadrangular, rather than a triangular prism. Indeed, the bulk, curvature, and angularity of the clavicle, increase in direct proportion with the exercise of the upper extremity. Whence, doubtless, it happens, that the clavicle is smoother, more slender, less curved, and (consequently) longer, in the female than in the male.

The lines of the clavicle are rounded and indefinite towards the middle of the bone; and, near the extremities, though sufficiently distinct, are apt to be confounded with certain irregular ridges, which are there occasioned by muscular and ligamentous attachments. These circumstances, together with the peculiarities of form frequently presented by individual specimens, render the clavicle a very difficult bone for the student clearly to apprehend. The best practical rule, in this and in similar cases, is to procure as many specimens as possible for reference, to retain them, during examination, in the natural position, and to commence with a rapid survey of the principal features, leaving such points as cannot readily be made out, for subsequent research, when some general notion of the form and relations of the bone shall have been acquired.*

233. From these introductory observations, we proceed to the minute description of the clavicle, in which we shall adopt the arrangement suggested by its natural divisions; considering, in the first place, its external *flattened portion*, secondly, its *prismatic portion*, and lastly, its *extremities*.

234. Flat portion of the clavicle. Is curved so as

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* The plan of occasionally deferring for a while the consideration of difficult points, is one of great practical utility in the study of all branches of science, and especially, perhaps, of anatomy. For the sequel of a description often throws light upon its commencement; and the more striking objects, noticed in a preliminary survey, serve afterwards as landmarks and guides, to indicate the position of minute particulars, which might otherwise have cost the student much uncertain and tedious investigation, or even have entirely eluded his research.

to present a concave edge in front, and offers for examination an upper and a lower *surface*, separated by an anterior and a posterior *border*. SURFACES. *Superior.* Convex, rough, perforated with nutrient foramina, and covered, in the recent subject, by the interlaced aponeurosis of two muscles,* whose fleshy fibres encroach a little upon it before and behind. *Inferior.* Uneven, and perforated with small vascular apertures. It presents at its posterior part a *tubercle* which is situated just where the *flattened portion* of the bone joins the *prismatic portion.* This rough eminence is called the *tuberosity of the clavicle;* it surmounts, in the skeleton, the coracoid process of the scapula, and gives attachment to a strong ligament.† From the tuberosity a rough ridge runs outward and forward, to the extremity of the bone, crossing obliquely the inferior surface of the flattened portion. This is called the *oblique line of the clavicle*, and gives attachment to another strong ligament.‡ BORDERS. *Anterior.* Thin, concave, and rough, for the insertion of a muscle.§ *Posterior.* Much thicker than the anterior, and often so flat as to deserve the name of a surface (indeed, it is continuous, as we shall presently find, with the posterior surface of the prismatic portion). It is rough, and gives attachment to a muscle.‖

235. PRISMATIC PORTION. Curved, so as to offer a convexity in front, and twisted on its axis, so that the aspect of its surfaces varies in different portions of their length. It presents three *surfaces*, separated by three *lines* or *borders*. SURFACES. *Anterior.* Convex, directed forward, and a little upward, at its sternal end, forward, outward, and considerably more upward, at its acromial extremity, where it becomes continuous with the superior surface of the flat portion. It presents, internally, the impression of a muscle;¶ externally it is smooth, and nearly subcutaneous, being only covered by an extremely thin muscular expansion,** and by some nervous filaments.†† *Posterior.* Concave and smooth, directed backward and upward at its inner extremity, backward, inward, and a little downward, towards its outer extremity, where

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* Deltoid and trapezius. † Conoid.
‡ Trapezoid. § Deltoid. ‖ Trapezius.
¶ Sterno-cleido-mastoideus. ** Platysma myoides.
†† Branches of the cervical plexus (one of which sometimes passes through the substance of the bone).

it presents the foramen for the principal nutrient artery of the bone,* and becomes continuous with the posterior border of the flat portion. This surfaces corresponds in the recent subject, to large and important nerves,† and vessels.‡ *Inferior.* Rough, perforated by numerous vascular foramina, gradually increasing in width toward its outer extremity, where it is continuous with the inferior surface of the flat portion. It is marked with a rough, longitudinal groove, wider externally than internally, which is called the *subclavian groove*, and gives insertion, by its concavity, to a muscle,§ and by its anterior lip, to a strong aponeurosis.‖ Internal to this groove, there is a rough impression, called the *rhomboid impression*, for the attachment of a ligament;¶ and, still further inward, there frequently appears a little narrow facet, by which the clavicle articulates with the cartilage of the first rib. BORDERS. *Superior.* Separates the anterior from the posterior surface, is rounded and indistinct internally, more obvious externally, where it joins the posterior border of the flat portion. *Anterior.* Separates the anterior from the inferior surface. It is rough internally for the attachment of a muscle,** and continuous externally with the anterior margin of the flat portion (which also gives insertion to a muscle).†† Near the junction of the prismatic and flat portions, this border of the clavicle presents a little smooth space to which no muscular fibres are attached. *Posterior.* Separates the inferior from the posterior surface. It is not always very distinct, but it follows the direction of a line drawn from the rhomboid impression to the tuberosity of the clavicle, along the posterior border of the subclavian groove.

236. EXTREMITIES. *Inner*, or *sternal.* Presents a triangular, articular surface, directed downward, inward, and forward, concave from before forward, slightly convex in the opposite direction, and united, by the intervention of an inter-articular fibro-cartilage, with the corresponding depression in the upper margin of the

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* Generally said by anatomists to occur in the subclavian groove, in which position, however, it is very rarely to be found.

† Brachial plexus.

‡ Subclavian artery and vein.

§ Subclavius.

‖ Aponeurosis of the subclavius.

¶ Costo-clavicular.

** Clavicular division, or portio attollens, of the pectoralis major.

†† Trapezius.

manubrium. Of its three angles, the *posterior-inferior* is distinguished by being prolonged downward and backward, so as to render this surface considerably larger than the surface with which it articulates; the *superior* is connected, by ligamentous fibres, with the upper extremity of the fibro-cartilage of the joint; the *anterior-inferior* is nowise remarkable. This extremity of the clavicle is surrounded by a rough border, into which several ligaments* are inserted. *Outer*. Presents an oval, articular facet, generally convex, sometimes slightly concave, directed forward and outward, to articulate with a corresponding depression on the acromion process of the scapula. The borders of this facet give attachment to ligaments.†

237. STRUCTURE. If its shape and functions assimilate the clavicle to the cylindrical bones of the extremities, while its transcendental analogies determine its position in the costal series, this double relation is in exact accordance with the interior conformation of the bone. Like the ribs it is very elastic, and cellular in the shaft as well as at the extremities; like the long bones, it is invested with a compact layer thicker near the middle than at either end, and possesses a medullary canal, small indeed, and indistinct, but sufficient to indicate an approximation to the cylindrical form. DEVELOPMENT. The bulk of the clavicle ossifies from a single point. A thin lamina, however, is subsequently developed at each extremity, as a separate epiphysis, which ultimately coalesces with the body of the bone. ARTICULATION. With the first bone of the sternum, and with the scapula. Frequently also with the cartilage of the first rib.

OF THE ELASTICITY OF THE CLAVICLE.

238. The clavicle has always been supposed to possess a certain elasticity in virtue of its double curvature; but no attempt, I believe, has hitherto been made to ascertain, by direct experiment, the amount of its resilient property. I have endeavoured, by the following experiments, to obtain an approximative measurement of the elastic force resident in this bone.

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* Anterior and posterior sterno-clavicular ligaments, and inter-clavicular ligament.

† Superior and inferior acromio-clavicular.

A clavicle was taken from a well-developed, middle-aged male subject, shortly after death, and laid upon a smooth surface, with its shaft perpendicular to the plane of a wall, against which its inner extremity rested.

Upon the outer extremity of the bone, thus disposed, a smart blow was struck with a hammer, in the direction of its long axis. The hammer rebounded from the end of the bone, *which sprang to a distance of nearly two feet from the wall.* My friend, Mr. Fergus, in whose presence the trial was made, suggested that the effect might depend, in some measure, on the elasticity of the cartilage with which the ends of the bone are invested. This objection was readily met by scraping off the cartilage, and repeating the experiment. The result proved the elasticity to be independent of the cartilage; for the bone sprang as far, in some of the trials even farther, than before. The bone was afterwards laid upon a stone floor, in such a position that it rested, like an arch, upon its two extremities, and presented the convexity of its prismatic portion towards the ceiling. A downward blow being struck upon this convexity, the bone sprang upward to a height of about a foot (as nearly as I could judge) from the ground. (The use of the hammer in these experiments is attended with some inconvenience. The extremity of the bone is apt to be crushed or splintered by too heavy a blow; and it eludes a stroke in the least degree oblique. In subsequent trials I have employed, with advantage, a stout rod of wood, in place of an iron hammer.)

From these observations we may infer, in general terms, that the clavicle possesses sufficient longitudinal elastic force to throw its own weight nearly two feet on a level surface; and sufficient transverse elastic force, opposite the centre of its anterior convexity, to raise its own weight about one foot vertically.

The physiological explanation of these facts is obvious. The clavicle is endowed with this remarkable amount of resilience, on account of the frequency and violence of the concussions to which it is exposed, and also of its importance, as a support to the upper extremity, and a defence for the large vessels and nerves which lie immediately beneath it. We shall offer some remarks, in further illustration of this subject, when we come to describe the slighter curvatures of the radius and ulna.

OF THE SHOULDER IN GENERAL.

239. The shoulder, formed of the two bones that have now been described, is a movable fulcrum, which supports the humerus in its position at the side of the thorax, and at the same time allows it great latitude of motion. For this purpose it presents a horizontal branch in front, a vertical one behind. The horizontal branch, the *clavicle*, resting against the sternum, prevents the humerus from falling inward. Curved, and highly elastic, it has the power of sustaining, without fracture, concussions of considerable violence, in the direction of its length; the arched and prismatic form of its body enables it to resist blows coming from the front; while the peculiar form of its sternal articular surface, which is alternately convex and concave, and fitted with an elastic, movable fibro-cartilage, gives it considerable freedom of motion, both in the horizontal and vertical plane. The posterior, vertical lever, the *scapula*, being confined by no other articulation than that between the acromion process and the clavicle, of course enjoys the utmost possible variety and extent of motion; and, at the same time, the constant apposition of its large anterior surface to the surface of the thorax (on which it glides freely by the interposition of flat muscles), keeps it firm and steady in every position that it assumes; while the costæ, and processes, which run, in every direction, from the neighbourhood of the glenoid cavity, afford powerful leverage to the muscles by which it is moved.

240. The shoulders, projecting outward on each side, alter the apparent dimensions of the thorax, giving it the appearance of an inverted cone, whereas, in fact, it is larger below than above.

OF THE ARM.

241. The *arm* is formed by a single bone, the *humerus*.

OF THE HUMERUS.

242. Depending from the shoulder above, and supporting the fore-arm below, this bone is the longest and largest of the upper extremity. It is cylindrical above, twisted on its axis in the middle, prismatic and flattened below; and it presents, for examination, a superior and an in-

ferior *extremity*, between which is extended the *body*, or *shaft*, of the bone.

243. SUPERIOR EXTREMITY. The largest and strongest portion of the bone. It presents a large globular *head*, supported by a very short *neck*, which separates it from two non-articular eminences, called the *greater* and *lesser tuberosities* of the humerus. HEAD. Nearly hemispherical, covered, in the recent state, with articular cartilage, and set obliquely on the shaft, so as to look upward, inward, and a little backward. It is received into the glenoid cavity of the scapula, with which it forms the ball-and-socket joint of the shoulder. The smooth, convex surface of the head is limited all round by an uneven margin, below which is the contracted portion already alluded to as the NECK. This is distinguished by the epithet *anatomical*, lest it should be confounded with the *surgical neck of the humerus*, which is situated just below the tuberosities, and has been so named on account of its liability to fracture. The *anatomical neck* is very short above, where it presents the appearance of a narrow groove separating the head from the tuberosities; it becomes longer below, where the direction of its axis, forming an obtuse angle with the axis of the shaft, may be readily distinguished. The anatomical neck is perforated below by several vascular foramina, and gives attachment, in its whole circumference, to a strong ligament.* TUBEROSITIES. *Greater*. Situated at the outer side of the bone, external to the head, and to the lesser tuberosity. Its outer surface is broad, convex, and continuous with the external surface of the shaft. Its superior surface is divided, by two slight ridges, into three flat facets, an *anterior*, a *middle*, and a *posterior*, each of which gives attachment to a muscle.† *Lesser*. This tuberosity is the more prominent of the two, notwithstanding its inferiority in bulk. It is situated in front of the head, anterior and internal to the greater tuberosity, from which it is separated by the *bicipital groove*. (247) It presents a rough, tubercular summit, for the attachment of a muscle.‡ It is just below these tuberosities

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* Capsular ligament of shoulder-joint.

† The anterior to the supra-spinatus, the middle to the infra-spinatus, the posterior to the teres minor.

‡ Subscapularis.

that the bone, beginning to contract, takes the name of the *surgical neck*.

244. INFERIOR EXTREMITY. Curved forward a little, and flattened from before backward, so that its transverse greatly exceeds its antero-posterior diameter. It presents for examination an undulating terminal *articular surface*, flanked by two tubercular eminences called the *condyles of the humerus*, and surmounted by three *fossæ*, named, respectively, the *olecranon depression*, or *fossa maxima*, the *coronoid depression*, or *fossa anterior major*, and the *radial depression*, or *fossa anterior minor*. CONDYLES. Two rough non-articular eminences, projecting, one on each side, from the lower extremity of the humerus, for the attachment of muscles and ligaments.* The *internal condyle* is by far the more prominent of the two, and presents a slightly enlarged summit, turned a little backward. The *external condyle* is flattened and tubercular. These eminences are continuous above with the sharp, curved ridges, by which the inner and outer borders of the shaft commence. ARTICULAR SURFACE. Longest in the transverse direction, and sloped obliquely, so as to descend lower internally than externally. This obliquity of the inferior articular surface has (as we shall hereafter demonstrate) an important influence on the position of the fore-arm in flexion. Its direction and degree may be gathered from the observation, that when the lower extremity of the humerus is made to rest on a horizontal plane, the upper end of the bone is thrown outward, full two inches and a half, from the perpendicular. The inferior articular surface is divided, by a shallow *groove*, into two lateral portions, viz., an external, small, globular eminence, called the *lesser head*, or *radial tuberosity, of the humerus;* and an internal, wide, pulley-like surface, called the *trochlea*. The *lesser head* is received into a cup-like cavity on the upper extremity of the radius. It does not extend to the posterior surface of the humerus, but

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* The external condyle attaches a tendon common to the extensor carpi radialis brevior, extensor communis digitorum, extensor proprius minimi digiti, and extensor carpi ulnaris; it also gives origin to the anconæus, to the supinator brevis, and the external lateral ligament of the elbow-joint.

The internal condyle gives origin to the common tendon of the pronator radii teres, the flexor carpi radialis, the palmaris longus, the flexor carpi ulnaris, and the flexor digitorum sublimis; also to the internal lateral ligament of the elbow-joint.

appears only on the fore part, and end, of the bone. The *groove*, which intervenes between the lesser head and the trochlea, is occupied by the inner margin of the above-mentioned cup-like cavity on the upper extremity of the radius. The *trochlea* turns over the end of the bone, so as to be equally apparent before, behind, and below. It is convex from before backward, concave from side to side, presenting two lateral *margins* separated by a shallow *groove*. This *groove* is wider and deeper on the posterior, than on the anterior aspect of the trochlea. It is embraced by the *sigmoid cavity* of the ulna, (258) to the undulations of which it presents a converse resemblance. The *outer margin* of the trochlea, narrow and little prominent, corresponds, in the elbow-joint, to the interval between the radius and ulna. The *inner margin* of the trochlea is considerably thicker, and, by its projection (which is especially evident before and below), gives to this surface the obliquity already described. If we enumerate, from without inward, the series of alternate eminences and depressions presented by this remarkable surface, we shall have, 1st, the *lesser head*, 2ndly, the narrow *groove* of separation, 3rdly, the *outer margin* of the trochlea, 4thly, the *groove* of the trochlea, 5thly, the *inner margin* of the trochlea. FOSSÆ. Of the three fossæ of this extremity, the *fossa maxima*, or *olecranon depression*, is by far the largest and most important. It is a deep, triangular excavation, situated immediately above the trochlea, on the posterior aspect of the humerus, and designed to receive the olecranon process of the ulna, during extension of the fore-arm. The *fossa anterior major*, second in size and depth, is placed above the trochlea, on the anterior surface of the bone, exactly opposite to the last-described, to which it is similar in form. This fossa receives the coronoid process of the ulna, when the fore-arm is flexed, and hence derives the name of *coronoid depression*. Its borders give attachment to a ligament.* The olecranon and coronoid fossæ are lined, in the recent subject, by the synovial membrane of the elbow-joint; in the skeleton, they are only separated at the bottom by a thin, diaphanous lamina of bone. In strongly marked specimens, this lamina sometimes presents a perforation, through which the tip of either process of the ulna may enter

* Anterior ligament of elbow-joint.

the fossa appropriated to the other. The *fossa anterior minor*, or *radial depression*, is a slight indentation, situated on the anterior surface, immediately above the lesser head. It is indistinct, often indeed scarcely perceptible, and receives the anterior margin of the head of the radius, in extreme flexion of the fore-arm.

245. Body. Irregularly cylindrical above, prismatic and flattened below, it presents in the middle a twisted appearance, as if its two extremities had been turned in opposite directions, the superior outward, the inferior inward. In consequence of this twist, its surfaces have different aspects in different portions of their length, a surface which is anterior above, becoming internal below, &c. The shaft presents for examination three *borders*, separating three *surfaces*.

246. Borders. *Anterior*. Runs from the anterior part of the greater tuberosity to the fossa anterior major, separating the internal from the external surface. It is rough and prominent above, where it forms the outer margin of the *bicipital groove* (247) and attaches a muscle;* rough also in the middle, where it forms the anterior boundary of the *deltoid impression* (247) and attaches part of another muscle;† smooth and rounded below. where it is covered by a third muscle.‡ *External*. Runs from the posterior part of the greater tuberosity to the external condyle, separating the external from the posterior surface. It is rounded and indistinct at its upper part, where it gives attachment to a muscle;§ interrupted in the middle by the *musculo-spiral groove;* (247) curved forward, and very prominent below, where it attaches two muscles.‖ and an aponeurosis.¶ *Internal*. Runs from the lesser tuberosity to the internal condyle, separating the internal from the posterior surface. It is prominent above, where it forms the inner margin of the bicipital groove, and gives attachment to three muscles;** very prominent, and curved inward, below, where it attaches, like the last described, an aponeurotic septum.†† Intermediately it is rounded and indistinct.

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* Pectoralis major. † Deltoid. ‡ Brachialis anticus.

§ The long head of the triceps extensor cubiti.

‖ Supinator radii longus, above; extensor carpi radialis longior, below. ¶ External intermuscular aponeurosis.

** The united tendons of the teres major and latissimus dorsi above, and the short head of the triceps extensor cubiti below.

†† Internal intermuscular aponeurosis.

247. SURFACES. *Posterior.* Flat, smooth, and expanded below, where it looks somewhat outward, as well as backward; rounded above, where it inclines a little inward. It is covered by a large muscle,* to which it gives attachment by its lower third, and also by its upper and outer part. *Internal.* Looks forward above, forward and inward below. At its upper part it is rendered very narrow, by the approximation of the inner and outer lines to form the *bicipital groove.* This groove (named after a tendon, which it serves to transmit),† commences above, between the two tuberosities; runs downward and a little inward, becoming gradually shallower; and disappears near the junction of the upper and middle thirds of the bone. Its margins are rough for the attachment of muscles; its concavity is smooth, and covered in the recent subject with a prolongation of the cartilage, and synovial membrane of the shoulder-joint. This surface is marked, halfway down, by the *coraco-brachial impression,* a narrow, rough surface, which attaches a muscle,‡ and presents the *medullary foramen,* running obliquely *downwards* into the bone. At its lower part it is smooth, and gives attachment to muscular fibres.§ *External.* Looks outward above, where it is rounded, and covered by a muscle;|| obliquely outward and forward below, where it is flat, curves a little forward, and gives origin to part of a muscle.¶ It is traversed in the middle by a broad shallow groove, which runs spirally from behind forward and downward, is called the *musculo-spiral groove,* and transmits a nerve,** and an artery.†† This groove is bounded above by the *deltoid impression,* a triangular, rough surface, of considerable extent, which gives insertion to a large muscle of the same name.

248. STRUCTURE. The shaft of the humerus is a cylinder of compact tissue, hollowed by a large medullary canal; its extremities contain a large quantity of very light

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* The triceps extensor cubiti, the long head of which takes origin from its upper and outer part, while the fleshy mass formed by the three united heads of the muscle, derives accessory fibres rom its lower third.

† That of the long head of the biceps flexor cubiti.

‡ Coraco-brachialis. § Of the brachialis anticus.

|| Deltoid. ¶ Brachialis anticus. ** Musculo-spiral.

†† A branch of the superior profunda, frequently called the musculo-spiral artery.

cancellous tissue, covered by a thin layer of compact. DEVELOPMENT. By eight points, of which three are in the upper extremity, one for each tuberosity, and one for the head, four in the lower extremity, one for each condyle, one for the trochlear groove, and one for the radial tuberosity, or lesser head. The remaining point, which is the first, both in importance, and in the order of appearance, is situated in the middle of the shaft, whence it gradually extends itself towards the extremities. The shaft of the humerus begins to ossify between the thirtieth and fortieth day of fœtal life. The extremities remain entirely cartilaginous during the first year after birth. From that time up to sixteen years of age, the ossific points successively appear; nor is it till the eighteenth, or even the twentieth year, that the ossific union of the body and extremities becomes complete. ARTICULATIONS. With the scapula, radius, and ulna, by the points specified above.

MECHANISM AND USES. The mechanism of the upper arm, and especially of its articulation with the shoulder, is so intimately connected with that of the adjacent muscles and ligaments, and presents so few purely osteological points, that its consideration hardly falls within the scope of the present treatise. What we have chiefly here to observe, is the combined freedom and variety of motion possessed by the shoulder-joint, in virtue of the shallowness of the glenoid cavity; and the security from dislocation afforded to the humerus, by the overhanging vault of the acromion and coracoid processes. The shape of the humerus is adapted to the performance of motions of velocity, by the little prominence of the tuberosities, and by their close approximation to the shoulder-joint. It results from this disposition, that several powerful muscles operate upon the bone, in the immediate vicinity of its turning-point, or fulcrum; so that the space through which they draw their respective points of insertion, is many times multiplied at the opposite end of the lever. We shall hereafter find, in the elongated neck, and projecting trochanters, of the thigh-bone (which is the analogue of the humerus in the lower extremity), provisions of a precisely opposite tendency.

OF THE FORE-ARM.

249. The *fore-arm* extends from the elbow to the wrist, and is formed of two bones, the *radius* and the *ulna*.

OF THE RADIUS.

250. A prismatic, slightly-curved bone, larger below than above, and situated at the outer part of the fore-arm, parallel with the ulna, to which it is inferior in length and bulk. Like all the long bones, it presents for examination a *shaft* or *body*, and two *extremities*. As the *shaft* is divided into surfaces, by lines which arise from particular points at each end of the bone, its study is greatly facilitated by the previous description of the *extremities*.

251. UPPER EXTREMITY. Is smaller than the lower, and presents a *head*, a *neck*, and a *tuberosity*. HEAD. This is the expanded articular summit of the bone. It is hollowed above by a cup-like depression, which receives the radial tuberosity, or lesser head, of the humerus; and it presents a smooth, cartilaginous circumference, broader internally, where it articulates with the *sigmoid cavity* of the ulna, (258) than externally, where it is embraced by a ligament.* NECK. This name is given to the round, smooth, constricted portion of the bone, which supports the head. It is the slenderest part of the radius, and surrounded by the ligament which embraces the head. BICIPITAL TUBEROSITY. An eminence situated at the inner and fore part of the bone, just where the neck joins the body. It is divided into two parts, a posterior, rough and tubercular, an anterior, smooth; the rough portion gives insertion to a tendon,† which glides over the smooth surface.

252. LOWER EXTREMITY. Large and quadrilateral; this extremity presents five *surfaces*, and a *styloid process*, for description. SURFACES. *Inferior*, or *terminal*. Concave, smooth, directed obliquely downward and inward, triangular in form, with the apex of the triangle outward, and divided, by a line which runs from before backward, into two parts; an *external*, triangular for articulation with the scaphoid bone; an *internal*, quadrilateral for

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* Annular ligament.

† That of the biceps flexor cubiti.

articulation with the semilunar bone. *Anterior.* Continuous with the corresponding surface of the body, and somewhat rough for the attachment of a ligament.* *External.* This surface is prolonged downward upon the *styloid process,* a blunt pyramidal eminence, which projects downward from the outer side of the lower extremity of the radius, and, by its summit, gives attachment to a ligament.† The external surface of the styloid process is marked with two *grooves,* which run from above obliquely downward and forward, and are separated by a slight ridge. Each transmits the tendon of a muscle.‡ *Internal.* Presents a narrow, concave, cartilaginous surface, which is called the *sigmoid cavity of the radius,* and articulates with a corresponding lateral convexity on the lower extremity of the ulna. *Posterior.* Convex, and continuous with the corresponding surface of the shaft; this surface presents three *grooves.* One, placed in the median line of the bone, is narrow, deep, bounded on each side by a very prominent tubercle, and directed from above obliquely downward and outward, for the transmission of a single tendon.§ The groove internal to this is broad and shallow for the transmission of five tendons,|| four of which belong to a single muscle. The external groove is also broad and shallow, and, in a well-marked bone, is subdivided into two minor grooves, by a slight longitudinal elevation. Each subdivision transmits the tendon of a muscle.¶

253. BODY OR SHAFT. Presents the form of a triangular prism, curved upon itself so as to be convex outward, and gradually increasing in size from above downward. It is divided by three *lines* or *borders,* into three *surfaces.*

254. LINES OR BORDERS. *Internal.* Separates the anterior from the posterior surface. It commences above the posterior part of the *bicipital tuberosity,* (251) and bifurcates below into two branches, which pass to the two

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* Anterior ligament of wrist joint.

† External lateral ligament of wrist joint.

‡ The anterior transmits the extensor ossis metacarpi pollicis; the posterior transmits the extensor primi internodii pollicis.

§ That of the extensor secundi internodii pollicis.

|| The four tendons of the extensor communis digitorum, and the tendon of the indicator.

¶ The internal transmits the extensor carpi radialis longior; the external, the extensor carpi radialis brevior.

extremities of the *sigmoid cavity*. (252) It is slightly concave, very sharp and prominent, directed toward the ulna, and connected with a broad ligament,* that stretches between the two bones. *Anterior.* Separates the anterior from the external surface. This line is prominent above, where it arises from the anterior part of the *bicipital tuberosity* and runs obliquely downward and outward; loses its distinctness in the middle, where it descends vertically; and becomes sharp and thin at its lower extremity, where it curves a little forward to terminate, just anterior to the root of the *styloid process*, in a small prominent *tubercle*. Its upper oblique portion is distinguished by the name of the *oblique line* of the radius, and gives insertion to two muscles;† its tubercular termination, at the root of the styloid process, gives attachment to another;‡ and a fourth§ is inserted into its lower part, for the space of about two inches above the tubercle. *Posterior.* Described as commencing superiorly at the posterior part of the neck, and as terminating inferiorly at the posterior part of the root of the styloid process. It is prominent and distinct in the middle, but *entirely disappears* above and below. If, however, the middle portion were produced upward and downward, it would reach the points assigned for its commencement and termination; and such a fictitious extension may be advantageously employed, in order to facilitate the distinction of the surfaces.

255. SURFACES. *Anterior.* Directed somewhat inward as well as forward, especially above. It is narrow, rough, and concave, at its superior extremity, and becomes wider, smoother, and flatter, as it descends. By its upper two-thirds,‖ and its lower fourth,¶ it gives attachment to muscles; and, at the junction of its upper and middle thirds, it presents the *medullary foramen*, entering the bone *obliquely upward.*** *Posterior.* Directed inward as

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* Interosseous.

† Supinator radii brevis, and flexor sublimis digitorum perforatus.

‡ Supinator radii longus.

§ Pronator quadratus.

‖ Flexor longus pollicis.

¶ Pronator quadratus.

** The medullary foramina of the radius and ulna run *upward*, that of the humerus runs *downward*. The direction of the medullary foramina in the corresponding bones of the leg is precisely the reverse; that is to say, whereas in the upper extremity they run *towards* the central joint of the limb (the elbow), in the lower extremity they run *from* the central joint (the knee).

well as backward, especially below. It is narrow, smooth, and rounded, in its upper third, where it is covered by a muscle;* concave in its middle third, where it gives origin to two muscles,† flat, and curved a little backward below, where it is traversed by the tendons of the five muscles,‡ which immediately afterward run in the grooves that have been described on the posterior surface of the lower extremity. *External.* Rounded above, marked in the middle with the rough impression for the insertion of a muscle,§ rendered narrow below by the approximation of the anterior and posterior lines (which terminate, one at the anterior, the other at the posterior part, of the root of the styloid process). By its upper third, this surface gives insertion to a muscle;‖ and below, it is covered by the two tendons which afterwards run in the grooves on the external surface of the styloid process.¶

256. STRUCTURE. Like that of the other cylindrical bones. DEVELOPMENT. By three ossific points, one for the shaft, which makes its appearance at the point where the medullary artery is subsequently found, one for each extremity, of which the inferior is the sooner developed. The upper extremity of the radius is remarkable as being, of all the epiphyses, the last to ossify, and the first to unite with the shaft. ARTICULATIONS. With the humerus, with the ulna (by two points), and with the scaphoid and semilunar bones of the carpus.

OF THE ULNA.

257. The ulna is a strongly-marked, prismatic bone, situated at the inner side of the fore-arm, parallel with the radius, which it exceeds in length, bulk, and strength; and from which it further differs, in that it tapers gradually from above downward, whereas the radius diminishes from its lower towards its upper extremity. The ulna is

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* Supinator radii brevis.

† Extensor ossis metacarpi pollicis above; extensor primi internodii pollicis below.

‡ Which enumerated from without inward (*i.e.* passing from the styloid process towards the sigmoid cavity of the radius), are, extensor carpi radialis longior, extensor carpi radialis brevior, extensor secundi internodii pollicis, indicator, and extensor digitorum communis.

§ Pronator radii teres. ‖ Supinator radii brevis.

¶ Extensor ossis metacarpi, and primi internodii, pollicis.

curved upon itself in such a manner, that its upper part is slightly convex both outward and backward, while its lower half is convex inward.* It is divided, like the long bones in general, into *shaft* and *extremities*.

258. UPPER EXTREMITY. Is the strongest and thickest part of the bone, and presents, for examination, two curved processes, the *olecranon*, and the *coronoid;* and two concave articular depressions, the *greater* and *lesser sigmoid cavities*. OLECRANON PROCESS. A large curved eminence, occupying the summit of the ulna, and forming the strongly-marked posterior angle of the elbow-joint. It is somewhat contracted at its junction with the shaft, and bends forward superiorly to terminate in a narrow prominent tip, which lies, during extension of the fore-arm, in the olecranon depression of the humerus. It is exactly by the extent of this process that the ulna exceeds the radius in length. The *posterior surface* of the olecranon is of a triangular form, smooth and subcutaneous. Its *superior force* is irregularly quadrilateral, marked with the rough impression of a large muscle;† and, in front of that, with a transverse groove which attaches part of a

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* I had never imagined that these slight undulations in the shafts of the cylindrical bones could play any important part in the mechanism of the limbs, until I happened to learn how greatly the durability of carriage-wheels is increased by a scarcely perceptible curvature in their spokes. An experienced mechanic assures me that, when the spokes of a wheel are sufficiently slender to curve under the pressure exerted by the heated tire-iron in shrinking, though the deviation from perfect rectilinearity in each spoke does not exceed two or three sixteenths of an inch, they are found to remain firm and unloosened at the nave, when wheels, having straight, and consequently rigid spokes, have opened at the joints, and become unsound. My informant states, that he has known wheels of slender proportions to do full one-third more service than others of stouter construction, and much greater *absolute* strength, entirely on account of the elastic play permitted by this seemingly trivial variation of form. These facts afford a striking and instructive illustration of the effect of apparently insignificant curvatures, in distributing the force of concussion, and promoting longitudinal resilience; and they leave in my mind no doubt that the very least of the undulations in the cylindrical bones has a direct and important influence, in promoting elasticity, and diminishing the chances of fracture. (For an approximative experimental estimate of the effect, of more considerable curvatures of the bones, the reader is referred to the section on the elasticity of the clavicle, page 202.

† Triceps extensor cubiti.

ligament.* Its *anterior surface* is smooth, cartilaginous, directed downward aad forward, and continuous with the superior surface of the coronoid process. It forms the upper part of the greater sigmoid cavity, for the account of which its fuller description is reserved. This surface is bounded, on each side, and above, by a prominent edge, immediately behind which a narrow groove runs round the olecranon, giving attachment, in the recent subject, to a ligament. The upper part of this groove lies close behind the tip of the process, on the superior surface (in the description of which it has just been mentioned); its inferior portions occupy the narrow *lateral surfaces*, of which we have only to add, that they separate the anterior and posterior aspects of the olecranon, and are continuous below the lateral surfaces of the shaft. CORONOID PROCESS. Projects horizontally forwards from the front of the ulna, below the olecranon. It is a sort of pyramid continuous by its base with the rest of the bone, and curved a little upward at its narrow extremity, which is received during flexion of the forearm, into the coronoid depression of the humerus. Of its surfaces, the *superior* is smooth, cartilaginous, directed upward and forward, and continuous with the corresponding surface of the olecranon, with which it concurs to form the greater sigmoid cavity (in the description of which it will be included). The *anterior* (or *inferior*) surface is irregularly concave, directed obliquely downward and forward, and rough for the attachment of a muscle.† It is continuous with the anterior surface of the body, the junction of the two being marked by a little rough eminence, called the *tubercle of the ulna*, which serves for the attachment of a ligament.‡ The *inner surface* presents a rough concavity which attaches part of two muscles,§ and is continuous below with the inner surface of the shaft. It is separated from the upper surface of the coronoid process by a prominent tubercular ridge which gives attachment to a ligament.|| The *outer surface* presents an oblong articular depression, concave in the direction of its long diameter, which is from before backward; narrow, and quite flat, from above downward. This depression is called the LESSER SIGMOID CAVITY. Its

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* Posterior ligament of elbow-joint. † Brachialis anticus.
‡ Oblique ligament of elbow-joint.
§ Pronator radii teres, and flexor digitorum sublimis perforatus.
|| Internal lateral ligament of elbow-joint.

curve is the quarter of a circle, precisely fitting the circumference of the head of the radius, with which it articulates. Its extremities give attachment, in the recent subject, to the ends of a ligament,* which furnishes the remaining three-fourths of the circle, completing an osseo-ligamentous ring, within which the head of the radius turns, as a swivel within its socket. The GREATER SIGMOID CAVITY is a large semilunar excavation, concave from above downward, but rendered convex in the opposite direction by the presence of a smooth, rounded ridge, which extends longitudinally from the tip of the olecranon to the tip of the coronoid process, and divides the cavity into two portions; an *internal*, larger and somewhat concave transversely (as well as from above downward): an *external*, narrower, and nearly plane from side to side. The greater sigmoid cavity exactly fits the trochlear surface of the humerus, upon which it rolls. It is contracted near the middle by two lateral notches, which indicate the junction of the two processes by which it is formed. The portion above the notches is more extensive, and situated on the olecranon; the portion below them is inferior in both dimensions, and belongs to the coronoid process.

259. LOWER EXTREMITY. Is much smaller than the upper; and presents, for examination, a rounded articular expansion, called the *head* of the ulna, and a conical eminence, called the *styloid process*. HEAD. Presents, *inferiorly*, a smooth articular surface, which plays, in the living subject, on a fibro-cartilage, interposed between it and the cuneiform bone of the carpus;† *externally*, it has a narrow, convex margin, covered with cartilage, and received into the sigmoid cavity of the radius. STYLOID PROCESS. Is situated on the inner and posterior side of the head, projects downward about a quarter of an inch, and terminates in a rounded tubercular summit, which gives attachment to a ligament.‡ The styloid process is separated from the head, *below*, by a rough depression, which gives attachment to the above-mentioned fibro-cartilage, *posteriorly*, by a shallow, vertical groove, which transmits the tendon of a muscle.§

260. BODY OR SHAFT. Prismatic above, where it curves

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* Annular ligament of elbow-joint. † The triangular.

‡ Internal lateral ligament of the wrist-joint.

§ Extensor carpi ulnaris.

forward and inward, rounded and smooth below, where it is bent a little outward. It gradually diminishes in size from above downward, and presents three *surfaces*, divided by three *borders*. BORDERS. *External*. Separates the anterior from the posterior surface. Commences, above, by two roots, one from each extremity of the lesser sigmoid cavity; is sharp, prominent, and arched, in the middle; and becomes indistinct below, where it terminates at the middle of the external articular surface of the head. It is opposed, in its whole extent, to the sharp inner border of the radius, and gives attachment to a ligament,* that extends between the two bones. *Anterior*. Separates the anterior from the internal surface. Commences, above, at the sharp curved ridge which runs between the inner and anterior surfaces of the coronoid process; is rounded and smooth, yet distinct, in the middle, and terminates, below, at the inner side of the head, just in front of the styloid process. It gives origin to two muscles.† *Posterior*. Separates the posterior from the internal surface. Commences, above, at the apex of the triangular surface observed on the back of the olecranon, and terminates, below, at the posterior part of the base of the styloid process. It is very prominent in the two upper thirds of its extent, but, inferiorly, becomes rounded and indistinct. It is flexuous in its course, and attaches an aponeurosis common to three muscles.‡ SURFACES. *Anterior*. Directed forward and inward. Wide and concave superiorly, narrow and convex below, it presents, at its junction with the coronoid process, the *tubercle* of the ulna, already described; and, two or three inches lower down, the *medullary foramen*, entering the bone obliquely *upward* (see note **, p. 213). This surface gives attachment to two muscles.§ *Posterior*. Directed backward and outward. Wide and concave above, where it is continuous with the outer surface of the olecranon process, it increases in width in the middle, and becomes narrow and rounded below. It presents at its upper part a ridge,

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* Interosseous ligament.

† By its upper third to the flexor digitorum profundus perforans: by its lower fourth to the pronator quadratus.

‡ Flexor digitorum profundus, flexor carpi ulnaris, extensor carpi ulnaris.

§ By its upper three-fourths, to the flexor digitorum profundus; by its lower fourth, to the pronator quadratus.

called the *oblique line of the ulna*, which runs, from the posterior extremity of the lesser sigmoid cavity, downward and backward to the posterior border, which it joins at an acute angle, about two inches below its upper extremity. This line gives attachment to a muscle,* and divides the posterior surface into two parts. The *superior*, and smaller of these portions, gives attachment to a muscle.† The *inferior*, and more extensive portion, is subdivided into two parts by a longitudinal ridge. The part *external* to the ridge is the wider of the two; it is concave, and gives attachment to four muscles.‡ The part *internal* to the ridge is also concave, and gives origin, by its middle third, to a muscle.§ *Internal.* Directed inward and backward. Broad and concave above, where it is continuous with the inner surfaces of the olecranon and coronoid processes; narrow and rounded below. Its upper three-fourths are covered by a muscle,‖ to which its upper third gives origin; its lower fourth is subcutaneous.

261. STRUCTURE. The ulna presents the ordinary structure of the class of bones to which it belongs. The olecranon process, in its interior conformation, as well as in its position and use, resembles the patella of the knee-joint. Indeed, it may be regarded as a short bone, united for the better performance of its functions, with the extremity of the ulna; and this view of its analogies is confirmed by its occasional appearance as an entirely separate bone: a curious variety, an example of which has been observed by Rosenmüller. DEVELOPMENT. By three ossific points; one for the shaft, which appears about the fortieth day of fœtal life; one for each extremity, developed in the sixth year after birth. It is remarkable that, though the inferior extremity ossifies earlier than the superior, this latter, on the contrary, is the first to unite with the shaft. This inverse relation between the order of ossification and the order of junction, is not peculiar to the epiphyses of the ulna; it is a general law, exemplified by all the cylindrical bones, in their progress to maturity. ARTICULATIONS. With the humerus above;

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* Supinator radii brevis. † Anconeus.

‡ To the extensor ossis metacarpi pollicis, above; and below this, in succession, to the extensor primi internodii pollicis, the extensor secundi internodii pollicis, and the indicator.

§ Extensor carpi ulnaris. ‖ Flexor digitorum profundus.

with the radius both above and below; and, by the intervention of the triangular fibro-cartilage, with the cuneiform bone of the carpus.

MECHANISM OF THE FORE-ARM.

262. Under this head are included the relations which subsist, first, between the ulna and humerus; secondly, between the radius and humerus; and thirdly, between the radius and ulna.

The most prominent characteristics of the *humero-ulnar* articulation, are, great stability and strength, with extensive and swift mobility in a single plane. The *strength* of the joint results from the firmness of the grasp with which the long curved processes of the ulna embrace the extremity of the humerus; and the *limitation* of its motion to one plane, depends upon the reception of the longitudinal eminence of the greater sigmoid cavity into the corresponding groove of the trochlea. The *direction* of the plane in which the ulna moves, has already been noticed in the course of the foregoing description. It inclines obliquely inward, at an angle of about 10° from the perpendicular line of the humerus; so that the hand, in flexion, is carried toward the median plane, instead of rising vertically to the shoulder. This obliquity of motion, which throws the hand at once into the central position in which the majority of its actions are most conveniently performed, is occasioned by the prominence of the inner margin of the trochlea, and the consequent inclination of the lower extremity of the humerus. The *extent* of the hinge-like motion of the ulna is determined by the proportion which subsists between the length of the olecranon and coronoid processes, and the depth of the depressions, provided, in the humerus, for their reception. This is such as to permit the extension of the ulna to nearly a right line with the humerus, and its flexion to an angle of about 30° with that bone. The *swiftness* of its motions is attained by a disposition similar to that which we have already pointed out in the humerus; viz., the approximation of its processes of muscular insertion to the fulcrum of the lever, and the consequent conversion of the *force* of its motors near the elbow, into *velocity*, at the distal extremity of the limb.

The articulation between the *humerus and the radius*, consists in the reception of a small rounded eminence of the former bone, into a shallow socket, hollowed on the top of the latter. It allows the radius to accompany the ulna in its motions of extension and flexion, and permits, in addition, a spindle-like rotation of its superior extremity to the extent of about 90°. The contact of these surfaces, however, contributes very little to the security of the elbow-joint, which depends almost exclusively upon the humero-ulnar articulation. The radius, indeed, would be capable of complete circumduction on the humerus, if it were not firmly bound to the ulna by two articulations; the mechanism of which we may next proceed to consider.

In the *superior radio-ulnar* joint, the ulna presents a cavity, within which the head of the radius rolls; in the *inferior radio-ulnar* articulation, on the contrary, the radius presents a cavity which glides around a convexity of the ulna. When the head of the radius rotates, so that its anterior surface becomes internal, the shaft of the bone crosses the ulna at an acute angle, and its lower extremity is thrown forward and inward. In this motion it carries with it the hand, to which it communicates the rotatory movements that are popularly attributed to the wrist.

263. It has occurred to me that the shape of the radius is subject to a simple and constant mathematical law, which enables us to express the relation of its extremities, by the following general formula. *The head of the radius is so disposed, in relation to the sigmoid cavity of the lower extremity, that the axis of the former, if prolonged downward, falls upon the centre of the circle, of which the latter is a segment.*

This law, to which I have not found a single exception, suggests a more precise definition of the motions of the radius on the ulna, than has hitherto, I believe, occurred to physiologists.

Many authors have loosely stated, that the radius rotates upon its own axis; an inexactitude into which Sir Charles Bell, amongst other eminent physiologists, has fallen. The inaccuracy of such a description may be rendered evident by the following experiment.

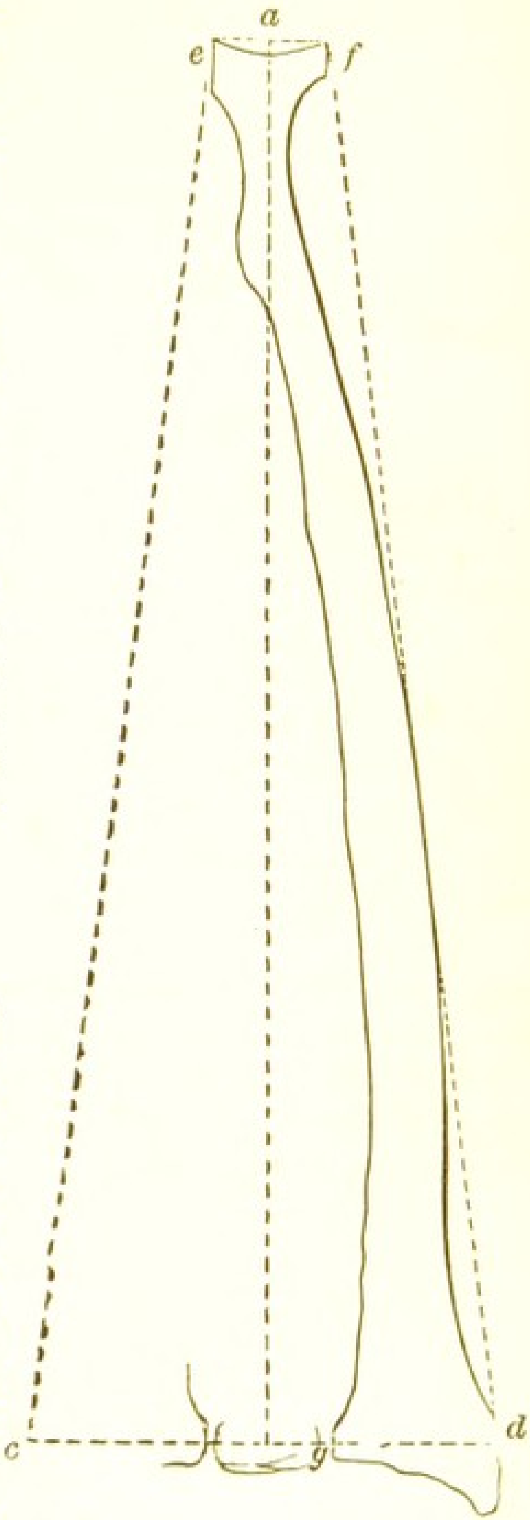
Let a recent fore-arm be fixed in a vice, by the olecranon process, in such a manner as to leave the radius its full freedom of rotation upon the ulna. Let a point be now inserted into the centre of the cup-like cavity on the head of the radius, and another into the centre of its inferior terminal surface, so that the two points may coincide with the two extremities of the long axis of the bone. The points being fixed, let it be attempted to rotate the radius, or in anywise to change its relative position with the ulna. This will be found impossible; the radius being set fast, and incapable of any kind of motion.

Cruveilhier is clearly aware that the radius does not turn on its own axis below; but he adopts the equally erroneous notion that the transverse diameter of its lower extremity is the radius of the curve which it describes around the ulna "*le rayon de l'arc de cercle qu'il décrit autour du cubitus.*" ("Anatomie Descriptive," tom. i. p. 421.) On this supposition, the inner extremity of a line drawn across the inferior surface of the radius, in the direction of its transverse diameter, would represent the lower end of the fixed axis around which the radius rotates. That this is impossible may be shown by making a dot upon the ulna precisely opposite the end of a line so drawn, and then rotating the radius. The extremity of the line will no longer correspond to the dot, but will be found removed from it, by the extent of a quarter of a circle. Now, a movable point cannot be the extremity of a fixed axis.

If it should be contended, on behalf of Cruveilhier's assertion, that the axis of rotation, though it cannot pass through the extremity of this line, may lie in the interval between the radius and ulna, at a point immediately beyond it, the refutation of such an opinion is of the same kind, and equally easy. It is only necessary to mark the terminal surface of the radius with lines converging to the point in question, and then to perform, as before, the movement of pronation. The lines will now cease to indicate the original point; perpetually changing their centre of convergence during the rotation of the bone, and leaving the true position of the stationary axis as uncertain as before.

The real axis of rotation of the radius is the line *a b* in the following diagram. This line represents the axis of a cone, of which *c d* is the base, and *e f* the truncated apex. The centre of its truncated apex corresponds with the centre of the head of the radius, and the centre of its base coincides with the centre of the circle of which the sigmoid cavity is a segment. Hence the axis of the cone must, according to the law above stated, coincide with the axis of the head. This coincidence is plainly shown in the diagram. The portion of the line *a b* which lies above the bicipital tuberosity, evidently represents the axis of the head; and, below the tuberosity, where it quits the bone, it corresponds with the imaginary prolongation of that axis downward.

If the prolonged axis of the head of the radius fell upon any other point than the intersection of the radii of the sigmoid curve, the advance of the shaft, in pronation, would involve a slight hinge-like motion of its superior joint; which, indeed, I had always imagined it to undergo, until I happened to perceive the true mathematical construction of the bone. The result of the existing disposition is, that the pronation of the radius, and the simultaneous advance, and inward motion, of its lower extremity, are performed *without disturbance to the parallelism of its superior joint.*



OF THE HAND.

264. The hand, which is the smallest, is also the most complex division of the upper extremity; containing twenty-seven bones, and thirty-two articulations. Moreover, as palpation and prehension are the distinguishing characteristics of the thoracic extremity, so does the hand, by which these functions are immediately performed, constitute its essential part; the arm and fore-arm serving but as subordinate agents, to remove the hand from the trunk, and to give scope and variety to its motions.*

The hand is of an ovoid form, convex posteriorly, con-

* Hence, these upper portions of the limb are often rudimentary, when the terminal division exists fully developed; as in the cetaceous mammalia.

cave in front. It is divided into three portions, distinguished by well-marked differences of size, form, and function; viz., the *carpus* or *wrist*, the *metacarpus* or *palm*, and the *phalanges* or *fingers*. Each of these divisions exceeds its predecessor in extent. Thus, to the length of the hand, which constitutes about a fourth of the entire limb (measured from the shoulder-joint to the tip of the longest finger), the carpus contributes (in round numbers) ten parts, the metacarpus eighteen, the phalanges twenty-eight.

OF THE CARPUS OR WRIST.

265. The carpus consists of eight small bones, disposed in two horizontal rows, of four each, and articulated, above with the fore-arm, below with the metacarpus, and intermediately with one another. The bones of the upper row, enumerated from the radial to the ulnar side (which is the direction always adopted in enumerating the bones of the hand), are the *scaphoides*, *semilunare*, *cuneiforme*, and *pisiforme*. The bones of the lower row, enumerated, in like manner, from without inward, are the *trapezium*, *trapezoides*, *magnum*, and *unciforme*.

The *pisiform* bone presents, in all its characters, a complete contrast to the rest of the series. It is peculiar in its form, in its size, in its relative position, and in its use. Hence in the following general description of the carpal bones, the pisiform must be understood to form a standing exception.

OF THE CARPAL BONES IN GENERAL.

266. Every carpal bone presents six surfaces, of which the *anterior* and *posterior* are rough for the attachment of ligaments; the *superior* and *inferior* smooth and articular; the two *lateral* also smooth and articular, when directed towards contiguous bones; otherwise rough and tubercular.

Of the non-articular surfaces, the *posterior* is generally wider than the *anterior*. Of the articular surfaces, the *superior* is generally convex, the *inferior* concave, the two *lateral* plane in the upper row, sinuously curved in the lower. All these rules, however, are subject to individual exceptions.

267. STRUCTURE. The interior conformation of the

bones of the carpus exemplifies that of the cuboid bones in general. They consist of a light and highly elastic cancellous tissue, enveloped in a very thin compact layer. DEVELOPMENT. By a single ossific point for each. These points appear successively at various periods, from the first to the fifteenth year after birth. Those of the os magnum and cuneiforme are first observed; that of the pisiform comes last. Indeed, of all the bones of the skeleton, the pisiform bone is the last to ossify.

The carpus is bound together by numerous ligaments, passing between the non-articular surfaces of adjacent bones. These ordinary fastenings of the carpus are implied, in the following descriptions, whenever mention is made of ligaments, without reference to any name at the foot of the page.

OF THE CARPAL BONES IN PARTICULAR.*

UPPER ROW.

268. SCAPHOIDES. A bone of an oblong form, the largest of its row, and so disposed that its long diameter runs, from above, obliquely downward, outward, and forward. SURFACES. *Superior.* Directed upward, outward, and backward. Convex, smooth, triangular, and articulated with the outer division of the articular surface on the lower extremity of the radius. (252) *Inferior.* Directed downward, outward, and backward. Convex, smooth, triangular, and divided, by a slight ridge running from before backward, into two portions; an *internal*, smaller in size, and quadrilateral in form, articulating with the trapezoides; an *external*, more extensive, and of triangular outline, articulating with the trapezium. (The

* I have described the carpal bones with a degree of minuteness which some persons may consider excessive, because I think that their shape and relations are far more rapidly and easily learnt by the aid of a precise than of a loose description. Cruveilhier, indeed, declares the separate examination of these bones to be tedious and useless, and satisfies himself with a collective description of each row. The inadequacy of this method is sufficiently shown by the errors into which it has betrayed its usually careful and accurate author (as, for example, that the pisiform articulates with the cuneiform by a *lateral* facet (p. 243); that the anterior surface of the semilunar bone is *less* extensive than the posterior (ibid.), &c.; misstatements rather implied than directly advanced; evidently not intended by the writer, but incidental to a vague and inexact method).

ridge of separation on this surface becomes indistinct, often quite imperceptible, when the articular cartilage is removed.) *Posterior.* Diminished in its vertical extent by the encroachment of the superior and inferior surfaces, which extend over this aspect, so as to leave between them only a narrow, rough groove, for the attachment of ligaments. *Anterior.* Directed forward, upward, and inward. Concave and rough above, elevated below into a prominent tubercle, which extends forward from the front of the carpus, for the attachment of a muscle,* and a ligament.† *External.* Directed upward and outward; narrow and rough for the attachment of a ligament.‡ *Internal.* Smooth and cartilaginous, divided, by a horizontal crescentic ridge, into two parts; a *superior*, directed inward and forward, narrow, semilunar, plane, and articulated with the semilunar bone; an *inferior* and larger, directed inward, forward, and downward, and contributing, by its oval concavity, to form the socket for the head of the os magnum. (274) ARTICULATIONS. With the radius above, the trapezium and trapezoides below, the semilunar bone and os magnum, internally.

269. SEMILUNARE. A bone of crescentic form, with the concavity directed downward; wider before than behind, and above than below; placed between the scaphoid and cuneiform bones. SURFACES. *Superior.* Smooth, quadrilateral, convex; continuous, in the united carpus, with the superior surface of the scaphoid; and directed upward for articulation with the inner of the two divisions on the terminal surface of the radius. (252) *Inferior.* Concave from before backward, plane from side to side, and divided, by a line running from before backward, into two parts; an *external* and larger, which forms the upper part of the socket for the head of the os magnum; an *internal*, very narrow, and directed a little inward, for articulation with the summit of the unciform bone. (275) *External.* Directed outward and backward. Narrow, semilunar, and plane, for articulation, with the scaphoid. *Internal.* Directed inward, forward, and downward. Smooth, flat, and quadrilateral, for articulation with the cuneiform bone. *Anterior* and *Posterior.* Rough for the attachment of ligaments. The anterior is the more

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* Abductor pollicis.

† Anterior annular ligament of the carpus.

‡ External lateral ligament of the wrist-joint.

extensive; the posterior being diminished, above, by the prolongation downward and backward of the superior surface. ARTICULATIONS. With the radius above, os magnum and unciform below, scaphoides and cuneiforme by its lateral aspects.

270. CUNEIFORME. A bone of a pyramidal form, having its long diameter placed obliquely, so that the base looks outward and upward, and the apex in the opposite direction. SURFACES. *Superior.* Divided into an *internal,* small, non-articular, portion; and an *external,* more extensive surface, convex and quadrilateral, smooth and cartilaginous, directed upward, inward, and backward, and articulated, by the intervention of an inter-articular cartilage,* with the end of the ulna. *Inferior.* Directed downward and outward, for articulation with the unciform bone; smooth, irregularly quadrilateral, and curved in such a manner that it is concave, and turned a little forward, externally; convex, and turned a little backward, at its inner extremity. *External.* Directed outward, upward, and backward; smooth, quadrilateral, and flat, for articulation with the semilunar bone. *Internal.* A small, non-articular surface, forming the lowest point of the bone, and roughened for the attachment of a ligament.† *Anterior.* This surface is rough externally for the attachment of ligaments; and presents, internally, a smooth, oval, slightly convex surface, which articulates with the pisiform bone. *Posterior.* Rough for the attachment of ligaments. ARTICULATIONS. With the semilunar bone externally, the pisiform in front, the unciform below; and above with the end of the ulna, through the medium of the triangular cartilage.

271. PISIFORME. This, the smallest of the carpal bones, is of an ovoid form, placed vertically, in front of the cuneiform bone, with which it articulates by a smooth concavity on its posterior aspect. It presents no other articular surface, being elsewhere rough for the attachment of muscles and ligaments.‡

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* Called the triangular fibro-cartilage of the wrist.

† A fasciculus of the internal lateral ligament.

‡ In front it gives attachment to the anterior annular ligament; externally, to a fasciculus of the internal lateral ligament of the wrist; above, to the flexor carpi ulnaris; below, to the adductor (sometimes incorrectly called *ab*ductor) minimi digiti; and, by its whole circumference, to ligamentous bands, by which it is fastened to the cuneiform bone.

SECOND ROW.

272. TRAPEZIUM. A bone of very irregular shape, situated between the scaphoid and the first metacarpal bone. SURFACES. *Superior.* Concave, and directed upward and inward, for articulation with the outer division of the lower surface of the scaphoid. *Inferior.* Directed downward and outward, convex from before backward, concave from side to side, and articulated with the first metacarpal bone. *Internal.* Divided into two parts by a horizontal ridge. The upper and larger portion is concave, and directed inward and backward for articulation with the trapezoid bone; the lower portion is a little flat facet, directed downward and inward, for articulation with a corresponding small surface on the second metacarpal bone. *External* and *posterior.* Rough for the attachment of ligaments.* *Anterior.* Presents, in the middle, a prominent ridge, running from above, downward, and a little inward. This corresponds to a similar, though much larger process of the unciform bone, and may be called the *oblique ridge* of the trapezium. It gives attachment to three muscles† and a ligament.‡ On its inner side is a *groove* which has a similar oblique direction, and gives passage to a tendon.§ ARTICULATIONS. With the scaphoides above, with the trapezoides and second metacarpal bone internally, and with the first metacarpal bone below.

273. TRAPEZOIDES. An irregular bone, the smallest of the second row, interposed between the trapezium and the magnum, larger below than above, and behind than before. SURFACES. *Anterior* and *Posterior.* Rough for the attachment of ligaments. The latter is the widest surface of the bone; the former gives origin to a muscle.|| *Superior.* Small, quadrilateral, and concave, for articulation with the scaphoid. *Inferior.* Concave from before backward, convex from side to side, and articulated with the second metacarpal bone. The surface sometimes articulates also with the extremity of the third metacarpal bone, by a narrow facet at its posterior and internal part.

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* The external lateral ligament is attached to the outer surface; the ordinary carpal ligaments to the posterior.

† Opponens, flexor brevis, and adductor pollicis.

‡ Anterior annular ligament of carpus.

§ That of the flexor carpi radialis. || Adductor pollicis.

External. Smooth, convex, directed outward and forward, and articulated with the corresponding surface of the trapezium. *Internal.* Concave and smooth in front, for articulation with the os magnum; rough behind, for the insertion of a ligament. ARTICULATIONS. With the scaphoid above, trapezium externally, os magnum internally, second (and occasionally third) metacarpal bone below.

274. MAGNUM. The largest bone of the carpus, in the centre of which it is placed. It presents a rounded portion called the *head*, above; a cubical portion called the *body*, below; and an intermediate contracted part, sometimes distinguished as the *neck*. The separate description of these parts would, however, involve an unnecessary degree of prolixity. It is sufficient to observe, that the head is received into a socket, formed by the scaphoid externally, and the semilunar bone above; and that it presents a smooth ridge, running from before backward, and corresponding to the junction of those two bones. Considered as a whole, the os magnum presents, like other cuboid bones, six *surfaces* for examination. SURFACES. *Superior.* Convex from before backward, more slightly so from side to side, and articulated with the concavity of the semilunar bone. *Inferior.* Divided, by two ridges running from before backward, into three portions. Of these the *middle* portion is by far the largest, and articulates with the third metacarpal bone. It is curved, so as to be convex posteriorly, slightly concave in front. The *outer* portion is next in size; it is concave, and directed downward and outward, for articulation with the second metacarpal bone. The *inner* portion is a little flat facet, situated at the posterior corner of the bone, directed downward and inward, and articulated with the fourth metacarpal bone. *Internal.* This surface of the bone presents, *posteriorly*, an oblong, concave, articular surface, which glides on the unciform bone; *anteriorly*, a rough surface, which attaches an interosseous ligament. *External.* Presents, at its lower and anterior part, a flat, smooth surface, for articulation with the trapezoides. *Behind* this surface is a rough space, for the attachment of an interosseous ligament. *Above* it is a rough groove, which represents the *neck*, and also attaches ligamentous fibres. Above this groove, again, is a smooth convexity, which articulates with the scaphoid, and forms the outer aspect of the *head*. *Posterior* and *Anterior.* Convex and

rough, for the attachment of ligaments. The former is much wider than the latter. Articulations. With the semilunar bone above; the second, third, and fourth metacarpal bones below; the scaphoides and trapezoides externally; the unciform bone on its inner side.

275. Unciforme. A large, wedge-shaped bone, placed, with its base downward, between the magnum and cuneiforme. It is characterized by a large hook-like process, which will be presently described. Surfaces. *Superior.* An extremely narrow facet, forming the apex of the bone, slightly convex from before backward, and directed upward and outward, to articulate with the semilunar bone. *Inferior.* Divided, by a ridge running from before backward, into two portions, of which the *inner* and larger is directed downward and inward, to articulate with the fifth metacarpal bone; while the *outer* looks directly downward, and articulates with the fourth metacarpal bone. Both these facets are concave from before backward; the outer is plane, the inner slightly convex, from side to side. *External.* Presents, *posteriorly*, a concave, articular surface, larger above than below, and articulated with the os magnum; in *front* of this, a small, rough, non-articular portion, for the insertion of an interosseous ligament. *Internal.* Directed obliquely inward and upward; curved in such a manner that it is convex, and looks a little backward, at its *upper* part; while it is concave, and turned somewhat forward, *below*. It articulates with the cuneiform bone. *Posterior.* Triangular, convex, and rough for the attachment of ligaments. *Anterior.* Presents, at its internal and inferior part, the *unciform process*, a large hook-like eminence, which first runs horizontal forward, and then curves outward, to give attachment, by its summit, to a strong ligament.* This process is flattened from side to side, so as to present two lateral *surfaces*, and a superior and inferior *border*. Externally, it is smooth, and grooved in the vertical sense, for the passage of several tendons;† and by its lower border it gives origin to two muscles.‡ This process, and the pisiform bone, by which it is surmounted, correspond to two smaller eminences occupying the same relative position at the opposite end of the carpus; viz., the

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* Anterior annular. † Flexor tendons of the hand.
‡ Opponens, and flexor brevis, minimi digiti.

oblique ridge of the trapezium, and the tubercle that projects from the scaphoid, immediately above it. These four eminences stand out from the front of the carpus, deepening its anterior concavity, and furnishing attachment to a strong, transverse ligament, which stretches across that concavity, closing it in front, and forming with it an oval ring, through which the flexor tendons run. They serve also for the attachment of several muscles, to which their prominence affords advantageous leverage; diminishing the obliquity, and, consequently, augmenting the force of their action upon the bones. Cruveilhier associates these processes as the four *apophyses of the carpus*, distinguishing them from each other by sub-appellations expressive of their relative position. Thus the pisiform bone is the *internal-superior*, and the unciform process the *internal-inferior*, apophysis: while the tubercle of the scaphoid, and the oblique ridge of the trapezium, are respectively the *external-superior*, and the *external-inferior*, apophyses of the carpus. This nomenclature is worthy of adoption, because it connects four eminences, which are naturally related by their position and use; also because it exhibits the pisiform in its true character, as an appendage to the cuneiform bone, rather than an independent element of the carpus; a view founded on the size and relations of the bone itself, and confirmed, as we shall hereafter find, by consideration of its analogue in the tarsus. ARTICULATION. The unciform articulates with the cuneiforme, semilunare, and os magnum of the carpus; and with the fourth and fifth bones of the metacarpal series.

OF THE CARPUS IN GENERAL.

276. The carpus, formed of these eight bones, is of an elliptical figure, with its long diameter transverse. It is convex from side to side, behind; but, in front, presents a concavity, increased by the four *apophyses of the carpus*, so as to form a deep groove, which transmits the flexor tendons of the hand. The upper border of the carpus is convex and even, to articulate with the radius, and, by the intervention of the triangular fibro-cartilage, with the ulna. The lower border also presents a general convexity, though interrupted, and, as it were, notched, for articulation with the metacarpal bones. It may be inferred from this form of the carpus, that the bones of the upper row (speaking generally) are wider above than

below; those of the lower row, on the contrary, wider below than above; and all, of both rows, wider behind than before.

It is usual, in treating of the carpus in general, to deliver some observations upon the structure and relations of each row considered as a whole. But I object to this horizontal division of the carpus, for reasons which will appear in the following section; in which also will be explained the principles of a new, and, as I believe, more philosophical arrangement of the carpus, deduced from an analysis of its mechanical construction.

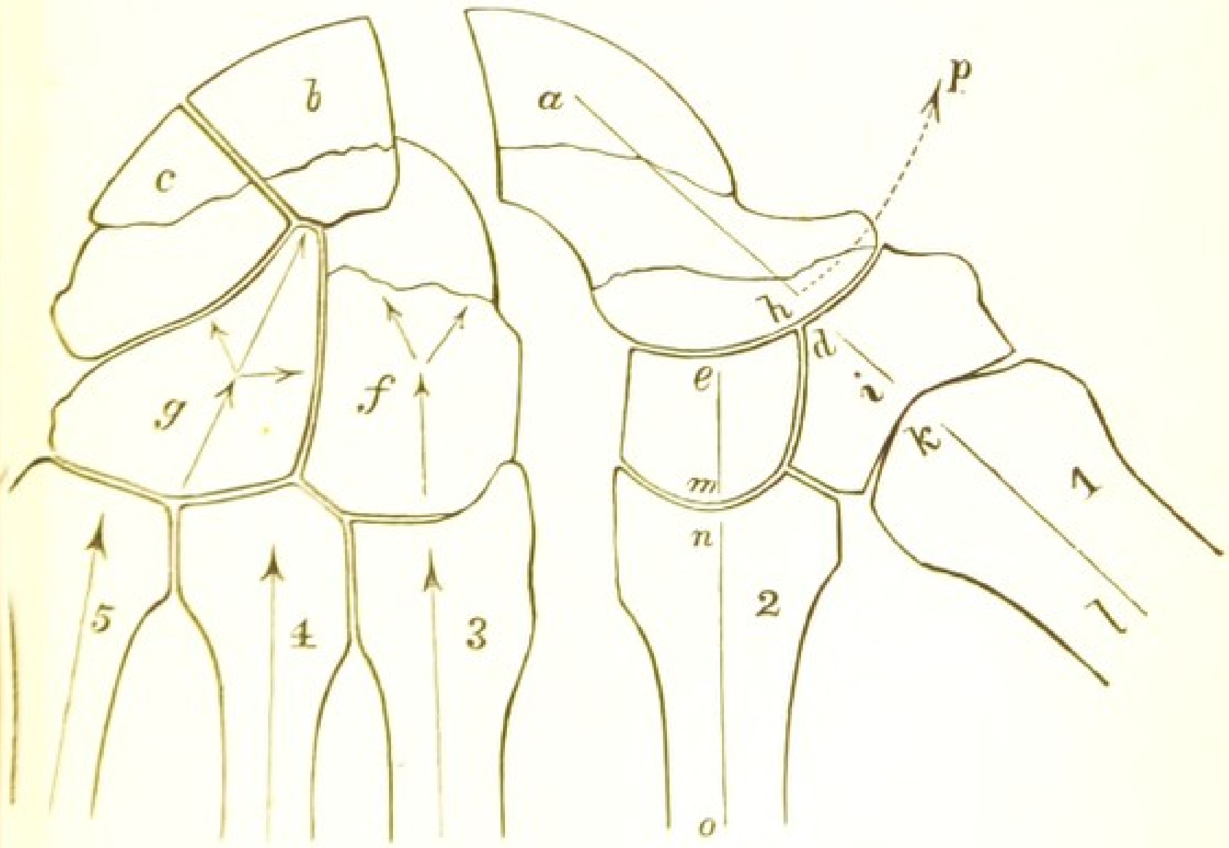
MECHANISM OF THE CARPUS.

277. Under this head we have to consider, first, the relations of the carpo-radial and carpo-ulnar articulations; and, secondly, the structure of the carpus itself, and the motions of its proper joints.

278. The *carpo-radial* articulation presents most of the characters of an enarthrosis, or ball-and-socket joint. The carpal articulating surface is convex in every sense, and capable of rolling from before backward, and from side to side, in the shallow terminal concavity of the radius; communicating to the hand the motions of *extension* and *flexion*, *abduction* and *adduction*, as well as the compound movement of *circumduction*, which results from the performance of the four simple motions in successive combinations of two. The adduction of this joint is more extensive than its abduction, for reasons which will be explained in the following paragraph. (279) Its extension can be carried further than its flexion, because the carpal articulating surface descends lower, and can, therefore, roll further upon the radius, behind than before. (This difference, however, is more than compensated by a capability of flexion resident in the carpus itself; (283) so that, disregarding particular joints, and considering the hand generally, the motion of flexion is superior to that of extension.)

The carpus has not the true globular form of an enarthroidal head, being considerably more extensive transversely, than in the antero-posterior diameter. Hence, it is totally incapable of rotation on its own axis (a motion characteristic of genuine enarthrosis), and is not brought into action by the pronation and supination of the hand. These motions are performed by the bones of the fore-arm, in a manner already described. (262) The advantage of this disposition is twofold. In the first place, the stability of the carpo-radial joint is increased by its lateral extension; and secondly, the long shaft of the radius affords space for the insertion of a much larger body of pronators and supinators, than could be brought to act directly upon the carpus itself.

279. The *carpo-ulnar* articulation is smaller, and far less important, than the last described joint. It is formed by the smooth lower extremity of the ulna, on the one hand, and by the superior aspect of the cuneiform bone on the other. Both its surfaces, when covered with their natural cartilage, are convex, and, consequently, not adapted to play upon each other. But they are prevented from coming into contact by an inter-articular cartilage; which, being slightly hollowed on both sides, furnishes each surface with a concavity adapted for its reception. It may be further observed, in regard to the carpo-ulnar joint, that it is only brought into play during the movement of adduction; its surfaces being separated by a considerable interval, when the hand is in a straight line with the fore-arm; and by a still greater, when it is



inclined outward. This non-contiguity, which depends upon the oblique aspect of the superior surface of the cuneiform bone, is in strong contrast with the constant and close apposition of the carpo-radial joint, and accounts for the superior freedom and extent of the motion of adduction.

280. The articulations of the *carpal bones with each other*, are chiefly designed to distribute the force of concussions transmitted from the metacarpus to the extremity of the radius. The number and complexity of these joints seem hitherto to have deterred anatomists from attempting an exact analysis of their curious mechanism. But their several actions may be clearly and orderly developed, by the simple expedient of ascertaining successively the effect of a shock transmitted along each of the metacarpal bones.

The preceding diagram represents a posterior view of the carpus, artificially separated (for reasons which will presently appear) into two lateral portions, and somewhat enlarged for distinctness' sake. *a* represents the scaphoid bone, *b* the semilunar, *c* the cuneiform, *d* the trapezium, *e* the trapezoides, *f* the magnum, and *g* the unciform; while the figures 1, 2, 3, 4, 5, are placed, each upon the metacarpal bone of which it is the numerical designation.

281. A blow, struck upon either the fourth or fifth metacarpal bone, in the direction of its length, is received by the unciforme; which, yielding to the shock, insinuates its wedge-like body further between the magnum and cuneiforme, dividing part of the shock between those two bones; while its narrow summit, impinging upon the semilunare, transmits another portion of the violence in a direct line through that bone to the radius.

A blow upon the middle metacarpal bone, passes directly to the os magnum, and is divided between the scaphoides and semilunare, with which the head of that bone articulates.

The several directions in which these shocks reach the carpus, are indicated in the diagram, by the arrows drawn upon the last three metacarpal bones; and their subsequent distribution is shown by the groups of arrows drawn upon the unciform bone and the os magnum.

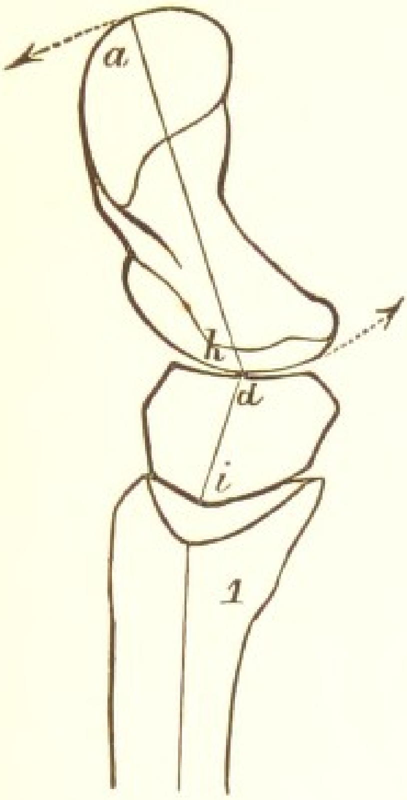
Several other motions are impressed upon this part of the carpus by concussion of the fingers which it supports. I have observed a slight twisting motion of the cuneo-unciform joint, in which the unciform bone advances a little at its outer side (gliding forward upon the os magnum) and retreats in a corresponding degree internally; a species of rotation which is evidently favoured by the alternate convexity and concavity of the articulating surfaces of this joint. There is also a hinge-like motion in the vertical plane performed by the os magnum, the head of which turns within its scapho-semilunar socket, so that its lower extremity passes a little backward.

The student must bear in mind, in studying these actions of the carpus, how speedily all its motions are arrested by the tension of the carpal ligaments; upon which, owing to this very circumstance, the force of every concussion is, in a great measure, spent.

282. We now come to consider that portion of the carpus which is interposed between the radius and the two most exposed of the metacarpal bones; viz., the first and second of the series; which bones, in all manual exertions (as, for instance, in striking with a tool grasped in the hand, thrusting with the open palm, falling upon the upper extremity, &c.) sustain the chief violence of every strain and concussion. And here, expecting to find a separate mechanical contrivance for the mitigation of violence passing along each of these bones, one is pleased to observe how with a single, and most simple provision, Nature has satisfied the double exigence. The contrivance to which I allude, consists in a twofold obliquity of the scaphoid bone; the exact direction and effect of which will be understood by reference to the smaller of the two divisions in the last diagram, which represents the two metacarpal bones in question, and the scaphoid (*a*) trapezium (*d*) and trapezoides (*e*) by which they are supported. The axes of these several bones are respectively indicated by the straight lines *a h*, *d i*, *k l*, *e m*, and *n o*; and, upon comparing the direction of these lines, it will be seen that the axis of the scaphoid is inclined upon that of the trapezoides, so as to form with it an obtuse angle, having its apex turned toward the radial side. The abruptness of this angle undergoes a momentary increase, during the passage of a concussion from the fore-finger to the radius; the lower end of the scaphoid moving in the direction *h p*, and, by this action, throwing the force of the shock, partly on the surfaces of the joint itself, partly upon those of the contiguous bones, and partly upon several of the carpal ligaments, which are put, for an instant, upon the stretch, and immediately afterwards,

by their reaction, restore the bones to their original position.

But this diagram exhibits no such angle interposed between the radius and the first metacarpal bone. The axes *a h*, *d i*, *k l*, form a continuous straight line, along which a concussion might travel, with unbroken violence, from the thumb to the extremity of the radius. In fact, the arrangement to which the thumb owes its elasticity cannot be seen in this view of the carpus. It is shown in the annexed sketch, which represents the scaphoides, trapezium, and first metacarpal bone, seen from the radial side. In this *lateral* view, the axis of the scaphoid (*a h*) is seen to form with that of the trapezium (*d i*) an obtuse angle, having the apex directed *forward*, and consequently, not visible in a diagram of the *back* of the carpus. The angle is precisely analogous, in its relations and use, to the former; promoting, by similar means, and probably in about an equal degree, the longitudinal elasticity of the finger which it supports.



283. Besides the motions thus impressed upon the carpus by concussions, its joints are brought into play during the ordinary movements of the hand. Thus, in *flexion*, the os magnum turns within its object, so that its lower extremity advances, together with the adjacent bones; while the scaphoid, gliding below upon the trapezium and trapezoides, assumes a less oblique position. In *extension*, precisely the opposite motions occur; the os magnum retreats at its lower extremity, and the inclination of the scaphoid is increased. *Abduction* and *adduction*, when suddenly and forcibly performed, produce slight gliding motions among the carpal bones, by which the jar of abrupt checks is considerably diminished. The carpus is also susceptible of a general movement, by which its anterior concavity is slightly increased. But these, and the like, are secondary actions—incidental rather than essential functions of the carpus; which appears to be

organized for the special, and primary purpose of affording an elastic support to the fingers.

284. This account of a few of the principal motions of the carpus, is chiefly derived from a minute experimental analysis of the mechanism of the human hand and foot, which has occupied me, at intervals, during several years; and may furnish, when completed, the material of a separate treatise. I shall conclude, for the present, by suggesting a new classification of the carpal bones, founded on this analysis, and as I believe, more extensively applicable, and, therefore, more convenient, than the present division into horizontal rows.

285. The carpus, considered with regard to its mechanical structure, consists of two *lateral portions;* an *external*, smaller, comprising the scaphoides, trapezium, and trapezoides, presenting the *trapezio-scaphoid*, and *trapezoido-scaphoid* angles, and supporting the first two metacarpal bones; an *internal*, larger, formed by the five remaining carpal bones and supporting the three inner bones of the metacarpal series. Each of these portions is further susceptible of a horizontal subdivision.

The *inner* portion, in the arrangement of which the characters of firmness and solidity are conspicuous, presents two bones and a fixed *apophysis* (the unciform) *below;* two bones, and a movable *apophysis* (the pisiform) *above.*

The *outer* portion, in the construction of which the character of elasticity predominates, presents two small bones, of cubical form, *below;* and one, of larger size, elongated figure, and a doubly oblique inclination, *above.* This portion, like the former, possesses two *apophyses*, the *superior*, tubercular (belonging to the scaphoid), the *inferior* an unciform ridge (of the trapezium). (These two portions of the carpus are shown, a little separated from each other, in the diagram at page 233.)

A precisely analogous difference in arrangement and elasticity, will hereafter be shown to exist between the lateral portions of the tarsus; so that this new division furnishes a ready means of classifying the cuboid bones, as well in the foot as in the hand; a double applicability which the horizontal division cannot be said to possess, except it be taken in connexion with certain transcendental views concerning the modification and transposition of bones, which the English schools are not yet prepared to admit. And if those views should be adopted, the principle of combining the horizontal and longitudinal divisions in one method, as here proposed, will still have the advantage of suggesting, at once, the *transcendental* and the *mechanical* relations of the carpus.

OF THE METACARPUS.

286. The *metacarpus* presents a series of five cylindrical bones, which are articulated with the carpus above, and descend, diverging a little, to support the phalanges below. These bones are designated numerically—first, second, third, fourth, fifth, proceeding from the radial to the ulnar side. They are all formed upon the same model, with the exception of the first, which is analogous in several of its characters to the phalanges. For this reason the first, or *os metacarpi pollicis*, will not be included in the following general account of the metacarpal bones; but will be reserved for separate description in the section on their differential characters.

COMMON CHARACTERS OF THE METACARPAL BONES.

287. Each metacarpal bone presents for examination two *extremities*, connected by a *body* or *shaft*.

288. EXTREMITIES. *Superior* or *Carpal*. This extremity is considerably expanded, somewhat of a cubical form, and wider behind than before. It presents five *surfaces*; a *superior*, smooth and cartilaginous for articulation with the carpus: an *anterior* and *posterior*, rough and tubercular for the attachment of ligaments;* and lastly, an *internal* and an *external*, presenting small articular facets, by which the metacarpal bones articulate with each other. *Inferior* or *digital*. Formed by an oblong, articular condyle, flattened on each side, and prolonged forward, so that its antero-posterior exceeds its transverse diameter. Like the upper extremity, it presents five *surfaces* for examination. The *inferior* or *terminal* surface is convex in all directions, but especially from before backward. It is wider, and extends further upward, before than behind. In the recent state, it is covered with cartilage, for articulation with the first phalanx of the corresponding finger. Each *lateral* surface presents a rough *depression*, bounded posteriorly by a small *tubercle*. To this tubercle, and to the posterior part of the depression, the upper extremity

* Dorsal and palmar carpo-metacarpal ligaments.

of a ligament* is attached. The *posterior* surface is wide and flat. The *anterior* is rendered slightly concave by two little tubercles, which project forward, one on each side, like diminutive condyles; and the shallow groove thus formed transmits the flexor tendons of the corresponding finger.

289. BODY or SHAFT. Of a prismatic form, curved so as to be convex from above downward behind, concave in the same direction in front, and divided by three *lines* into three *surfaces*. LINES. *Anterior*. This line commences above by two roots, one from each side of the superior extremity; becomes rough and prominent as it descends; and bifurcates below to terminate at the two little condyloid eminences of the inferior extremity. The superior and inferior bifurcations of this line enclose small triangular spaces, which form, as it were, vestiges of an anterior surface, and furnish a bearing for the flexor tendons, in their passage across the palm. It is on or near the anterior line, a little above the middle of the shaft, that the *medullary foramen* is seen, entering the bone obliquely *upward*. (In adult specimens, however, this aperture is usually closed up, and its place cannot be discerned.) *Inner* and *outer*. A common description will suffice for these lines. Each descends from one side of the superior extremity, to the lateral tubercle on the corresponding side of the lower extremity. Smooth, but sufficiently distinct, they separate the posterior from the two lateral surfaces. SURFACES. *Posterior*. Convex from above downward, and wider above and below than in the middle. Its upper half is divided, by a longitudinal ridge, into two narrow portions. This ridge bifurcates at the middle of the bone, and its branches run to the lateral tubercles of the lower extremity. Thus the posterior surface is divided into three portions; two *superior*, directed laterally, of triangular form (with the apex downward), giving attachment to muscles;† one *inferior*, and more extensive, also of triangular figure (but with the apex above), flat, directed backward, and covered by the tendons which extend the fingers. *Lateral*. These surfaces are separated from each other by the anterior line. They are slightly concave from above downward, and convex in the opposite direction. They correspond to the *interosseous spaces*

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* Lateral ligament of the metacarpo-phalangeal joint.

† Dorsal interossei.

which exist between the shafts of the metacarpal bones, and they give attachment to the muscles which those spaces contain.*

290. STRUCTURE. The metacarpal bones have already been stated to belong to the class of cylindrical or long bones; we have here to add, that they present the interior conformation common to that class; an account of which will be found appended to the description of the humerus. (248) DEVELOPMENT. The four metacarpal bones to which the above general description exclusively applies are developed by two points each; one for the shaft, and one for the lower extremity. The metacarpal bone of the thumb has a peculiar development, which will be mentioned among its differential characters. ARTICULATIONS. With the carpal bones, and with each other above; with the phalanges below.

OF THE DIFFERENTIAL CHARACTERS OF THE METACARPAL BONES.

OF THE FIRST METACARPAL BONE, OR OS METACARPI POLLICIS.

291. This is the shortest and widest of the metacarpal bones. It is placed on a plane anterior to that of the other four; and it is so turned, that its anterior surface looks somewhat inward toward them. Moreover, it diverges from its carpal joint more than any other bone of the series; whence the great width, and triangular form, of the interosseous space between this and the second metacarpal bone.

292. EXTREMITIES. *Superior.* Is most extensive in the transverse diameter. Its *carpal articulating* surface is remarkably curved, being concave from behind forward, and convex from side to side, to correspond with the lower surface of the trapezium, upon which it enjoys considerable variety and extent of motion. Its *lateral* surfaces are distinguished by the absence of articular facets (for this bone articulates with no other of its series); the *outer* presents a rough tubercle for the attachment of a muscle.† The *anterior* and *posterior* surfaces appertain to the prolongations of bone which ascend before and

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* Interossei. † Extensor ossis metacarpi pollicis.

behind, from this extremity, to embrace the trapezium. These two processes deserve attention. The anterior is long and thin; the posterior is the shorter, thicker, and apparently the stronger of the two. *Inferior.* This extremity differs in several respects, from the corresponding portion of the other metacarpal bones. It is more extensive from side to side, than from before backward; its terminal surface is less convex especially in the transverse direction; and prolonged upward in front to form two little articular condyles, one on each side, which correspond to the two sesamoid bones of the thumb.

293. SHAFT. The great width and the oblique position of the shaft of this bone have already been noticed. Its *anterior line* gives attachment to a muscle,* and is less distinctly marked than the *lateral lines*, each of which also attaches a muscle.† The *posterior surface* is wide, and destitute of the bifurcated ridge which the other metacarpal bones here present.

294. DEVELOPMENT. This bone is developed by two ossific points; one for the shaft, the other for one of the extremities. But, whereas in all the rest of the series, it is the *lower* extremity which ossifies separately, in this bone, on the contrary, the extra point occurs in the *upper* extremity; a character tending (as we shall presently find) to assimilate this bone to the phalanges. Of the remaining metacarpal bones, the third is the longest. The second, fourth, and fifth, diminish in length in the order of enumeration. (The first, as we have already observed, is the shortest and thickest of the series.) They are further distinguished by peculiarities of form, almost exclusively confined to their upper extremities.

OF THE SECOND METACARPAL BONE, OR OS METACARPI INDICIS.

295. This is the longest bone of the series. Its *carpal extremity* is prolonged upward internally, and presents *before* and *behind*, rough muscular impressions.‡ Its terminal surface is divided into three parts; of which the

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* Flexor brevis pollicis.

† The internal attaches the abductor indicis, and the external, the opponens pollicis.

‡ For the flexor carpi radialis in front, the extensor carpi radialis longior behind.

middle is by far the largest, concave from side to side, and slightly convex from before backward, for articulation with the trapezoid bone; the *outer* is a flat quadrilateral facet, directed upward, outward, and forward, for articulation with the trapezium; the *inner* is a narrow surface, directed upward and inward, for articulation with the os magnum. *Internally*, this extremity articulates by two flat facets, placed one before the other, with corresponding surfaces on the third metacarpal bone.

OF THE THIRD METACARPAL BONE.

296. Upper extremity. Presents, at its external and posterior part, a strong pyramidal eminence, which, in the articulated hand, is seen extending upward behind the os magnum. The carpal articulating surface is concave behind, and convex in front. It corresponds to the middle of the three divisions of the inferior surface of the os magnum. Each *lateral* surface of this extremity presents two little articular facets (which are sometimes united so as to form a single surface) for articulation with similar facets on the adjacent metacarpal bones. Its *posterior* surface is marked with a small tubercle, which indicates the attachment of a muscle.*

OF THE FOURTH METACARPAL BONE.

297. Upper extremity. The *terminal surface* is divided into two parts; an *internal*, large, slightly convex from before backward, plane transversely, and articulated with the unciform bone; an *external*, very small, flat, situated posteriorly, and articulated with the os magnum. Its *outer* surface presents two oval facets, separated by a deep groove, and articulated to the corresponding facets on the third metacarpal bone. Its *inner* aspect presents a narrow, concave, articular surface, which unites with a similar one on the fifth metacarpal bone.

OF THE FIFTH METACARPAL BONE.

298. Upper extremity. Presents a *terminal surface*, convex from before backward, slightly concave from side to side, and directed a little outward, to articulate with

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* Extensor carpi radialis brevior.

the unciform bone; an *outer surface*, narrow, slightly convex, and articulated with the fourth metacarpal bone; an *inner surface*, marked with a rough tubercle, for attachment of a muscle.*

299. BODY. Is remarkable for its posterior surface, which, instead of the usual longitudinal bifurcated ridge, presents a simple *oblique line*, running diagonally, from the inner side of the upper extremity, to the outer side of the lower. It is thus divided into two parts, of which the *outer* is concave, for the attachment of a muscle,† while the *inner* (also the inferior, and the more extensive of the two) is smooth, flat, and covered by tendons.‡

OF THE METACARPUS IN GENERAL..

300. The metacarpus, viewed collectively, constitutes a region of quadrilateral form, wider below than above, convex on the dorsal, concave on the palmar aspect. Its MECHANISM may be considered under two heads; first, the relations of the metacarpus to the carpus, or the *carpo-metacarpal articulations;* second, the mutual relations of its several bones to each other, or the *inter-metacarpal articulations.*

301. The *carpo-metacarpal* joints are formed, generally speaking, by the contact of slightly-curved surfaces, susceptible only of very limited gliding motions on each other. But the articulation between the trapezium and the metacarpal bone of the thumb, is distinguished from the rest, as well by the peculiarity of its form, as by its superior mobility. Its articulating surfaces are alternately convex and concave, in opposite directions, so as mutually to embrace and receive each other; exemplifying a kind of joint which occurs in several parts of the skeleton, and may, perhaps, be conveniently distinguished by the name of *reciprocal enarthrosis.* Like the radio-carpal articulations, this joint possesses, in a limited degree, all the motions of an ordinary enarthrosis, except rotation; which is obviously prevented by the configuration of the opposed surfaces. To the diversified motions of this joint, the great mobility of the thumb, and its power of *opposition* to the fingers (an action characteristic of the hand), are, in a great measure, to be ascribed.

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* Extensor carpi ulnaris. † Fourth dorsal interosseous.
‡ Extensors of the little finger.

Of the remaining carpo-metacarpal articulations, two only are remarkable. The *second* presents a recess, formed by the trapezium, trapezoides, and magnum, into which the metacarpal bone of the index finger is received, and by which it is very firmly maintained in its position. The *fifth* resembles the first in the double curvature of its articulating surfaces; and its motions, though far more limited in degree, are of the same kind.

302. The *inter-metacarpal joints* are formed merely by the meeting of flat, lateral facets, on the upper extremities of the metacarpal bones; they are specimens of the simplest form of *arthrodia* or *gliding joint;* and their motions, being speedily checked by the neighbouring ligaments, are neither extensive nor important.

OF THE FINGERS.

303. The fingers are five jointed columns, of a conical form, articulated by their bases to the metacarpal bones, and free in the rest of their extent. Each finger consists of three *phalanges*, distinguished from each other, as first, second, and third, or *metacarpal*, *middle*, and *terminal*. The only exception to this rule occurs in the thumb; in which the middle phalanx is deficient, and the first articulates immediately with the third; wherefore, viewed collectively, the fingers present a series of fourteen *phalanges*, disposed in three horizontal rows, of which the first and third contain five bones each, the second only four. The phalanges of each row resemble one another, and differ from those of the two other rows. However, neither the difference nor the resemblance is so absolute, but that there remain, on the one hand, certain characters common to the whole series of phalanges, and, on the other, means of identifying, among its fellows, each individual member of either row. We have, therefore, to consider, in the first place, the characters of the phalanges in general; secondly, the characters peculiar to the bones of the first, second, and third rows respectively; and lastly, the means of distinguishing, and ranging in right order, the particular bones of each row.

CHARACTERS COMMON TO ALL THE PHALANGES.

304. The phalanges are bones of the class called cylindrical; and they, consequently, present for examination, a *body*, or *shaft*, and two *extremities*.

305. The *extremities* are more extensive in the transverse than in the antero-posterior diameter, convex behind, slightly concave in front, rough and tubercular on each side. The *superior* extremity exceeds the *inferior* in size; it is of a somewhat cubical form, and presents a concave terminal articulating surface, adapted to the convex extremity of the bone above. The *inferior* extremity, being articular in the two upper rows, non-articular in the third, is not susceptible of a general description. The *shaft* tapers, more or less, from above downward, and is curved upon itself in the direction of its length, so as to be convex posteriorly, concave in front. It presents an *anterior* and a *posterior surface*, separated by two *lateral borders*. Its surfaces are smooth; the *posterior* is convex in both directions, and in relation with the extensor tendons; the *anterior* is concave longitudinally, in general also slightly hollowed from side to side, and covered by the flexor tendons. Its sides are rounded and prominent, for the attachment of ligaments.* The *lateral borders* are sharp and rough; they commence superiorly at the anterior corners of the cuboid upper extremity; converge as they descend, in consequence of the tapering form of the bone; and terminate, below, at the sides of the inferior extremity.

CHARACTERS DISTINGUISHING THE PHALANGES OF EACH ROW.

306. First row. The phalanges of this row are the longest and largest of the series. Their *upper extremity* is hollowed above by a shallow articular concavity, which receives the head of the corresponding metacarpal bone. This depression, being of an oval form, with its long diameter from side to side, is insufficient of itself to cover the head of the metacarpal bone, which is more extensive in the antero-posterior than in the transverse diameter. But, in the recent subject, a glenoid ligament,

* Lateral ligaments.

of dense fibrous texture, is attached to the anterior border of this extremity, and prolongs the cavity upward and forward, supplying that portion of the socket in which the phalanx itself is deficient. A tendon is attached to each lateral surface, and another (occasionally) to the posterior aspect, of this extremity.* The *lower extremity* is terminated by a smooth, trochlear surface, which presents two lateral convexities, separated by a wide, shallow groove. This surface is prolonged further upward, its width is greater, and its convexities are more prominent, before than behind. The *sides* of the lower extremity present roughened depressions for the attachment of ligaments.† The *shaft*, in this, and in the following row, has the appearance of a cylinder, of which the anterior half has been removed by a longitudinal section, and the remaining portion curved a little on itself, and slightly grooved from above downward in front. The *surfaces* and *borders* are accurately represented by the foregoing general description. The borders give attachment to the fibrous sheaths in which the flexor tendons run.

307. SECOND ROW. The phalanges of this row are intermediate in size, as in position, between those of the first and third. They are distinguished from the former by the articular surface of the upper extremity, which presents two lateral depressions, separated by a smooth ridge, and corresponding to the little condyles of the phalanx above. In other respects their configuration exactly resembles that of the preceding row. They give attachment each to two tendons.‡

308. THIRD ROW. These little bones, which sustain the nails behind, and the sensitive pulp of the fingers in front, are immediately recognised by their small size, the rapidly tapering form of the shaft, and the peculiar character of the non-articular lower extremity, which presents, anteriorly, a convex roughened surface, of a

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* The lateral surfaces give insertion to the interossei; the posterior surface attaches, in the thumb, the extensor primi internodii pollicis, and occasionally, in the remaining fingers, little slips given off by the tendons of the extensor communis digitorum.

† Lateral ligaments.

‡ By their rough lateral borders to a bifurcated tendon of the flexor digitorum sublimis perforatus; by the posterior surface of the upper extremity to the middle of the three slips, into which each tendon of the extensor communis digitorum divides.

semilunar or horseshoe figure, bounded inferiorly by a serrated semicircular margin, that separates it from the posterior aspect, and constitutes the tip, or free termination of the bone. The ends of this semilunar surface are directed upward, and I have sometimes observed them prolonged, in the form of little conical processes, about a line long, with free pointed extremities. The *upper extremity* of this phalanx is very large in proportion to the lower; its circumference is remarkably tubercular, and presents in front and behind rough tendinous impressions.* Its *superior surface* is an exact repetition of the corresponding articular aspect in the phalanges of the second row.

MEANS OF DISTINGUISHING THE PARTICULAR PHALANGES OF EACH ROW.

309. The phalanges of each row exactly resemble one another in form, and would be indistinguishable but for their difference in size. Their dimensions are proportionate to those of the fingers to which they belong. Thus, as the middle finger is the longest of the fingers, so its phalanges are respectively the longest bones of the three rows. The ring finger, fore-finger, little finger, and thumb, follow the middle finger, diminishing in length in the order of enumeration. The comparative width and thickness of the fingers is represented by the same order, except that the ring finger and fore-finger change places, and that the thumb stands first instead of last—its phalanges being at once the shortest and the stoutest of the series.

Thus, then, the phalanges of each row are only known from one another by their relative dimensions; and a comparison of the whole row is necessary for the identification of either one.

310. In the recent subject, several phalanges are distinguished by the possession of special motors. Such are

* In the thumb, the anterior surface of this phalanx, gives attachment to the flexor longus pollicis; the posterior, to the extensor secundi internodii pollicis. In the other fingers, the anterior surface gives insertion to a tendon of the flexor digitorum profundus perforans; the posterior, to a conjoined slip formed by the two lateral of the three portions into which each tendon of the extensor digitorum communis divides.

the phalanges of the thumb, of the index-finger, and of the little finger.*

311. STRUCTURE. The internal conformation of the phalanges resembles that of the cylindrical bones in general. (248) DEVELOPMENT. Each phalanx is developed by two points of ossification, one for the body and lower extremity, the other for the upper extremity. The first appears early in fœtal life, the second not until several years after birth. The two separately-developed portions unite between the eighteenth and twentieth year. ARTICULATIONS. The first phalanx of each finger articulates with the corresponding metacarpal bones, the second and third articulate each with its predecessor.

312. MECHANISM. The mechanism of the fingers is simple. The *metacarpo-phalangeal* joints are enarthroses, capable of flexion, extension, abduction, adduction, circumduction, and, in a very limited degree, of rotation. *Flexion* may be continued till the articulating bones form a right angle with each other; *extension* can be carried only a few degrees beyond the right line; *abduction* and *adduction* are intermediate in point of freedom between flexion and extension; the scope of *circumduction* may be inferred from that of its constituent motions; *rotation* is very obscure and limited. The inter-phalangeal joints are of the class called ginglymoid; they enjoy hinge-like motion in a single plane, flexion to a right angle, extension to a right line. Their motion is steadied, and their liability to dislocation diminished, by the reception of a central ridge on the lower surface into a corresponding groove of the upper; and of two lateral convexities of the upper, into depressions of similar form and dimensions, hollowed on the lower.

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* The extensor primi and secundi internodii pollicis, and the flexor longus pollicis, are attached to the phalanges of the thumb, at points already indicated; and besides these, the flexor brevis, abductor, and adductor pollicis, are inserted into the upper extremity of its first phalanx. The index and little finger possess, each of them, a special extensor, which unites its tendon to that of the common extensor; and the little finger is furnished also with a short flexor, and a short adductor, attached to the superior extremity of its first phalanx.

OF THE HAND IN GENERAL.

313. The functions of the hand, though for the most part matters of common experience, assume a new interest when considered in connexion with its anatomical structure. Their number and variety, contrasted with the simplicity of the mechanism by which they are performed, illustrate the characteristic tendency of Nature to produce, by the simplest possible means, the most numerous and diversified possible results. Guided by this general truth, and bearing in mind the foregoing anatomical descriptions, let us review some of the ordinary actions of the hand. Compare, for instance, the light and gently-varying compression with which it confines a fluttering bird, to the firm and unrelaxing hold with which it grasps a warlike weapon, or wields some heavy tool. Consider the swiftness of its movements in following a speaker with the pen; their variety in loosening a tangled knot; their nicety and precision in passing a thread through the eye of a needle. How steadily it guides the edge of the scalpel in a critical operation of surgery; with what singular truth it shapes the course of the schoolboy's marble, or points his arrow to its mark! Nor are these the most wonderful of its performances. Trained to the juggler's sleight, its joints become yet nimbler and more pliant. Its evolutions, in the practice of several mechanical arts, are swifter than the eye can follow, of unerring regularity, independent of the guidance of vision, and productive of the most surprising results. In the musician, the statuary, the painter, it becomes the minister of more subtle volitions, and a higher instinct; in them, accordingly, it acquires still greater freedom and fluency of motion, a yet more exquisite refinement and fidelity of touch. In the orator it assumes a new character, and functions of an entirely different order. For him, it is a powerful organ of expression, an indispensable auxiliary to speech. Accompanying, with significant gestures, the thoughts and emotions of the mind, it becomes the visible exponent of its secret workings—the *tongue*, so to speak, of a language common to all mankind. Bring together the wandering Arab—the red warrior of the American forests—the feathered barbarian of Africa—the civilized European. Which of them will mistake the meaning of a hand, clenched in anger, or shaken in defiance; stretched

abroad in the attitude of command, or raised to heaven in solemn attestation; waved triumphantly above the head, or pointing the finger of scorn; beckoning, to summon attendance; barring the lips, to enjoin silence; calmly extended in benediction; flung wildly forth in despair; covering the face in shame; wrung in the bitterness of grief; spread, shuddering in horror; folded tranquilly in the act of prayer? Our limits forbid us to pursue this subject, or to multiply illustrations. We will select, for our concluding example, a function of the hand, which stands in strong contrast to all that have gone before, and furnishes a new proof of the remarkable *versatility* of its powers. This delicate organ—capable, as we have seen, of moving with the speed and precision of clockwork—may be doubled to form a weapon of offence, and employed, in the manner of a bludgeon, to give heavy blows, or to repel the strokes of an assailant. These violent concussions it sustains uninjured; eluding their force by its elasticity; and returning, with unimpaired activity, to the operations of the lathe or the loom.

OF THE LOWER EXTREMITY.

314. We have already had occasion to observe, that in the lateral segments of the lower jaw, the prehensile appendages of the thorax, and the pair of limbs attached to the pelvis, the transcendental anatomists trace the threefold repetition of a common type, subject to such modifications of size and form as are necessary to fit it, in each instance, for the performance of special functions. These analogies are overlooked, or denied, by descriptive anatomists, so far as the jaw is concerned: but the similarity between the thoracic and pelvic extremities, is so striking, that their relation to a common standard is now universally recognised. Thus the *thigh, leg, and foot*, in the inferior extremity, correspond to the *arm, fore-arm, and hand*, in the superior; while the *haunch*, articulating with the *thigh*, is strictly analogous to the *shoulder* which supports the *arm*. And, as the regions of each limb have their respective analogies in the other, so have also the subdivisions of each region—so have the bones of each subdivision—so have even the principal lines and processes of each separate bone. So far as the admission of descriptive anatomists extends, the consideration of these analogies falls within the plan

of the present treatise. A comparative review of the thoracic and pelvic extremities will, accordingly, be found in the concluding section of this chapter. Meanwhile we shall proceed to describe, in succession, the three regions enumerated above; viz., the *thigh*, the *leg*, and the *foot;* referring the student to the fourth chapter (192—206); for a description of the *haunch*, and for an account of its true relations.

OF THE THIGH.

315. The *thigh* is formed by a single bone, called the *femur*.

OF THE FEMUR.

316. Transmitting the entire weight of the trunk from the haunch to the tibia, this bone is the largest, heaviest, and strongest, not only of the limb to which it belongs, but of the whole skeleton. It presents a general curvature in the longitudinal direction, rendering it convex in front, concave on the opposite aspect. In the natural position it inclines from above downward and inward, approaching its fellow at the lower extremity, but being separated from it, above, by the whole width of the true pelvis. This inclination is increased by the conformation of the superior extremity, which presents an elongated neck, intervening obliquely between the head and the shaft, so as to throw the summit of the latter still farther outward from the median line. The student should regard the bone in an articulated skeleton, so as to acquire a general notion of its form and position, before proceeding to the separate examination of its *extremities* and *shaft*.

317. SUPERIOR EXTREMITY. Presents for examination a *head*, a *neck*, two *trochanters*, the *greater* and the *smaller;* a line connecting the trochanters, called the *inter-trochanteric line;* an eminence which may be denominated the *tubercle of the femur;* and a ridge, which, from its winding course, I propose to designate the *spiral line of the femur*. These objects have the following relative position. The *head* is supported on the summit of the *neck*, which stands inward at an obtuse angle from the shaft, and is bounded at its base, above by the *trochanter major*, below by the *trochanter minor*, behind by the *inter-trochanteric line*, in front by the *tubercle of the femur*, and by the upper part of the *spiral line*. HEAD.

A smooth ball, of very regular form, somewhat more than hemispherical, directed upward, inward, and a little forward, for articulation with the acetabulum. It is separated from the neck by a sinuous line. Its surface is everywhere covered with cartilage, except at a point just behind and below its centre, where it presents a rough depression for the attachment of a ligament.* NECK. A strong, pyramidal process, directed upward, inward, and a little forward, from the body, so as to form with it an obtuse angle of about 125°. It is flattened from before backward, so that its greatest strength is in the vertical direction; joined to the shaft by its base, to the head by its summit; and contracted a little in the middle of its length. Its *superior border* is wide and short, perforated with large and numerous vascular foramina, and limited externally by the trochanter major. Its *inferior border* is longer and narrower than the superior, and curves a little backward below, to terminate at the trochanter minor. Its *anterior* and *posterior surfaces* present no remarkable features for notice. The *posterior* is the longer, smoother, and more concave of the two; it is bounded below by the inter-trochanteric line. The *anterior* is less even, perforated with a large number of nutrient foramina, and bounded below by the *tubercle*, and the *oblique line* of the femur. The whole of the neck is enclosed within the capsular ligament of the joint, which is attached around its base. TROCHANTER MAJOR. A large quadrilateral eminence, occupying the truncated angle formed by the junction of the upper border of the neck with the outer side of the shaft. It rises above the level of the neck, in a continuous line with the body, of which it appears a vertical prolongation. It is flattened from side to side, so as to present an internal and an external *surface*, separated by four *borders*. But the trochanter major is joined to the rest of the bone at its anterior and inferior part, and only projects as a free eminence above and behind. Hence, while superior and posterior borders are *true* borders, forming by their union a prominent angle, the anterior and inferior borders are mere *lines*, separating the outer aspect of the trochanter from the adjacent surface of the shaft. This trochanter should be studied minutely, because it gives attachment to several large and important muscles. SURFACES. *External.* Con-

* Ligamentum teres of the hip-joint.

vex, quadrilateral, and divided into two triangular portions, by a rough *line*, which runs diagonally from its posterior-superior, to its anterior-inferior corner. The *diagonal line* gives attachment to a flat tendon.* The triangular surface above the line is covered by this tendon, which glides upon it by the intervention of a synovial bursa. The surface below the line is smooth, and covered with a synovial sac, to permit the free gliding of another tendon.† *Internal.* The anterior-inferior part of this surface is continuous with the rest of the bone; the posterior-superior portion is free, and hollowed by a rough depression, called the *digital*, or *trochanteric fossa*, which gives attachment to four muscles.‡ BORDERS. *Superior.* A thick, free edge, nearly horizontal, and marked with the impressions of two tendons.§ *Inferior.* A rough line, which runs parallel to the superior border, separating the outer surface of the trochanter from the corresponding aspect of the shaft, and attaching the upper fibres of a large muscle.‖ *Posterior.* A vertical border, presenting a free, rounded edge, which forms the posterior lip of the digital fossa. *Anterior.* An irregular line, running parallel to the posterior border and usually more prominent above and below. ANGLES. Of the four angles formed by the junction of these borders, only one, the *superior-posterior*, requires particular description. It is a free, prolonged angle, curved a little inward, so as to overhang the digital fossa, and giving attachment to part of a tendon.¶ TROCHANTER MINOR. An epiphysis of pyramidal form, situated at the inner and posterior part of the bone, just where the lower border of the neck joins the shaft. It is directed inward, backward, and a little downward; its summit is rough, and gives insertion to a tendon.** It has three *borders*, a *superior*, joining the lower border of the neck; a *posterior*, continuous with the inter-trochanteric line; an *inferior*, in which the inner branch of the linea aspera (320) terminates. Its *surfaces*

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* Glutæus medius. (Sometimes, when this muscle is well developed, the fibres of its tendon are attached, not only to the diagonal line, but to the surface above it.)

† Glutæus maximus.

‡ Which, enumerated from above downward, are gemellus superior, obturator internus, gemellus inferior, obturator externus.

§ Pyriformis behind, glutæus minimus in front.

‖ Vastus externus. ¶ Pyriformis.

** United tendon of psoas magnus, and iliacus internus.

present no remarkable features; the *posterior* is smooth, and covered, in the recent subject, with a bursa, to permit the free gliding of a muscle.* TUBERCLE OF THE FEMUR. A well-marked apophysis, often of considerable size and prominence, situated on the anterior aspect of the bone, at the base of the neck, internal to the trochanter major. It is the meeting-point of three muscular insertions.† Between this tubercle and the anterior border of the great trochanter, there is a triangular concave surface, covered, in the recent subject, with a bursa, to permit the gliding of a tendon.‡ The surface is sometimes described as the anterior aspect of the trochanter major. It is separated from the shaft by a line, which runs downward and outward from the tubercle, and joins the lower border of the trochanter major forming with it the superior limit of the attachment of a large muscle. INTER-TROCHANTERIC LINE. A distinct ridge, passing from the posterior-inferior angle of the trochanter major, downward and inward to the trochanter minor. It runs along the base of the neck, forming the inferior boundary of its posterior surface, and giving attachment to part of a ligament.§ SPIRAL LINE. Commences at the tubercle of the femur, runs from thence obliquely downward and inward along the base of the neck, passes beneath the trochanter minor, winds spirally across the internal surface to the posterior aspect of the bone, and there terminates, by falling upon the *linea aspera.* (320) Above the level of the trochanter minor it is rough, separates the anterior surface of the neck from the corresponding aspect of the shaft, attaches part of a ligament,§ and forms the upper boundary of the origin of a large muscle.|| Below the level of the trochanter minor it is less prominent, and gives attachment to the upper fibres of another muscle.¶

318. INFERIOR EXTREMITY. This extremity is of a cuboid

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* Quadratus femoris.

† Vastus externus, and crureus, below; glutæus minimus, above.

‡ Glutæus medius. (Bourgery makes this surface the place of insertion of the glutæus minimus, which Cruveilhier describes as attached to the upper border of the trochanter major, and to the line extending from that border to the tubercle. I have seen two instances in which the insertion of this muscle agreed with Bourgery's description; but its attachment generally coincides with the account given by Cruveilhier.)

§ Capsular. || Crureus. ¶ Vastus internus.

form, and has a terminal articulating surface of remarkable extent. It is larger than the superior extremity; more extensive in the lateral than in the antero-posterior diameter; wider behind than before. It presents two lateral condyloid eminences, of an oblong form, flattened from side to side, projecting considerably behind, where they are separated by a deep notch, slightly prominent also in front, where they are continuous with each other and with the shaft of the bone. These two processes are called the *condyles* of the femur; and the interval between them is the *inter-condyloid notch.* The *external condyle* projects further forward than the internal. It is also somewhat more extensive, both in the antero-posterior and in the transverse diameter. The *internal condyle*, on the other hand, is more prominent laterally, and descends lower than its fellow; so that when the bone stands on a level surface, its upper extremity is thrown outward from the vertical line. The condyles are not parallel to each other. The long axis of the external condyle runs directly backward, that of the internal condyle runs obliquely backward and inward. Notwithstanding these differences, the condyles present a strong general resemblance to each other, and are susceptible, to a great extent, of a common description. Thus, the *inferior surface* of each condyle is convex, and rests, during extension of the leg, in a shallow cavity formed partly by the tibia, partly by one of the fibro-cartilages of the knee-joint. The *posterior extremity* of each condyle presents a smooth convexity, continuous with the inferior surface, and received, during *flexion* of the leg, into the same cavity, which supports that surface during *extension.* The *anterior extremity* of each condyle is smooth and articular. The two anterior extremities form, by their union, a *trochlear surface*, on which the patella, or knee-pan, glides. This trochlear surface presents a median vertical *groove*, and two lateral *convexities.* The *groove* extends downward and backward, as far as the inter-condyloid notch. Of the *convexities*, the *external* is more prominent, wider, and prolonged further upward than the *internal.* Of the *lateral* surfaces of the condyles, two are opposed to each other, and form the lateral boundaries of the inter-condyloid notch. These are the *inner* surface of the external condyle, and the *outer* surface of the internal condyle. They are small surfaces, equal in extent, each concave and rough for the attachment of a ligament.* The two remaining lateral surfaces are much more extensive, and present each a considerable eminence for muscular and ligamentous insertion. These eminences are called the *tuberosities* of the femur. The *internal tuberosity* is situated on the inner surface of the internal condyle. It is a large convexity, rough for the attachment of a ligament,† and surmounted by a small, but very distinct *tubercle*, which indicates the inferior limit of the insertion of a large muscle.‡ Immediately behind this tubercle, upon the upper aspect of the inner condyle, there is a rough *depression*, which gives origin to a tendon.§ *The external tuberosity* projects from the outer surface of the external condyle. It is smaller and more angular than the internal; it presents, just behind its most prominent point, a distinct rough *depression*, for the attachment of a tendon.‖ This tuberosity also attaches a ligament.¶ Below it there is a groove which commences at a point vertically under the centre of the tuberosity, and from thence runs obliquely backward and upward, to the posterior extremity of the condyle. At the anterior extremity of this groove there is a rough impression which gives origin to a tendon.** The groove itself is smooth, covered with cartilage in the recent state, and designed for the reception of the tendon just mentioned, during extreme flexion of the leg. The inferior lip of this groove is also smooth, and covered with cartilage, to permit the free gliding of the same tendon. Such are the objects presented by the condyles. The *inter-condyloid notch* is a space bounded, *laterally*, by surfaces of the condyles already described, and in *front*, by the lower extremity of the shaft. It is open above, below, and behind, and it lodges a pair of ligaments that are attached to its sides.†† The lower extremity of the femur is perforated with many nutrient foramina. These are especially large

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* The inner surface of the external condyle gives attachment, by its posterior part, to the anterior crucial ligament; the outer surface of the internal condyle gives attachment, by its anterior part, to the posterior crucial ligament.

† Internal lateral ligament of knee-joint.

‡ Adductor magnus. § Internal head of gastrocnemius.

‖ External head of gastrocnemius.

¶ External lateral ligament of knee-joint.

** That of the popliteus. †† Crucial (see note *, above).

and numerous at the bottom of the inter-condyloid notch.

319. SHAFT. The shaft of the femur is the most perfect realization of the cylindrical type that the human skeleton presents. It is, indeed, somewhat expanded and flattened at its extremities, and strengthened behind by a prominent longitudinal ridge; but, excepting these modifications, it is a cylinder of almost perfect regularity, presenting a smooth rounded surface, uninterrupted by ridges or impressions of any kind. The whole of this smooth surface is covered by the large muscular masses which serve to extend the leg; and the description of the shaft mainly consists in an account of its relations to these muscles. In pointing out these relations, however, it is necessary to speak of the *anterior*, *internal*, and *external* aspects of the shaft; and for the precise application of these terms, two *lateral* lines are required, in addition to the posterior ridge. For this reason, anatomists select two distinct lateral eminences of the upper, and two of the lower extremity; and, between these points, trace two imaginary lines along the sides of the shaft. When the terminal points are well marked, this artificial subdivision is sufficiently definite for practical purposes; *and it is in this sense only that the student can with propriety be directed to look for lateral lines, and separate surfaces, on the body of this bone.* We have already had occasion to notice the inclined position of the shaft of the femur, as also its longitudinal curvature (316). We may here add that its lower extremity is flattened more than the upper, and in a different plane. The upper extremity is flattened from before backward and inward; the lower, from before directly backward. Hence that appearance of the shaft to which authors allude, when they speak of it as *twisted* on its long axis.

320. LINES. *Posterior*, or *Linea aspera.* This line appears, in the middle third of the shaft, as a longitudinal rib, or crest, having two elevated *lips*, separated by a rough, depressed *interval.* Above, and below, its lips diverge from each other, forming the *superior* and *inferior bifurcations of the linea aspera.* Of the *superior* bifurcation, the *outer* branch is the rougher, and ascends almost vertically to the base of the trochanter major; the *inner* branch, shorter and less distinctly marked, passes to the lower border of the trochanter minor. These branches are separated by a triangular smooth space,

covered, in the recent subject, by two muscles.* In the middle of this space there is an indistinct vertical line, called the *linea quadrata*, which commences at the posterior inferior angle of the trochanter major, runs downward for about two inches, and gives insertion to a muscle.† Of the *inferior* bifurcation, the *outer* branch is the more prominent, and runs to the summit of the external tuberosity; the *inner* branch is interrupted, in the middle of its course, by a smooth space for the passage of an artery;‡ it terminates at the little *tubercle*, by which the internal tuberosity is surmounted. (318) The branches of the inferior bifurcation are somewhat longer, and more widely separated, than those of the superior. The triangular surface which they include, is called the *popliteal space of the femur*. In the recent subject, it is traversed by a large nerve and vessels,§ and corresponds to the region of the thigh, called the *ham*. It presents, laterally, two rough oblong impressions, situated just above the condyles, close to the boundary-lines, and serving for the attachment of aponeurotic fibres.|| The linea aspera gives attachment, in its whole length, to numerous muscles.¶ It is perforated opposite the middle of the shaft by the medullary foramen, which enters the bone obliquely upward. *External.* This line is traced from the anterior inferior corner of the trochanter major, to the prominent anterior extremity of the external condyle. It separates the anterior from the external surface, and gives attachment to muscular fibres.** *Internal.* This

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* Quadratus femoris, and a few fibres of adductor magnus.

† Quadratus femoris.

‡ The femoral, which at this point takes the name of the popliteal.

§ Popliteal.

|| Belonging to the two heads of the gastrocnemius.

¶ The vastus internus is attached to the inner lip, and the vastus externus to the outer lip, in their whole length. The adductor magnus is also attached to the whole length of the linea aspera, taking hold of its outer branch above, its inner branch below. Between the adductor magnus and the vastus *externus*, two muscles are attached; viz., the glutæus maximus to the outer branch of the superior bifurcation, the short head of the biceps to the interval between the lips, lower down. Between the adductor magnus, and the vastus *internus*, three muscles are attached; viz., the pectineus to the inner branch of the upper bifurcation, the adductor brevis, and the adductor longus, to the interval between the lips, lower down.

** Of the crureus.

line commences at the spiral line, opposite the level of the trochanter minor, and terminates, below, at the anterior extremity of the internal condyle. Its upper extremity appears, in well-marked specimens, as a vertical ridge which descends two or three inches, and then disappears. Elsewhere, the internal line, like the external, is a mere conventional boundary, not really distinguishable from the anterior and internal surfaces, which it is said to separate. It gives attachment to muscular fibres.*

321. SURFACES. *Anterior.* This surface lies between the lateral lines just described. It looks forward and a little outward above, directly forward below, is narrow and convex in the middle, expanded and somewhat flattened at its extremities. It is covered by a muscle,† which takes origin from its upper three-fourths, and glides, by the intervention of a synovial bursa, upon its lower fourth. *External.* Bounded, in front, by the external lateral line, behind by the outer lip of the linea aspera. It is continuous, above, with the outer surface of the trochanter major, below, with the corresponding aspect of the external condyle. It is covered in its whole length by a muscle,† to the fibres of which it gives origin by its upper three-fourths. *Internal.* Lies between the inner lip of the linea aspera, and the internal lateral line. It is continuous, above, with the lower border of the neck, below, with the inner surface of the internal condyle. It is smooth, and covered by a large muscle, to the fibres of which, however, it does not give origin.‡

322. STRUCTURE. As in form, so in structure, the femur is the most perfect specimen of its class that the human skeleton furnishes. The internal conformation of the cylindrical bones has already been described. (248) It is usually added, with regard to the femur, that the elevated ridge of the linea aspera is formed of a peculiarly dense, ivory-like tissue. But upon examining, with a microscope, transverse sections of the femur, I have not been able to perceive any such difference in the quality of the bone; the whole surface, as far as I can judge, is equally compact.

The arrangement of the cancellous tissue in the ends of

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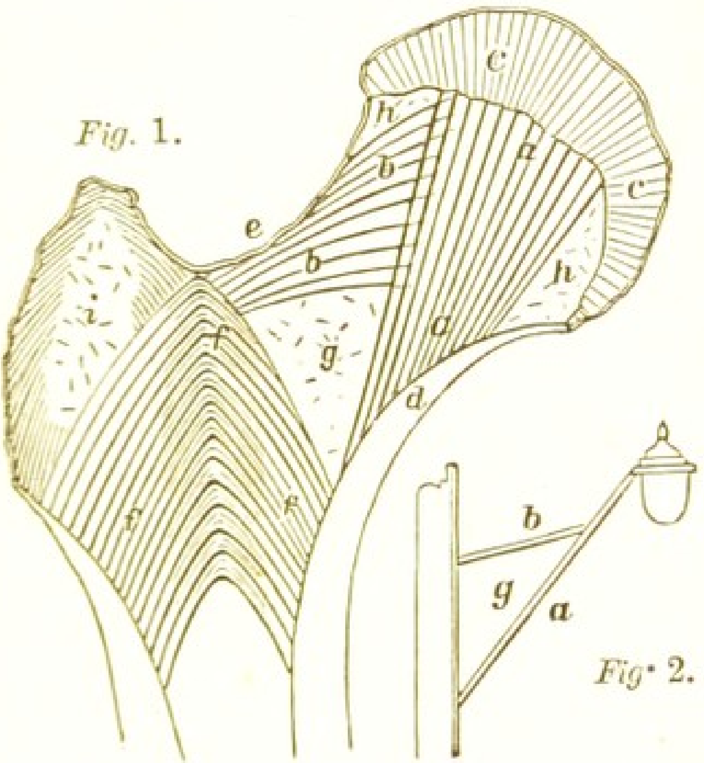
* Of the crureus. † Crureus. ‡ Vastus internus.

the femur, is very remarkable; and, as it illustrates the general mechanical principles which determine the structure of this tissue throughout the skeleton, it should engage our particular attention. In the lower extremity of the bone, it consists of numerous slender columns, which spring on all sides from the interior surface of the compact cylinder, and descend, converging towards each other, so as to form a series of inverted arches, adapted, by their pointed form, to sustain concussion or pressure transmitted from below. These converging columns not only meet, but decussate each other; and they are further strengthened by innumerable connecting filaments and laminæ, which cross them in all directions, so that no single arch could break without those in its neighbourhood also giving way. Hence, notwithstanding the tenuity and brittleness of each several fibre, the reticular structure possesses great strength as a whole. I have endeavoured by the following experiment to obtain some notion of its resisting force. A cubical inch of cancellous tissue was cut from the centre of the external condyle of an adult macerated femur, and subjected to gradually increasing pressure, with the following results. It sustained four hundredweight without sensible alteration: sank a little on one side upon the addition of the next half hundredweight; and continued to yield upon every further increase of pressure; so that, when the weight amounted to six hundredweight, its height was reduced to half-an-inch. This reduction, however, took place entirely at the expense of the upper portion of the cube; its lower moiety, which presented a much closer texture, bore the whole pressure of six hundredweight, without visible alteration. The weight of the cube submitted to this trial was fifty-four grains troy. It was placed during the experiment in the natural position, with its principal fibres upright. The side on which the cube first gave way, corresponded to the outer and posterior part of the condyle; and its structure was here evidently looser and more fragile than on the side which, in the natural position, had lain nearest to the axis of the bone. In Mr. Rennie's experiments on the strength of woods, a cubic inch of solid elm was crushed by 1284 lbs. avoirdupois—about two and a half times the weight beneath which the cube of reticular tissue began to yield. This comparison may assist the reader in forming a just estimate of the strength of the reticular tissue.

The cancellous tissue in the upper extremity of the shaft presents a similar arrangement—the convexities of the arches being here, however, directed upward.

The general structure of the neck is shown at Fig. 1 in the subjoined diagram. It resembles in its mechanical principles a bracket of the kind represented in Fig. 2, in which *a* is the principal support, and *b* a cross piece tying *a* to the wall or column which sustains the whole. It is evident that the piece *a* contributes by its *rigidity*, and the piece *b* by its *tenacity*, to the support of the weight;



in other words, that the weight tends to *bend* the former, and to *stretch* the latter. Referring to Fig. 1 (in which the direction of the principal fibres is shown with fictitious distinctness—the cross filaments, &c., being purposely omitted) we find the pieces *a* and *b* of the bracket respectively represented by the sets of bony fibres marked *a a* and *b b*.

The fibres *a a* are inclined columns supporting the epiphysis of the head *c c*, and resting below upon the thick under wall *d* of the neck. These fibres (*a a*) are shown, in the diagram, as if they were perfectly straight, but they are not exactly so formed. They are slightly curved towards the trochanter major above; and, below, they are also curved towards the trochanter, so as to fall in with the curved wall of the neck below, from which they branch off. This construction gives considerable elasticity to the neck, and tends to obviate fracture; whether in jumping down from a height, or in any other case tending to throw suddenly the inertial momentum of the trunk upon this part of the femur. The transverse fibres *b b* decussate the columns *a a*, and tie them to the thin upper wall *e* of the neck, and to the arch-work *f f* of the upper extremity. The interval *g* (which obviously corresponds to the interval *g* between the parts *a* and *b* of the bracket, Fig. 2) is filled with a loose reticular tissue, presenting no determinate nor uniform arrangement. A tissue of similar character occupies the spaces marked *h*. The trochanter major *i* contains a pretty close tissue, the principal fibres of which intersect one another, and partake of the arched construction. DEVELOPMENT. By three principal ossific centres, one for the body, one for each extremity; and by two secondary points, for the two trochanters. The ossific point of the shaft appears between the thirtieth and fortieth day of fœtal life; that of the lower extremity, within the last fifteen days of the period of gestation.* This extremity of the femur is remarkable as being the only epiphysis in which ossification commences before birth. And as it is the first of all the epiphyses to ossify, so (in accordance with the general law, that epiphyses unite with the shafts of the bones in the *inverse* order of their ossification) it is the one which remains longest a separate piece. The ossific centre of the upper extremity appears, a year after birth, in the head (the neck being a prolongation of the shaft, not a part of the superior epiphysis). The greater trochanter begins to ossify at three or four years of age; the lesser trochanter, at thirteen or fourteen. It is not till twenty years of age that the junction of all these pieces to the shaft is complete, and that the femur attains perfect ossific continuity. ARTICULATIONS. By its head, with the os innominatum; by its inferior extremity, with the patella

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* Hence the existence of this point in a still-born fœtus enables us to pronounce with certainty upon its age; a point which, in many cases of medical jurisprudence, it is of importance to determine.

in front, and with the tibia, and the menisci* of the knee-joint, below.

323. Variations of form in the femur. The femur is one of those bones the form of which is influenced in a remarkable degree by difference of age and sex. Thus the angle formed by the neck with the body approaches more nearly to a right angle in the female than in the male, and in the old subject than in the adult. The length of the neck has also been observed to diminish, with advancing years; so that the head gradually sinks below the level of the trochanter major, and approaches the shaft, to which, in extreme old age, it becomes absolutely contiguous. These changes, however, are not so constant as Cloquet and other anatomists would seem to represent them; for in examining the thigh-bones of very old subjects in the dissecting-room, I have found many entirely free from the above-described peculiarities, and indistinguishable, in respect to form, from the femur of the well-formed adult. Benjamin Bell, indeed, who first drew attention to the process of interstitial absorption upon which these progressive metamorphoses depend, describes it not as a healthy action natural to the senile period of life, but rather as an abnormal process incident to a debilitated or otherwise morbid condition of the economy in particular individuals.

MECHANISM OF THE THIGH.

324. Our observations on this subject will have reference, 1st, to the structure and mechanism of the hip-joint; and 2ndly, to the inclination of the neck of the thigh-bone, and the compensating obliquity of its shaft.

The articulation of the hip may be regarded as the type of the enarthrodial, or ball-and-socket joint. The acetabulum, though not quite hemispherical in the dry bone, presents, in the recent subject, a figure somewhat exceeding the moiety of a sphere; its cavity being deepened, and its orifice contracted, by a fibro-cartilaginous brim, called the *cotyloid ligament*, which embraces and firmly retains the head of the femur. The air is entirely ex-

* Called the internal and external semilunar fibro-cartilages.

cluded from between the polished contiguous surfaces of this joint, so that their separation from each other is resisted by an atmospherical pressure of 15 lbs. for every square inch of their extent. This fact has long been known in the English schools, though the brothers Weber appear to claim it as their discovery, in their recent publication entitled *Mechanik der Menschlichen Gehwerkzeuge.**

The hip-joint, like all enarthroses, possesses movements of flexion and extension, abduction and adduction, rotation and circumduction. Of all these motions, that of *flexion* is by far the most important and extensive. It can be continued till the front of the thigh touches the anterior surface of the abdomen. *Extension*, on the contrary, can be carried but a few degrees beyond the right line, being checked by the contact of the superior surface of the neck of the femur with the outer side of the brim of the acetabulum. *Abduction* is more extensive than the last; it is limited by the striking of the upper border of the neck of the femur against the upper part of the brim of the acetabulum. *Adduction* is a movement of small extent when the skeleton is in position; being stopped, almost at the outset, by the encounter of the femur which is put in motion with the corresponding bone of the other side. But if a clear space be afforded by flexing the opposite limb, adduction may be carried to an angle of about 45 degrees. Here it is checked, in the recent subject, by the tension of the external ligaments of the hip-joint. In the macerated skeleton, however, this movement may be continued till the femur lies horizontally beneath the pelvis. The femur may also be made

* Dr. Todd informs me that the contiguous surfaces of the shoulder-joint are held together in a similar manner by atmospheric pressure. He has ascertained by experiment that so long as the capsule of the shoulder-joint remains air-tight, the head of the humerus is retained within the glenoid cavity of the scapula; but that, upon cutting open the capsule so as to admit air into the joint, the two bones immediately separate from each other. The same effect takes place without perforation of the capsule, when the atmospheric pressure on the external surface of the joint is removed by means of an air-pump. These tests are only applicable to joints having a loose capsule; but it is probable that the pressure of the air contributes more or less to the maintenance of union in all the diarthrodial articulations.

to *cross* its fellow, by combining adduction with a slight movement of flexion or extension; the limb put in motion passing, in the former case before, in the latter case behind, the opposite extremity. The motion of *circumduction* requires no particular notice; that of *rotation* will be more readily understood when we have briefly noticed the inclination of the shaft of the femur, and the angular disposition of its head and neck. The purpose and meaning of this double obliquity of the thigh-bone appear to have been very generally misunderstood by physiologists. The explanation most commonly received is that advanced by Sir Charles Bell, in his well-known treatise on Animal Mechanics. This eminent physiologist compares the obliquity of the neck of the thigh-bone to the inclination of the spokes in a cart-wheel, technically termed the *dishing* of the wheel. He conceives that when a cart stands on a horizontal plane (Fig. 1), so that the weight is equally divided between the two wheels, the

Fig. 1.

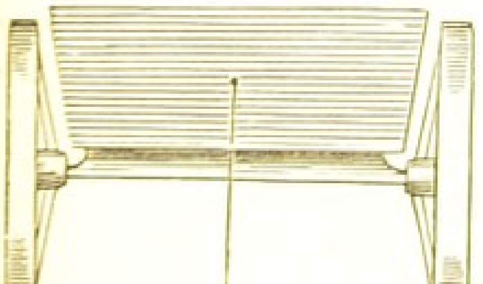
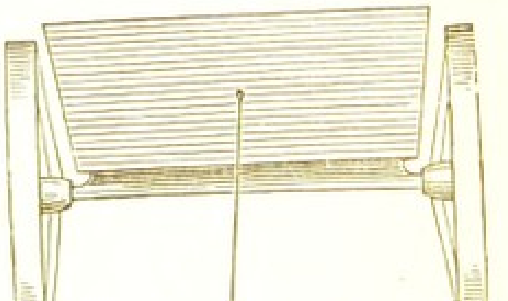


Fig. 2.



bearing-spokes of each wheel are oblique to the line of the pressure; but that, when the cart stands on the side of a hill (Fig. 2), so that more weight is thrown upon one wheel than upon the other, the bearing-spoke of the more heavily-laden wheel becomes parallel to the line of pressure, and is thus adapted to support the increased strain. In the same manner, he supposes the necks of the thigh-bones to be inclined outwards when we stand erect, in order that when we throw our weight upon one leg, the neck of the corresponding femur may approach the vertical position and so sustain without injury the accumulated pressure of the trunk.

To this comparison, however, it may be objected that the inclination of the spokes in a wheel is counteracted by an equivalent inclination (*a a*, Fig. 3) of the axle on which the wheel turns; so that, when the cart rests on a horizontal plane, the bearing-spoke (or spoke immediately beneath the axle) is not inclined, as Sir Charles Bell supposes, but stands in a vertical position, as shown in Fig. 4).* But if the fact were otherwise—if the dishing of the wheel had really the effect attributed to it by Sir Charles Bell—the cases compared would still be dissimilar. A straight spoke, inclined at an angle to the line of pressure, is only oblique with regard to the object supported; and its obliquity may be removed by a change of its relative position to that object. But the femur is a column *bent upon itself;* its obliquity is not relative, but inherent; it cannot, therefore, be diminished by any change of position, but requires for its removal an alteration in the form of the bone itself. It is true that, in standing on one leg, the neck of the femur becomes more vertical; but then the shaft becomes, in exactly equal proportion, more oblique; so that the total obliquity of the column remains the same, and the strain tending to break the bone at the angle suffers no diminution. Hence, both in fact and in principle, Sir Charles Bell's explanation appears to be erroneous.

Fig. 3.

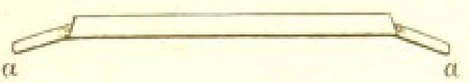
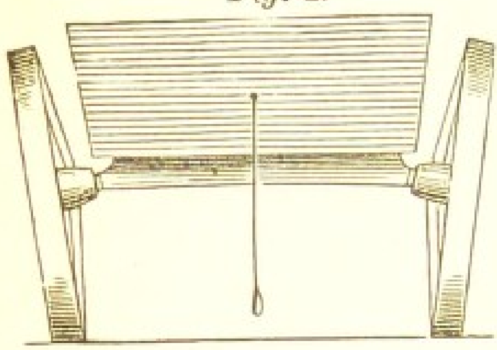


Fig. 4.



Several important advantages are attained by the double obliquity of the femur, in compensation for the loss of strength undeniably incurred by the angular bend in its axis. In the first place, the separation of the shafts from each other, resulting from the length and inclination of the neck, gives room between the thigh-bones for the large muscular masses which lie on the inner side of each femur. With all the advantages of the existing obliquity, the interval is but just large enough for the purpose; and if the thigh-bones were straight, the muscles in question could only find room between

* See Parnell "*On Roads*," &c. p. 305.—"The arms of the axles should be so bent as to bring an upright spoke."

them, by a removal of the sockets to a greater distance from the median plane, which would involve an enlargement of the whole pelvis.

In the second place, it results from this form of the bone, that when its lower extremity advances in the vertical plane, its head and neck turn on a horizontal axis;—in other words, that the *angular* motion of its shaft is converted into a *rotary* movement at the hip-joint. The advantages of this conversion are obvious. First, it tends to equalize the extent of bearing surface in the hip-joint during the progress of the thigh from extension to flexion, or the reverse; so that, whether the body is supported on the femur while standing beneath the pelvis, or while flexed to a right, or even to an acute angle (as often happens in such actions as climbing a steep hill, ascending a flight of abrupt stairs, and the like), the head of the bone is never subjected to undue pressure. For, the *rotation* of a hemispherical head within a socket of the same form (Fig. 1) involves no diminution in the extent of the contiguous articulating surfaces; but the *angular* motion of a joint of this kind (Fig. 2) throws part of the ball out of the socket, and leaves part of the socket without bearing to rest upon; so that the weight, instead of being distributed equally over the whole surface of the head, is concentrated upon that portion which remains within the cavity. In the case of flexion to a right angle (represented in Fig. 2), the

Fig. 1.

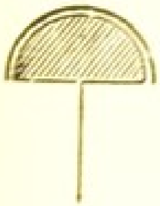


Fig. 2.

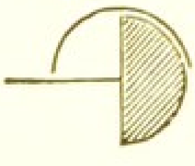


Fig. 3.

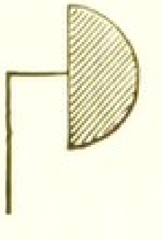
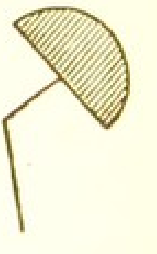


Fig. 4.



effective surfaces of the joint would be reduced to exactly one-half their ordinary extent, and would consequently have to sustain double the usual amount of pressure. This evil would be entirely obviated if the head were placed on a neck projecting at right angles from the shaft (Fig. 3); and it is considerably diminished by the existing approximation to that form (Fig. 4).

Again, flexion is greatly increased in extent by this conversion of angular into rotary motion; for the *angular* motion of a deep enarthrosis, such as that of the hip, would be soon stopped by the contact of the neck of one bone with the brim of the socket of the other: whereas, *rotation* meets no such check in the conformation of the joint itself, but may be continued indefinitely, until opposed by the tension of ligaments, the encounter of a neighbouring limb, or other adventitious obstacle. Thus, under the existing arrangement, the thigh may be flexed until its anterior surface touches the abdomen, its lower extremity describing a curve of at least 145 degrees; whereas, if the acetabulum were directed vertically, and the head, neck, and shaft of the femur formed one continuous line, so that their motions extended without modification to the joint, the range of the thigh in flexion would be reduced to 45 or 50 degrees.*

On the whole, then, three principal advantages appear to result from the double inclination of the femur, in return for the diminution of strength necessarily involved in that form: viz. 1st, enlargement of the space for the adductor muscles between the thigh-bones; 2ndly, equalization of the extent of bearing-surface in the hip-joint throughout its passage from extreme flexion to extreme extension, or the reverse; 3rdly, increase of the range of the thigh in flexion—the most important and frequently repeated of all its movements. To these we may add, as an incidental advantage resulting from the length and obliquity of the neck, the removal of the great trochanter to a considerable distance from the centre of motion, and the consequent acquisition of force (in the stead of superfluous velocity) by the muscles attached to that process.† Nor, again, can it be doubted that the angular

* The common statement, that the length and obliquity of the neck give increased freedom to the motion of the hip-joint, is evidently erroneous. The movements of the ball within the socket would lose nothing in extent, if the neck were shortened by half, and placed in a right line with the shaft. The existing conformation does not increase the total amount of mobility, but only alters its distribution. If the *angular* motion of the shaft is increased in extent, its *rotary* movement suffers a precisely equivalent diminution. Whatever *adduction* gains in freedom, *abduction* of necessity loses; and so on for the rest. (The misapprehension here noticed is akin to the vulgar mechanical errors, that a fly-wheel *increases* the force of an engine, that a lever *multiplies* power, &c.)

† This is sometimes put forward as in itself an adequate reason for the double obliquity of the femur; but such an explanation appears to me insufficient; for it would, I think, have been a clumsy expedient to weaken the whole column by an angular bend, for

disposition of the neck tends to increase the longitudinal elasticity of the femur, and must therefore contribute to disperse concussions transmitted through the bone to the pelvis.

We may now return to the movement of *rotation*, the nature of which has been indirectly explained in the foregoing remarks. It is evident that if *angular* movements of the shaft of the femur are performed by *rotation* of its head within the acetabulum, the converse proposition must be true, that *rotation* of the shaft is performed by *angular* movements at the hip-joint. The student must, however, bear in mind that the neck being oblique, not perpendicular to the axis of the shaft, this reciprocal conversion of movements is only partial; the angular and rotatory motions of the shaft being each performed by a movement of the joint intermediate between the two.

It would be unnecessary to dwell upon the mechanical advantages which the shaft of the femur derives from its cylindrical form, its longitudinal curvature, and the dense rib, or linea aspera, which runs along its posterior surface. The *hollow cylinder* is known to be the most advantageous form for a column, *i.e.*, the mode of disposition in which a given weight of material is capable of sustaining the greatest amount of pressure. The effect of *longitudinal curvatures* in preventing absolute rigidity, and distributing the force of concussion, has already fallen under our notice; and the *linea aspera* serves evidently as a buttress to that side of the column which, on account of its concavity, sustains the chief force of longitudinal compression, and is most liable to be crushed by the constant weight of the trunk, or by the still severer pressure to which the bone is *occasionally* subject (as in the action of jumping from a height to the ground, carrying heavy burdens on the back, &c.).

The lower extremity of the femur enters into the structure of the knee-joint, and will be noticed in our account of the mechanism of that important articulation.

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the sole purpose of gaining a leverage which would have resulted as certainly, and without any such sacrifice of strength, from a slight prolongation of the trochanter major.

OF THE LEG.

325. The leg is formed of three bones; two of the cylindrical class, called the *tibia* and *fibula*, respectively analogous to the ulna and radius of the upper extremity; the third a small appendage, named the *patella* or *knee-pan*, resembling the *sesamoid* bones on the one hand, and the *olecranon* process of the ulna on the other.

OF THE TIBIA.

326. The tibia occupies the anterior and internal part of the leg, extending in a direct line from the thigh to the foot. It is the largest bone of the leg, and, indeed, excepting only the femur, of the entire skeleton. It is of a prismatic figure, considerably expanded above, where it enters into the composition of the knee; more slightly enlarged below, where it contributes to form the ankle-joint. In the well-formed male it stands vertically, so as to be parallel with its fellow of the opposite side; but in the female, in whom the femur descends very obliquely inward, the tibia has a compensating inclination downward and outward. We shall examine, in the usual order, the *extremities* and *shaft* of the bone.

327. SUPERIOR EXTREMITY. At least twice as large as the lower; of an oblong form, with the long diameter transverse; divided into two lateral eminences, called the TUBEROSITIES OF THE TIBIA. These eminences are continuous with each other in front, but separated posteriorly by a shallow notch, called the *popliteal notch*, which gives attachment to a ligament.* In size, the internal tuberosity somewhat exceeds the external; in form, the two eminences closely resemble each other—so that the surfaces are susceptible, in a great measure, of a common description. SURFACES. *Superior.* The superior surface of each tuberosity presents a smooth oval concavity, deepened in the recent subject by a semilunar fibro-cartilage, and articulating with the corresponding condyle of the femur. The articular surface of the internal tuberosity is longer, and somewhat more concave than that of the external; which, on the other hand, is the wider cavity of the two. Between these surfaces, and somewhat nearer to the posterior than to the anterior aspect

* Posterior crucial.

of the bone, appears the *spinous process of the tibia*, a pyramidal eminence, presenting at its summit two sharp tubercles, and giving attachment before and behind to ligaments.* Before and behind this eminence are rough surfaces, presenting well-marked ligamentous impressions.† *Lateral.* The lateral surface of each tuberosity is convex and rough. That of the internal tuberosity gives attachment to a ligament.‡ *Anterior.* This aspect of the tuberosities presents a continuous surface, of triangular form, wide above, narrow below, where it terminates at an oblong eminence of considerable size, called the *tubercle of the tibia.* This tubercle is divided into two parts; an *inferior*, rough, for the attachment of a strong ligament;§ a *superior*, smooth, and covered in the recent subject by a bursa, over which the ligament glides. *Posterior.* The *posterior* surface of the internal tuberosity presents a horizontal groove for the attachment of a muscle.|| The *posterior* surface of the external tuberosity presents a flat, nearly circular facet, directed downward, backward, and outward, for articulation with the fibula. Above this facet and nearer the median line is a smooth, extremely shallow groove for the transmission of a tendon.¶

328. Inferior extremity. This extremity is of a quadrilateral form, more extensive in the transverse than in the antero-posterior diameter, and distinguished by a strong process called the *malleolus internus*, which projects downward from its inner side. Surfaces. *Anterior.* A smooth convex surface covered in the recent subject by several tendons.** *Posterior.* Presents a superficial groove, directed downward and a little inward, continuous with a similar groove on the astragalus, and serving for the transmission of a tendon.†† This groove is usually very indistinct, and should be carefully distinguished from

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* The two ligaments by which the extremities of the external semilunar cartilage are fastened to the bone.

† The *anterior* surface gives attachment to the anterior crucial ligament, and the anterior ligament, of the internal semilunar cartilage; the *posterior* surface gives attachment to the posterior ligament of the internal semilunar cartilage, and a few fibres of the posterior crucial ligament.

‡ Internal lateral ligament of the knee-joint.

§ Ligamentum patellæ.

|| Semimembranosus.

¶ Popliteus.

** Extensors of the toes.

†† Flexor longus pollicis.

a much deeper groove which runs by its side, and in a nearly parallel direction, on the back of the malleolus internus. *External.* Presents a triangular rough excavation, corresponding to a similar convexity on the fibula, to which it is attached by an interosseous ligament. It is bounded by two ridges, the anterior more prominent than the posterior, both rough for the attachment of ligaments.* (Cruveilhier describes this excavation as presenting at its lower part a narrow smooth surface for articulation with a similar facet on the fibula. This I have never seen. In all the specimens I have examined, the excavation everywhere attaches the interosseous ligament; the lower border of which consequently appears in the ankle-joint, level with the tibial articular surface.) *Internal.* This surface extends downward upon the MALLEOLUS INTERNUS, a strong process of pyramidal form, flattened from within outward, convex and subcutaneous on its *inner* side, smooth and cartilaginous *externally*, where it is continuous with the terminal articular surface of the bone. The *anterior border* of this process and its truncated *extremity* or *summit* present marks of ligamentous insertion.† Its *posterior border* is traversed by a deep groove, sometimes double, which runs obliquely downward, inward and forward, for the transmission of two tendons.‡ *Inferior.* This surface, by which the tibia articulates with the astragalus, is of a quadrilateral form, wide externally, where it meets at a right angle the narrow articular margin of the depression which receives the fibula; somewhat narrower internally, where it is continuous with the smooth outer surface of the malleolus internus. It is uniformly concave in the antero-posterior direction, but is rendered alternately convex and concave in the opposite sense by the presence of a median elevation running from before backward, and separating two lateral depressions.

329. BODY OR SHAFT. Presents the form of a triangular prism, curved twice upon itself, so that its inner aspect is convex from above downward at the upper part,

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* Anterior and posterior ligaments of the inferior tibio-fibular articulation.

† For the internal lateral ligament of the ankle-joint, or tibio-tarsal ligament.

‡ Tibialis posticus, and flexor communis digitorum pedis; the former being in front of the latter, and somewhat on its outer side.

concave in the same sense below. It is also twisted on its axis in such a manner that its posterior surface, which looks directly backward above, looks backward and outward below. Its most slender part is not in the middle of its length, but at the junction of its upper three-fourths with its lower fourth,* and from this point to each extremity it increases gradually in thickness. It presents three *surfaces*, separated by three *borders*.

330. BORDERS. *Anterior*. This is the most elevated border of the three, and for that reason is called the *crest of the tibia*. It commences above at the tuberosity of the tibia, and terminates below at the anterior border of the malleolus internus. It pursues a sinuous course, turning a little outward at its upper extremity, and taking a considerable bend inward below. It is very sharp and prominent at its upper and middle part, rounded and indistinct in the lower third of its length. In the living subject it lies immediately beneath the skin, and is popularly termed the *shin*. It gives attachment to an aponeurosis.† *Internal*. This border is the least *distinctly* prominent of the three. It runs from the posterior part of the internal tuberosity to the posterior border of the malleolus internus. It is somewhat indistinct above and below, but the intervening portion is sufficiently well marked. It gives attachment to some fibres of three muscles.‡ *External*. Commences above at the external tuberosity just in front of the articular facet for the head of the fibula, and bifurcates below to form the anterior and posterior margins of the triangular depression which receives the lower extremity of the fibula. It is sharp, especially in its middle portions, and gives attachment to an aponeurosis.§

331. SURFACES. *Posterior*. This surface is divided into two parts by a ridge, called the *oblique line of the tibia*, which runs from the articular facet for the head of the fibula downward and inward to the internal border, which it joins at an acute angle just where the upper joins the middle third of the shaft. The oblique line is rough for the attachment of a fascia,‖ and part of a muscle.¶ The surface above it is of a triangular form,

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* Hence the frequency of fracture at this point.

† The aponeurosis of the leg.

‡ Popliteus, soleus, and flexor longus digitorum pedis.

§ Interosseous membrane. ‖ Popliteal.

¶ Inner head of soleus.

wide at its upper part, terminating in an acute angle below, and looking directly backward. It is concave from above downward, convex transversely, and rough for the insertion of a muscle.* The portion of surface which lies below the oblique line (comprising about two-thirds of the whole) is flat and smooth, narrower above, where it is directed backward, than below, where it looks somewhat outward as well as backward, in consequence of the twist of the bone. This surface is covered by two muscles,† to which its upper two-thirds give origin; and it presents at its superior part, immediately beneath the oblique line, the *medullary foramen* of the tibia,‡ entering the bone obliquely downward. *Internal.* A smooth surface, wider above than below. Its upper part looks inward and forward, and is covered by an aponeurotic expansion;§ its lower part looks directly inward, and lies immediately beneath the skin. *External.* The two upper thirds of this surface are directed inward, and hollowed by a shallow vertical groove for the attachment of a muscle.‖ The lower third winds around the bone, looking at first forward and inward, afterward almost directly forward. It is smooth, convex, and covered by several tendons.¶

332. STRUCTURE. Agrees in every respect with that of the long bones in general, which has already been fully described. DEVELOPMENT. By three points, one for the shaft and one for each terminal epiphysis. The ossific centre of the body appears from the twenty-fifth to the fortieth day of fœtal life; that of the superior epiphysis within the first, that of the inferior epiphysis within the second, year after birth. The superior epiphysis is a thin terminal layer, prolonged downward in front, so as to include the tubercle of the tibia. The inferior epiphysis

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* Popliteus.

† Tibialis posticus, and flexor communis digitorum, which arise side by side, the former external to the latter.

‡ This hole is remarkably large, and, in well-marked specimens, preceded by a groove. It is through this foramen that Cruveilhier has traced a nerve, accompanying the medullary artery into the substance of the bone.

§ Derived from the conjoined tendons of the gracilis, sartorius and semitendinosus.

‖ Tibialis anticus; and also, at the upper part, some fibres of the extensor digitorum communis.

¶ Those of the tibialis anticus, extensor proprius pollicis, extensor communis digitorum, and peroneus tertius. These tendons lie in the order of enumeration, proceeding from within outward.

in like manner includes the malleolus internus. In one instance, however, a separate ossific point has been observed by Béclard in the malleolus internus; and Cruveilhier states that the tubercle also is sometimes developed from a centre of its own. The ossific union of these pieces coincides with the period of perfect development, which varies from eighteen to twenty-five years in different individuals. The law of inverted order already stated is plainly exemplified here; for the inferior epiphysis, which is the latest to ossify, is the first to unite with the shaft. ARTICULATIONS. With the femur and head of the fibula above; with the astragalus and inferior extremity of the fibula below.

OF THE FIBULA.

333. The fibula is the slenderest, in proportion to its length, of all the cylindrical bones. It is placed on the outer side of the leg, nearly parallel to the tibia, but inclining a little forward as it descends, so that its lower extremity is on a plane somewhat anterior to that of the upper. It is of an irregularly prismatic form in the upper three-fifths of its length, but flattened from side to side in the lower two-fifths. It is curved longitudinally so as to present a convexity towards the tibia, a concavity in the opposite direction. It has the appearance of being twisted on its axis, the surface which is external above winding round so as to become posterior below. In this and other instances of *torsion*, however, the student is not to imagine that the bone is really twisted, or that the fibres of its shaft take a spiral direction; the appearance is entirely superficial, and always depends on the passage of tendons or nerves in a winding course along the bone. I make this remark because Cruveilhier speaks of the "*law* of torsion of bones;" an expression calculated to suggest the notion that their twisted appearance is something more than a mere modelling of external surface, and that a torsion or spiral arrangement of the fibres does actually exist. We shall consider, as usual, first the *extremities*, and afterwards the *shaft*, of the bone.

334. UPPER EXTREMITY OR HEAD. An epiphysis of irregularly rounded form, presenting a terminal *articular surface*, a blunt eminence called the *styloid process* of the fibula, and an uneven *circumference*. The *terminal surface* is a flat facet, directed upward, forward, and inward, to articulate with the corresponding facet on the

external tuberosity of the tibia. The *styloid process* projects upward from the posterior part of the head, and by its rounded summit gives attachment to a ligament.* The *circumference* gives attachment on all sides to muscles and ligaments.†

335. LOWER EXTREMITY, OR MALLEOLUS EXTERNUS. This epiphysis is larger and descends lower than the malleolus internus of the tibia, to which it corresponds. It has the form of a triangular pyramid, somewhat flattened from side to side, joined by its base to the shaft, and presenting for examination three *surfaces*, three *borders*, and a rounded *extremity* or *summit*. Its *outer surface* is convex, subcutaneous, and continuous with a triangular surface, also subcutaneous, on the outer aspect of the shaft. Its *inner surface* is divided into, 1st, an *articular portion* of triangular form, wider above than below, slightly convex, and corresponding to an articular surface on the outer side of the astragalus; 2ndly, a small *non-articular portion*, situated behind and below the former, and presenting a rough depression for the attachment of a ligament.‡ The *posterior surface* of the malleolus externus is narrower than the other two, and channelled by a shallow groove, which runs obliquely downward and outward, and transmits two tendons.§ Of the three *borders* of this epiphysis, the *anterior* is thick, uneven, and marked at its lower part with the impression of a ligament;|| the *external* is an elevated ridge, forming the outer boundary of the groove on the posterior surface; the *posterior* is rounded and smooth; all three converge towards the *summit* of the process, which is a conical eminence, prolonged obliquely downward and outward, and furnishing attachment to a ligament.¶

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* Short external lateral ligament of the knee.

† The *external* side of the head gives attachment to the long external lateral ligament of the knee, the posterior fibres of the tendon of the biceps, and the upper fibres of the peroneus longus; its *internal* side, to a few tibio-fibular ligamentous fibres; its *anterior* aspect, to the anterior ligament of the superior tibio-fibular joint, the anterior fibres of the tendon of the biceps, and the upper and anterior fibres of the peroneus longus; its *posterior* aspect, to the posterior ligament of the superior tibio-fibular joint, and the upper fibres of the outer head of the soleus.

‡ Posterior external lateral ligament of the ankle-joint.

§ Those of the peroneus longus and brevis.

|| Anterior external lateral ligament.

¶ Middle external lateral ligament.

336. SHAFT. We have given, in our preliminary notice of the fibula, a general sketch of its body or shaft, describing its torsion, its longitudinal curvature, and its inclined position, and adding, with respect to its form, that it is prismatic above, transversely flattened towards the lower extremity. We may here, therefore, proceed at once to the minute examination of its *lines* and *surfaces*.

337. LINES. *Anterior*. Commences above at the front of the head, runs vertically downward to the middle of the bone, then curves a little outward, and bifurcates, sending one branch to the anterior, and one to the external border of the malleolus externus. These branches form the lateral boundaries of a triangular subcutaneous space, continuous below with the subcutaneous surface of the malleolus externus. (Sometimes the posterior branch of this bifurcation is taken alone, as the continuation of the anterior line, which is then said to wind backward and terminate at the external border of the malleolus externus, while the triangular subcutaneous interval is described as part of the anterior surface.) *Interosseous*. The interosseous line, though not remarkable for its prominence, is a boundary of great importance in a myological point of view, because it gives attachment to the interosseous membrane that stretches between the tibia and fibula, and separates the extensor muscles, which lie in front, from the flexor muscles, which are attached behind. This line runs close on the inner side of the anterior line, nearly parallel to it in the upper two-thirds of its length, where the interval between the two is seldom more than an eighth of an inch wide, diverging from it a little in the lower third of its course, so that the intervening space increases in width to about a quarter of an inch. The upper termination of the interosseous line varies in different subjects; sometimes it reaches the head of the bone at a point just internal to the origin of the anterior line; sometimes it becomes indistinct and ceases about an inch below the head. Inferiorly it terminates at the apex of a rough, convex, triangular space, situated on the inner aspect of the bone, just above the articular surface of the malleolus externus. *Posterior*. This line commences above at the base of the styloid process, and terminates below at the posterior border of the malleolus externus. Between this line and the interosseous line, on the internal aspect of the bone, there is

a very prominent ridge, called the *oblique line of the fibula*, which commences above at the inner side of the head, descends, at first vertically, then obliquely forward, and terminates below by falling on the interosseous line at the junction of the upper three-fifths with the lower two-fifths of the shaft. (In many specimens, however, the oblique line cannot be traced forward so far as the interosseous line, but ceases, rather abruptly, at the distance of about a quarter of an inch from it.) This ridge, which derives its name from its oblique direction, belongs to the internal surface of the bone, the upper part of which it divides into an anterior and a posterior portion. Strictly speaking, therefore, its description should be reserved till that surface comes under examination; but we have noticed it here lest the student should mistake it for either of the lines between which it lies. All these ridges of the fibula give attachment to processes of fibrous membrane, separating the muscles that arise from the intervening surfaces.*

338. SURFACES. *Anterior.* The narrow interval lying between the anterior and interosseous lines is all that can with propriety be called the anterior surface of the fibula, because it is all that lies in front of the interosseous membrane, and gives origin to the extensor muscles of the toes. Its upper two-thirds are flat; its lower third is wider than the portion above, and grooved in the longitudinal sense. In its whole length it gives attachment to muscles.† The triangular subcutaneous space, that surmounts the malleolus externus, may be described as part of this surface (337), which must then be said to wind round the bone at its inferior extremity, so as, from looking *forward* above, to acquire a direction

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* The *anterior* line gives attachment to an intermuscular septum separating the peroneus longus and brevis from the extensor digitorum communis and its continuation the peroneus tertius; the *interosseous* line, to the interosseous membrane; the *posterior* line, to an intermuscular septum separating the peronei from the soleus and flexor pollicis longus; the *oblique* line, to an intermuscular septum separating the tibialis posticus from the flexor pollicis longus.

† The extensor digitorum communis, and the peroneus tertius, form a continuous muscle, which arises from the anterior surface in its whole length, occupying the narrow upper two-thirds exclusively, and the outer half of the lower third, or wider portion of the surface. The inner half of the lower third gives origin to the extensor proprius pollicis.

outward below. *External*. This surface is directed outward in its upper two-thirds, where it is uneven and grooved longitudinally; but looks backward below, where it presents a smooth surface continuous with the posterior surface of the malleolus externus. It is covered below by the tendons of two muscles,* to which its upper half gives origin. *Internal*. This surface extends from the interosseous line in front, round to the posterior line behind. Its lower third is smooth and plane. Its two upper thirds are divided into an *anterior* and *posterior* portion by the *oblique ridge* already described. The *anterior portion* of the inner aspect (bounded behind by the oblique ridge, in front by the interosseous line) looks inward and forward, and is grooved longitudinally for the attachment of a muscle.† The *posterior* portion of the inner aspect (bounded in front by the oblique ridge, and behind by the posterior line) merges below into the smooth lower third of this aspect, forming with it one continuous surface, which looks inward and backward above, directly inward below. It presents at its upper part some rugosities for the attachment of part of a muscle,‡ and at its lower extremity the rough triangular space already noticed in the description of the interosseous line. (337) This space is convex, and corresponds to a rough depression on the tibia, to which it is bound in the recent subject by strong ligamentous fibres.§ The portion of surface, which intervenes between the rugosities above and this triangular rough space below, is smooth, and gives origin in its whole length to a muscle.‖ The medullary foramen sometimes appears on the middle of this surface, sometimes on the oblique line, entering the bone obliquely downward.

339. It is necessary to inform the student, that this account of the shaft of the fibula differs essentially from the description given by previous anatomists. I have described the interosseous ridge as one of the three principal lines of the fibula, considering the surfaces between which it runs as separate aspects of the bone. Cruveilhier, Cloquet, and other authorities, break the interosseous line into two parts—a lower, which they take together

* Peroneus longus and brevis.

† Tibialis posticus. ‡ Outer head of soleus.

§ Interosseous ligament of the inferior tibio-fibular articulation.

‖ Flexor longus pollicis.

with the oblique line to form the internal border of the bone, and an upper, to which the name of interosseous line is exclusively applied. The surfaces lying on either side of this line they describe together as the *internal surface.* This is in my opinion an arbitrary and unphysiological method, calculated to convey an erroneous notion of the muscular relations of the bone; for the surfaces separated by the interosseous line, and by those writers included under a common name, lie, in the recent subject, on opposite sides of the interosseous membrane—occupy different regions of the limb—and attach antagonist sets of muscles; that which is in front of the membrane giving origin only to extensors, that which is behind it exclusively to flexors.* By the method which I have proposed, this anomalous combination of surfaces is avoided, and the interosseous ridge, assuming its proper importance as a regional boundary, is recognised as a continuous line, and described in its whole length under a single name. If it should be objected that the surfaces separated by the oblique line, and described by me as subdivisions of the internal aspect, differ in direction far more than the surfaces included by other writers under a common name, the reply is obvious. The surfaces which I combine *both* lie behind the interosseous membrane, *both* belong to the posterior region of the leg, and *both* attach muscles of the flexor set. They are analogous in all essential points, and their difference in direction is merely an incidental circumstance occasioned by the prominence of the oblique ridge, the obvious design of which is to increase the extent of surface for muscular attachment (as may be inferred from the fact, that the oblique ridge extends only over so much of the internal aspect as gives attachment to two muscles—disappearing below where only one muscle takes rise).

340. STRUCTURE. The medullary canal of the fibula is

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* Bourgery has been so far misled by this error, that he says—"Chacun des trois angles (*du peroné*) donne attache par son sommet aux aponévroses de séparation qui limitent les trois groupes musculaires de la jambe."—*Anatomie de l'Homme*, tom. i. p. 112 This statement, taken in connexion with his description of the internal border of the fibula, would imply that the tibialis posticus belonged to the same group of muscles as the extensor proprius pollicis, extensor communis digitorum, and peroneus tertius,—a combination altogether preposterous, and certainly never intended by the philosophical anatomist here cited.

very narrow and irregular, and extends only through the middle third of the shaft. The areolar tissue of the extremities, and especially of the malleolus externus, is unusually strong, its fibres being very thick, and the cellular intervals small in proportion. This compactness of structure, which is observed also in the malleolus of the tibia, may account for the infrequency of fracture of the ankles, notwithstanding their prominence, and consequent exposure to concussion. DEVELOPMENT. By three points; one for the body; one for the lower, and one for the upper extremity. The first appears in the seventh week of fœtal life; the second about two years, and the third five years, after birth. The ossific union of these pieces is complete at a period varying from twenty-one to twenty-five years after birth. ARTICULATIONS. With the tibia above; with the tibia and astragalus below.

OF THE PATELLA.

341. The patella is a small flat bone, of triangular form with rounded angles, thicker above than below, and situated vertically, base upward, in front of the knee-joint. It presents for examination two *surfaces*, two *lateral borders*, a *base*, and an *apex*.

342. SURFACES. *Anterior.* Convex, and marked with longitudinal striæ, between which appear many small ellipsoid foramina for nutrient vessels. This surface is covered in the recent subject with tendinous fibres,* which adhere closely to it, and occasion its striated appearance. In the recent subject it may be felt beneath the skin, from which it is only separated by the superficial fascia, and by a large synovial bursa. *Posterior.* This aspect presents a smooth surface, of oval form, with the long diameter transverse, covered in the recent subject with cartilage, for articulation with the trochlea of the femur, to the undulations of which it exactly correspoads. It presents two lateral concavities separated by a vertical rounded ridge. The elevation fits the trochlear groove of the femur and the lateral concavities correspond to the two condyles. As the external condyle is larger and more prominent than its fellow, so is the external depression of the patella more extensive and deeper than the internal. Below this surface there is a narrow, convex, non-articular space, perforated by several nutrient foramina, and directed

* Of the quadriceps extensor.

obliquely downward and backward towards the head of the tibia, from which it is separated in the recent subject by adipose tissue. The lower part of this surface assists in giving attachment to a ligament.*

343. LATERAL BORDERS. Thin curved borders, each giving attachment to a ligament and part of a tendon.†

344. BASE. Thick, and cut obliquely at the expense of the anterior aspect, so as to present a rough broad margin, directed upward and forward, for the attachment of a strong tendon.‡

345. APEX. Thin, and directed downward for the attachment of a strong ligament.§

346. STRUCTURE. Of light cancellous tissue, covered by a thin compact layer, which presents in front a remarkable striated or fibrous appearance, as we have already had occasion to observe. DEVELOPMENT. The ossification of the patella commences in the end of the first, or beginning of the second year after birth; but is not complete till the age of twelve. It proceeds, with rare exceptions (of which Rudolph has recorded an example), from a single central point. ARTICULATION. With the femur only.

MECHANISM OF THE LEG.

Under this head we have to consider the osseous structure of the knee, and of the two tibio-fibular articulations. Our remarks on the ankle-joint will follow the description of the foot.

347. The knee-joint, which is the largest joint in the body, is formed by the articulation of the femur with the tibia below, and with its appendage, the patella, in front. It belongs to the class of ginglymoid, or hinge-joints; its motions being confined to flexion and extension in a single plane, with the addition of a very limited rotatory movement when the leg is bent so as to relax the ligaments.

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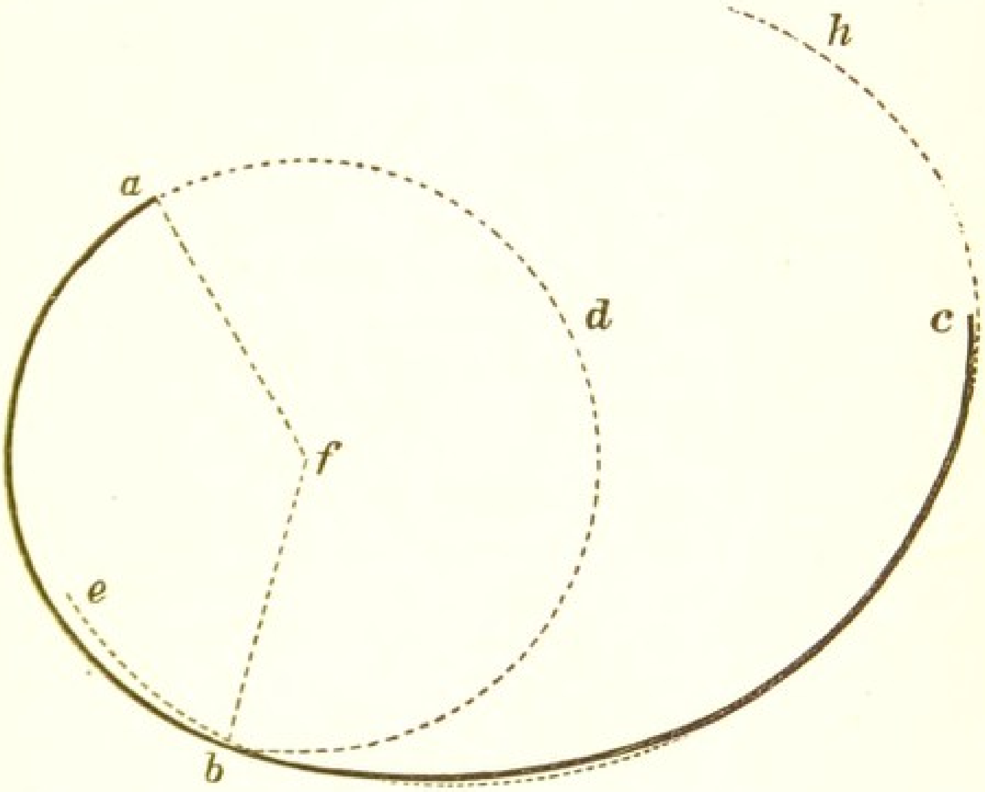
* Ligamentum patellæ.

† The *internal* lateral border gives attachment to the internal lateral ligament of the patella, and to that portion of the common extensor tendon which is derived from the vastus internus; the *external* lateral border gives attachment to the corresponding ligament and tendon of the outer side. (The lateral ligaments of the patella have been overlooked by many anatomists. They are well described by Bourgery, *Anatomie de l'Homme*, tom. i. p. 178.)

‡ Of the quadriceps extensor.

§ Ligamentum patellæ, or *infra-patellar portions of the extensor tendon*—as it might with more propriety be called.

The ginglymoid motions have a range of about 140°, *extension* being arrested when the bones are in a right line with each other; *flexion*, when they form an angle of about 40°. Neither these, however, nor the rotatory movements of the knee, are checked by the encounter of the bones. Their limitation depends on the oblong form of the condyles, the curvature of the articular surfaces, and the disposition of the ligaments which bind them to the tibia. The subjoined diagram represents the antero-posterior curvature of the external condyle (taken from the



bone itself, and transferred at once to the engraver's block, by the employment of a strip of lead, in the manner described at page 158, *supra*). The portion *a b*, belonging to the back of the condyle, coincides exactly with the segment *a b* of the circle *a b d*. The remaining portion *b c*, which includes the inferior and trochlear aspects of the condyle, approximates closely to the figure of the elliptical curve *e g h*. The curvature of the internal condyle is similar to that of the external, but on a smaller scale, and less regularly elliptical in front.*

Now, such being the shape of the condyles, it is obvious

* The radii of the posterior curves of the internal and external condyle are respectively five-eighths and six-eighths of an inch long, in average-sized thigh-bones.

that, in order to the performance of a hinge-like motion of the joint, one of two actions must take place. Either the *anterior* extremities of the condyles must *descend* into the articular cavities of the tibia, while their *posterior* extremities *rise;* or, on the other hand, their *posterior* extremities must *descend* (turning on the centre of the circular curve *a b*), while their *anterior* extremities rise. In order, therefore, to prevent extension beyond a right line, at the same time that a free range of flexion is permitted, it is only necessary to attach the ligaments *at* or *behind* the point *f*, so that they may *permit* the ascent of the *anterior* ends of the condyles, and *prevent* that of their *posterior* extremities. And, without entering into a description of the ligaments, with which we are not at present concerned, we may state in general terms, that their disposition and points of attachment are in strict accordance with this principle.*

Rotation of the knee-joint is impossible during extension of the leg; first, because in that position the oblong lower surface of the condyles of the femur fit closely to the oval cavities formed by the tibia and semilunar cartilages for their reception; and secondly, because the principal ligaments of the joint are, during extension, put upon the stretch, so as to oppose gliding motions in any direction. But rotatory movements become possible when the joint is flexed, because, in that posture, exactly opposite conditions prevail. The ligaments at the back of the joint are relaxed; and the rounded hinder extremities of the condyles, coming into cavities of an oblong form, are susceptible of a gliding movement backward and forward within them. Under these circumstances, rotation may be performed in either of three different modes:—The *internal* condyle may act as a pivot, while the *external* glides backward and forward in the corresponding cavity of the tibia; or, *vice versâ*, the *external* condyle may be the fixed point, while the *internal* is set in motion; or, lastly, *both* condyles may move together, the one advancing while the other recedes.

* The posterior crucial ligament presents the only exception to this general rule, its anterior fibres being attached to the very front of the inter-condyloid notch. These fibres, however, are so obliquely placed, and so long, that they are only tightened in full flexion, and can therefore have no effect in preventing the commencement of that motion.

(The simultaneous advance or retreat of both condyles is prevented by a strong pair of ligaments,* lodged in the inter-condyloid notch). The natural movements of rotation, produced by muscular action, are of the first kind; the external condyle moving backward and forward, while the internal is comparatively (though not perhaps *absolutely*) fixed. (We have here described rotation as performed by the condyles of the femur on the tuberosities of the tibia: it will be understood, of course, that the corresponding movements may be executed by the latter on the former).

348. The relative position of the patella, which we have next to consider, is not affected by rotation; but, in the ginglymoid motions of the joint, the condyles of the femur glide over its posterior surface, bringing successively into contact with it every point of their elliptical portion—from the summit of the trochlear groove, which touches it in extension, back to the hindmost points of the flattened under-surfaces, which reach it in extreme flexion. In very strong extension, indeed, when the ligamentum patellæ is stretched to its full length, the patella rises half its diameter above the trochlea. It is prevented, during the natural actions of the joint, from moving laterally, by the elevated borders of the trochlear groove, of which the external is the more prominent. When the extensor muscles are relaxed, however, the patella yields readily to external force, and may be pushed aside in either direction (but further inward than outward) from its median position on the trochlea. The *uses* of the patella, as a protection to the knee, are obvious. It defends it from violence in the manner of a shield; and distributes, over a considerable extent of surface, pressure which would otherwise be accumulated on the prominent extremities of the condyles.

349. The influence of the patella in regulating the action of the extensor muscles is a very remarkable feature in the mechanism of the knee-joint, and one which has never, I think, been thoroughly studied and explained. It has, indeed, been stated that the patella furnishes the extensors with a longer leverage than they would otherwise possess, and the observation is correct so far as it goes; but it falls short of the truth. The patella does

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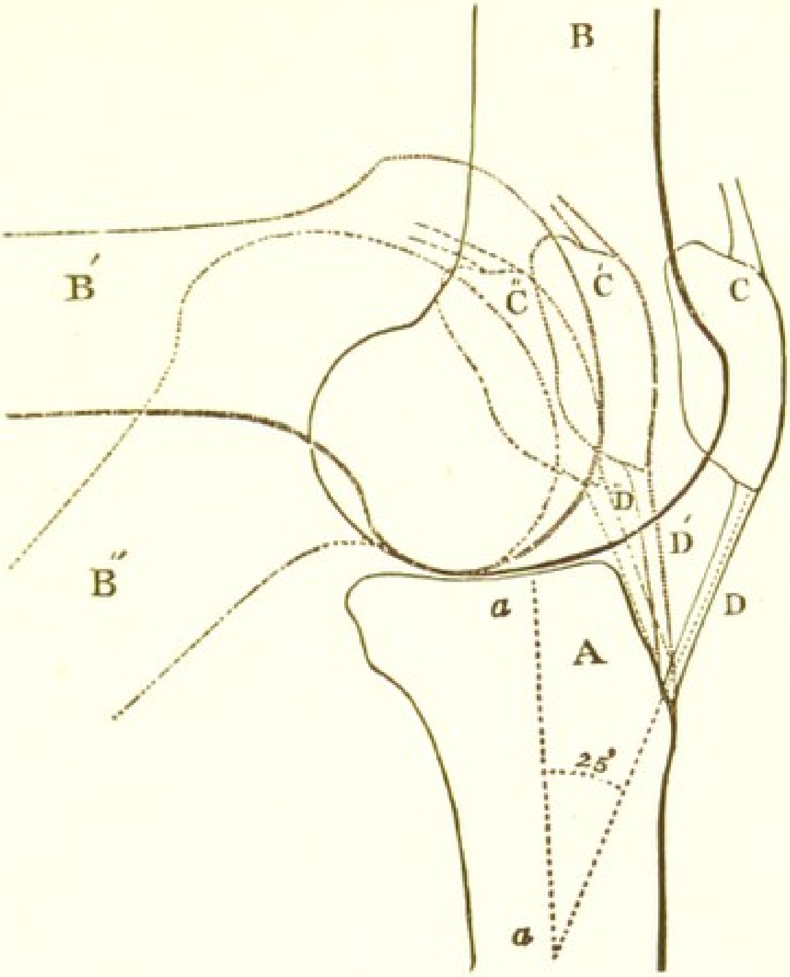
* The crucial ligaments.

more than this. It causes the extensors to act on the tibia with a leverage which *varies constantly* during the passage of the limb from flexion to extension, or the reverse; adapting them to furnish *force* and *velocity* in the exact proportion at each instant required. This function depends upon an advancing and receding movement of the patella, which is well understood by anatomists, though its purpose appears to have escaped their notice. In extension, the patella is thrust forward by the prominent extremities of the condyles, so that the infra-patellar portion of the extensor tendon (or *ligamentum patellæ*, as it is called) slopes forward from its tibial insertion, at an angle of from twenty to twenty-five degrees with the vertical axis of the tibia. Whereas, in flexion, the flattened under-surfaces of the condyles are presented forward, and the patella falls back into the space previously occupied by their anterior extremities; so that, when the joint is half bent, the ligamentum patellæ becomes parallel to the axis of the tibia, and, in extreme flexion, even inclines backward from the point at which it acts on that bone.

These three positions of the patella, and of the infra-patellar portion of the extensor tendon, are shown in the annexed diagram, in which A represents the tibia, B the femur, C the patella, and D the ligamentum patellæ, in the posture of full extension. D is inclined forward at an angle of twenty-five degrees, from the vertical axis *a a* of the tibia. B′, C′, and D′, respectively represent the femur, patella, and ligamentum patellæ, in demi-flexion of the joint; and here D′ is parallel to the axis of the tibia. B″, C″, and D″, represent the same parts as they appear in full flexion—the patella sunk between the condyles, and the ligamentum patellæ sloping obliquely *backward* at an angle of about twenty degrees from the vertical line.

In the first of these positions, the extensor muscles acquire force at the expense of velocity. As the patella recedes into the third position, the extensors act more and more obliquely on the tibia; and an increasing proportion of their *force* is exchanged for *velocity*.

The use of this progressive conversion may easily, I think, be perceived. In the posture of full extension, the muscles attached to the patella are employed, not to set the tibia in *motion*, but, on the contrary, to keep it firmly *fixed* in a position already assumed. This is an action with which *velocity* is incompatible by its very nature: *force* being the only condition which can possibly be re-



quired. But when the muscles are employed to restore the limb from the posture of flexion to the rectilinear attitude, the case is changed; *motion* to the extent of 140° has now to be communicated to the tibia, *force* ceases to be the sole requisite, and a certain amount of *velocity* becomes indispensable. To these varying necessities of the limb, the shifting leverage of the patella exactly corresponds; lengthening when *force* alone is required, shortening when there is also occasion for *velocity*. Nor is the *gradual* transition from one kind of leverage to the other without its use. It distributes the velocity of extension in such a manner, that the motion is swifter at its commencement than towards its close; so that the strain on the ligaments which finally arrest the action is moderated, while the average speed of motion remains the same. It also gives the extensors considerable purchase on the tibia a little before it has reached full extension, enabling them to keep the limb very firmly stiffened, even in attitudes of slight flexion. My view, then, of the whole matter may be shortly expressed in the following terms:—

The shifting leverage of the patella enables the extensors to *move* the leg into required positions with sufficient *velocity*, and to *fix* it in them with adequate *force*.

350. The fibro-cartilages of the knee-joint serve to deepen the cavities of the tibia, and, by promoting longitudinal elasticity, to distribute the force of concussion. Other uses have been attributed to them; but their functions, as well as those of the ligaments of the knee, are still, for want of an exact method of analysis, imperfectly understood. Some hitherto unobserved points in their anatomy and mechanical construction will form the subject of a separate paper.

351. The rank and function of the tibia, as the principal bone of its region, and the main supporter of the thigh, are clearly indicated by its relative bulk and position. The slender shaft of the fibula serves merely as an accessory column, furnishing some additional support to its outer tuberosity, and extending the surface for muscular insertion. To this latter purpose, the interosseous membrane, that stretches between the two bones, is also subservient.

352. The *superior* tibio-fibular articulation is a small arthrodial joint, of the simplest kind, capable only of obscure gliding motions. The *inferior* tibio-fibular articulation is analogous in its structure to the amphi-arthrodial joints; the opposed surfaces being separated, and at the same time firmly connected, by an intervening plane of short, strong ligamentous fibres. This joint is rendered almost immovable by the reception of the lower end of the fibula into a triangular excavation of the tibia. These tibio-fibular articulations, indeed, have no such rotatory movements to execute as are performed by the corresponding joints of the fore-arm; and their existence probably depends rather on the tendency of Nature to the preservation of a uniform type in the construction of analogous parts, than on any mechanical advantage thence resulting to the limb. They are evidently the dwindled vestiges of a superior organization — rather exemplifying a pre-existent law, than fulfilling a present function.

OF THE FOOT.

353. The foot, or terminal division of the lower extremity, represents an elliptical arch, resting at each extremity on the ground, and supporting, at right angles to its convex aspect, the column of the leg and thigh. It is composed of twenty-seven bones, united by thirty-two articulations, and arranged in three divisions, called the *tarsus*, *metatarsus*, and *phalanges*. These divisions correspond to the three regions of the hand, and, like them, are distinguished by well-marked peculiarities of size, form, and mechanical structure. Thus, each division of the foot is shorter and wider than its predecessor;—their relative length being in round numbers as 9, 6, and 4; their comparative width as 11, 13, and 16. Again, the *tarsus* consists of *cuboid* bones, articulated to each other by arthrodial or gliding joints; the *metatarsus*, of *long* bones, articulated to each other and to the tarsus by arthrodial joints; while the *phalanges*, which are also long bones, articulate with each other and with the metatarsus by *ginglymoid* or *hinge joints*. Before, however, we can understand the mechanism of these regions, or perceive their analogies to the corresponding divisions of the hand, it is necessary to take them to pieces, and to study, one by one, the several bones of which they are composed. To this minute examination we shall immediately proceed, premising only, in general terms, that as mobility is the distinctive quality of the hand, so strength is the predominating character of the foot; while elasticity belongs in an equal degree to both. Hence the breadth of the hand, the great length of the fingers in comparison to the carpus and metacarpus, and the free divergence of the thumb. Hence, on the contrary, the narrow elongated form of the foot, its diminutive phalanges, and the massive structure of the tarsus. Hence, lastly, in both these organs, the multiplicity of joints, the angular disposition of the bones, and the obliquity of their articulating surfaces.

OF THE TARSUS.

354. The tarsus consists of seven bones, viz., the calcaneum or os calcis, the astragalus, the cuboid bone, the scaphoid or navicular bone, and the three cuneiform bones, internal, external, and middle. In this enumera-

tion the tarsal bones are arranged in the order of their size, from the calcaneum, which is the largest, down to the middle cuneiform, which is the smallest of the series.

355. The tarsus is not susceptible, like the carpus, of a transverse division into two rows; for its inner border presents *three* bones placed one before the other, its outer border only *two*. But the tarsal bones may be naturally and conveniently classified by the longitudinal method of division, suggested in a former part of this work (284—5). Considered, indeed, with reference to its mechanical construction, the tarsus at once separates itself into two lateral portions; an *external*, remarkable for solidity and strength; an *internal*, characterized chiefly by its elasticity. The external division consists of two bones, viz., the calcaneum behind, the cuboid in front. The internal division comprises the remaining five bones, arranged in the following order;—the astragalus behind, in front of that the scaphoid bone, and foremost of all, the three cuneiform bones ranged side by side. These bones we shall at once proceed to describe; reserving for the sequel our observations on the construction and mechanism of the tarsus.

OF THE TARSAL BONES IN GENERAL.

356. The bones of the tarsus present greater diversities of size and form, and fewer common characters, than those of the carpus. Each, however, has six surfaces, articular where they come into contact with neighbouring bones, elsewhere rough for the attachment of ligaments; each is formed of light, elastic, cancellous tissue, enclosed in a thin compact layer; and each is developed by a single ossific centre, with the exception only of the calcaneum, which has an additional point at its posterior extremity. The development of the tarsal bones takes place in the following order:—The central point of the calcaneum appears in the fifth month of fœtal life; that of the astragalus, a month later; those of the remaining bones appear successively at various periods during the first four years after birth. The secondary ossific point of the calcaneum does not make its appearance till from eight to ten years after birth.

OF THE TARSAL BONES IN PARTICULAR.

OUTER DIVISION.

357. This division consists of two bones,—the *calcaneum* or *os calcis*, and the *cuboid bone*.

358. CALCANEUM, OR OS CALCIS. This is the largest bone of the foot. It is of an elongated form, transversely flattened, and larger at its posterior extremity, which projects backward to form the strong lever of the heel, than at its anterior extremity, which is called the *greater process* of the calcaneum—in contradistinction to a small apophysis, situated on the inner side of the bone, and called its *lesser process*. The calcaneum is placed obliquely in the tarsus, so as to touch the ground only at its posterior end. SURFACES. *Superior.* Presents in the middle two articular surfaces; an *external* and larger situated on the body of the bone; an *internal*, which is also somewhat anterior, supported by the lesser process. Both these surfaces are of oblong form, with their long diameters inclined obliquely outward and forward; both are plane transversely; and both are directed upward and forward to articulate with corresponding surfaces of the astragalus. The external is wider behind than before, and longitudinally *convex;* the internal, on the contrary, is longitudinally *concave*. These surfaces are separated by an oblique groove, running from behind forward and outward, and rough for the attachment of a ligament.* *Before* the larger surface appears the rough upper aspect of the greater process, presenting an irregular depression (continuous with the oblique groove), for the attachment of several ligaments,† and a muscle;‡ *behind* it is the upper aspect of that part of the os calcis which projects backward to form the heel—a narrow surface, convex transversely, concave longitudinally, and corresponding, in the recent subject, to a mass of adipose tissue that lies in front of the great tendon of the heel. *Inferior.* A narrow surface, convex transversely, and considerably wider behind than before. Posteriorly, it presents two *tubercles*, separated by a

* Interosseous astragalo-calcanean.

† The anterior-external fibres of the interosseous astragalo-calcanean ligament; also the superior calcaneo-scaphoid, and the internal calcaneo-cuboid ligaments.

‡ Extensor brevis digitorum.

rough *depression;* anteriorly, a single *tubercle,* and, in front of it, a little transverse *groove.* Of the posterior tubercles, the *external,* small and rounded, gives attachment to a muscle;* the *internal* and larger attaches two muscles,† and presents, first, a broad *inferior surface,* for the support of the heel; secondly, a prominent *inner border,* which, by its lateral projection, deepens the concavity of the internal surface. From the depression between these tubercles, a long ligament takes rise; another, shorter and less superficial, is attached to the anterior tubercle; and a third set of fibres, shortest and deepest of all, is implanted into the depression in front of the anterior tubercle.‡ The striated surface between the anterior and posterior tubercles gives origin to muscular fibres.§ *External.* This surface presents, near its centre, a prominent tubercle for the attachment of a ligament.‖ *Behind* this tubercle is a wide, even surface, giving attachment at its upper and anterior part to a small ligament;¶ *before* it is a narrower surface, belonging to the greater process, and presenting two oblique *grooves,* separated by a *tubercular ridge.* The grooves, which run downward and forward, transmit two tendons;** the intervening ridge gives attachment to an aponeurotic slip.†† *Internal.* This surface is surmounted, in front, by the *lesser process,* and elevated, at its posterior-inferior corner, by the lateral projection of the large tubercle of the heel. Traced diagonally from one eminence to the other, it presents a concavity of considerable depth; in the opposite sense it is convex. Its concavity represents a wide groove, directed obliquely downward and forward, for the transmission of nerves, vessels and tendons,‡‡ to the sole of the foot. The line of junction between this

* Abductor minimi digiti.

† Adductor brevis pollicis, and flexor brevis digitorum. (The former arises on the inner side of the latter, from the prominent internal margin of the tubercle.)

‡ These ligaments are called by Meckel the superficial, middle, and deep layers of the calcaneo-cuboid ligament. The first is commonly called the long plantar—the second and third together, the short plantar ligament.

§ Of the flexor accessorius, and flexor brevis digitorum.

‖ Middle external lateral. ¶ External astragalo-calcanean.

** The superior groove transmits the tendon of the peroneus brevis; the inferior, that of the peroneus longus.

†† A slip of the external annular ligament.

‡‡ Plantar nerves and vessels, and flexor tendons.

and the inferior surface gives origin to a muscle.* The LESSER PROCESS is a curved plate of bone, projecting horizontally inward from the anterior-superior part of this surface: above, it supports the astragalus by an oval concave articular surface, already described; *below*, it is convex, and channelled longitudinally by a deep groove (sometimes double) for the transmission of two tendons.† The *circumference* of this apophysis is continuous externally with the body of the bone, elsewhere free and rough for the attachment of ligaments.‡ *Posterior.* Wider below than above, and divided into two parts—an *inferior*, convex, and rough for the attachment of a tendon ;§ a *superior*, less extensive, flat, and in the recent subject covered with a thin layer of cartilage, and a synovial bursa, over which the tendon plays. *Anterior.* A smooth, sinuously curved surface, of irregularly triangular form, corresponding to the posterior surface of the cuboid bone. Its inner side is surmounted by a little horizontal prominence which, in the articulated tarsus, meets a corresponding prolongation of the cuboid, the two processes mutually embracing each other. Traced from the tip of this process downward and outward, the surface is concave in the greater part of its extent, convex for a small space below. In the opposite direction it is plane, except at the base of the little overhanging prominence, where it is transversely convex. This surface forms the anterior aspect of the GREATER PROCESS. The superior, inferior, and lateral aspects of this process are continuous with the corresponding surfaces of the rest of the bone, and their description has been included in the foregoing account. The only surface, indeed, on which the longitudinal extent of the greater process is definitely marked, is the superior; where it is limited behind by the convex articular surface for the astragalus.

359. CUBOID BONE. This bone forms a continuous line

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* Flexor accessorius.

† Flexor longus pollicis, and flexor communis digitorum. (When there are two grooves, the latter tendon runs in that which is internal, or nearest the tip of the process.)

‡ The superficial layer of the internal lateral ligament, the inferior, calcaneo-scaphoid ligament, and some astragalo-calcanean fibres.

§ That of the gastrocnemius, called the *tendo-Achillis.*

with the calcaneum, in front of which it is placed. In shape and position it resembles a truncated pyramid, with its base turned upward and inward, its apex in the opposite direction. The former aspect contains at least four times the superficial extent of the latter; whence the shape and obliquity of the other surfaces may be inferred. The comparison to a cube, implied in the name of this bone, is therefore inappropriate; it might be more aptly termed the *pyramidal* bone, in contradistinction to its *cuneiform* or *wedge-shaped* neighbours. SURFACES—*Superior*, or *dorsal*. An uneven surface directed obliquely upward and outward, and presenting several rough ligamentous impressions.* Its inner is longer than its outer border, the former dividing it from the base, the latter from the truncated apex of the pyramid which the bone represents. *Inferior*, or *plantar*. This surface is more extensive, especially along its internal border, than the superior. It looks downward and inward, and is traversed by a smooth *groove*, which runs from without obliquely inward and forward, for the transmission of a tendon.† This groove is bounded posteriorly by a *ridge*, the prominent outer extremity of which (called the *tuberosity* of the cuboid) presents a convex cartilaginous facet, for articulation with the sesamoid bone of the tendon that lies in the groove. The ridge, and the surface behind it, are rough for the attachment of ligaments,‡ and tendinous fibres.§ The anterior lip of the groove, and the whole inner margin of the surface, also give attachment to ligaments.|| *Posterior*. A smooth triangular surface, directed backward and a little outward, for articulation with the surface of the os calcis, to the sinuosities of which it is conversely adapted. Its inner corner is somewhat prolonged backward beneath the little horizontal process of the calca-

* For the attachment of dorsal ligaments, extending from this bone backward to the calcaneum, inward to the scaphoid and external cuneiform bones, forward to the fourth and fifth metatarsal bones.

† That of the peroneus longus.

‡ The ridge itself attaches the long plantar, the surface behind it the short plantar ligament.

§ Fibres of the abductor pollicis, and of the flexor brevis minimi digiti.

|| The anterior lip of the groove to plantar ligaments extending from the cuboid to the two last metatarsal bones; the internal margin of the surface to bands passing from the cuboid to the scaphoid and external cuneiform bones.

neum, around the base of which it turns.* This mutual overlapping of the two bones is so arranged as to permit the descent of the cuboid on the calcaneum, but to oppose its motion outward or upward. *Anterior.* An articular surface, of irregularly triangular form, directed obliquely forward and outward, and divided by a vertical line into two facets; an *internal*, quadrilateral, concave from above downward, and articulated to the fourth metatarsal bone; an *external*, rather larger, of triangular form, slightly concave, and articulated to the fifth metatarsal bone. *Internal.* This surface, forming the base of the pyramid represented by the cuboid, is directed inward, upward, and a little forward. It presents, at its middle and upper part, a small cartilaginous surface for articulation with the external cuneiform bone; and behind this, occasionally, another smaller facet for articulation with the scaphoid. In the rest of its extent, it is rough for the attachment of two interosseous ligaments.* *External.* A narrow surface, directed outward and downward, and presenting the commencement of the groove and ridge that traverse the inferior surface.

INNER DIVISION.

360. This division comprises the astragalus, the scaphoid, and the three cuneiform bones.

361. Astragalus. The largest bone of the inner division, and next to the calcaneum, of the whole foot. It occupies the middle and upper part of the tarsus, resting on the calcaneum below, supporting the tibia above, and articulating laterally with the two malleoli. It presents in front a smooth convexity, called the *head*, which is joined to the body of the bone by a constricted portion called the *neck*. Surfaces. *Superior.* Presents, at its posterior part, a large, smooth, *trochlear surface*,† wider before than behind, convex longitudinally, slightly concave from side to side, and articulating with the tibia. In front of this appears the upper aspect of the neck, presenting a rough depression for the attachment of ligaments.‡ *Inferior.* Presents two *articular surfaces*, a

* Cubo-cuneiform and cubo-scaphoid.

† That of the peroneus longus.

‡ Astragalo-scaphoid, and anterior fibres of the superficial layer of the tibio-tarsal ligament.

larger and a smaller, separated by a deep *groove*, which runs from the inner and posterior corner of the bone obliquely forward and outward, becoming wider and deeper as it advances. This groove corresponds to a similar one in the calcaneum, (358) forming with it, when the bones are united, a *canal* for the lodgment and insertion of a strong interosseous ligament.* Of the articular surfaces, the larger is external and posterior to the smaller, which is nearly equal to it in length, though little more than half as wide. Both these surfaces are directed downward and backward, and both are of an oblong form, with their long diameters extending forward and outward, parallel to each other, and to the intervening groove. The larger is wider behind than before, concave in the direction of its long diameter, plane in the opposite sense, and articulated to the corresponding surface on the body of the calcaneum. The smaller is of elongated oval figure, convex longitudinally, and plane in the opposite direction. It articulates, behind with the lesser process of the calcaneum, and in front with a strong ligament† that stretches beneath it from the calcaneum to the scaphoid bone. (The portion of this surface which articulates with *bone*, is sometimes separated from that which rests upon *ligament*, by a constriction, or transverse groove, dividing this aspect into two facets.) *Internal.* Presents at its upper part a small, slightly concave, articular surface of oblong form, continuous above with the trochlear surface, and covered in the recent subject with a prolongation of the same cartilage. This surface is directed inward, upward, and a little backward, to articulate with a corresponding surface on the internal malleolus. Below it there is a rough excavation for the attachment of a strong ligament.‡ *External.* Presents in the middle a triangular articular surface, larger than the internal, and, like it, continuous above with the trochlear surface, and encrusted with a prolongation of the same cartilage. It is concave from above downward; slightly convex in the opposite sense, at its lower part; and directed a little upward and backward, as well as outward, to articulate with the external malleolus. Below and behind this surface are some rough ligamentous

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* Calcaneo-astragaloid. † Inferior calcaneo-scaphoid.
‡ Deep layer of the internal lateral, or tibio-tarsal ligament.

impressions.* In front of it appears the narrow outer border of the neck, also rough for the attachment of a ligament.† *Posterior*. A surface of small extent, traversed by a groove which runs obliquely downward and inward, and serves for the transmission of a tendon.‡ *Anterior*. A convex surface of oval form, somewhat broader at its outer than at its inner extremity, and obliquely placed, so that its long diameter runs inward and downward. It forms the *head* of the astragalus, and is received into the cavity of the scaphoid bone, which, however, it somewhat exceeds in length. The inner extremity of this surface is separated from the corresponding extremity of the under surface by a triangular space, covered with cartilage, and directed obliquely downward and inward to meet the inner fibres of a strong ligament on which it plays.§

362. SCAPHOID, OR NAVICULAR BONE. A bone of oval form, presenting articular surfaces before and behind, separated by a narrow, roughened circumference. Slightly curved in the direction of its length, excavated posteriorly, and more pointed at its inner than at its outer extremity, it certainly bears sufficient resemblance to a shallow boat, to justify the comparison implied in its name. Somewhat thicker above than below, it is interposed, like a wedge, between the astragalus and the cuneiform bones; resting against the oblong head of the former, and presenting a corresponding inclination of its long axis downward and inward. SURFACES. *Posterior*. An oval, concave, articular surface, broader externally than internally, and somewhat shorter than the head of the astragalus, which it therefore imperfectly receives. *Anterior*. An oblong surface, less regularly oval than the posterior, presenting from side to side a general convexity, divided by two ridges into three articular *facets*. Of these the *innermost* and largest is convex, wider below than above, and articulated to the internal cuneiform bone; the *middle*, second in extent, and distinctly triangular in form, is wider above than below, and sinuously curved for articulation with the middle cuneiform; while the *outermost* and smallest of the three, wider above than below, and

* For the posterior division of the external lateral ligament, and some external calcaneo-astragaloid fibres.

† Anterior division of the external lateral ligament.

‡ That of the flexor longus pollicis.

§ Inferior calcaneo-scaphoid ligament.

slightly concave, corresponds to the external cuneiform bone. *Superior.* Directed obliquely upward and inward, convex transversely, and rough for the attachment of ligaments.* *Inferior.* Narrower than the superior, and like it, rough for the attachment of ligaments.† *Internal.* This end of the bone forms a tubercular prolongation, directed downward and inward, and called the *tuberosity* of the scaphoid bone. It gives attachment to a tendon,‡ and to part of two ligaments.§ *External.* This surface is rough for the insertion of a ligament,|| and sometimes presents a small facet for articulation with the cuboid bone, to the inner surface of which it is opposed.

363. Cuneiform bones. Three wedge-shaped bones, placed side by side at the anterior and internal part of the tarsus, with the scaphoid behind them, the metatarsus in front, and the cuboid bone on their outer side. They are distinguished, numerically, as first, second, and third, counting from within outwards ; or, more commonly, as internal, middle, and external. Each presents six aspects, corresponding respectively to the *base*, the *cutting edge*, the two quadrilateral *inclined surfaces*, and the two triangular *parallel* surfaces, of a wedge. They are all placed somewhat obliquely, extending a little *outward* as well as forward from the front of the scaphoid. This inclination differs from that of the neck of the astragalus on one hand, and from that of the metatarsal bones on the other, giving to the inner division of the tarsus a double curvature, which constitutes, as we shall presently find, a very important feature in its mechanical construction.

364. Internal cuneiform bone. This bone is the largest of the three, and the only one among them that

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* Dorsal ligaments, radiating from the scaphoid to the other six tarsal bones.

† The inferior calcaneo-scaphoid ligament ; also, strong plantar ligaments, extending from the scaphoid to the cuboid, and to the internal cuneiform bone ; and some irregular fibres, passing from the scaphoid to the middle and external cuneiform bones.

‡ That of the tibialis posticus.

§ Viz.—first, a strong band extending backward from this tubercle to the lesser process of the calcaneum, and belonging to the inferior calcaneo-scaphoid ligament; and, secondly, some strong fibres running forward to the internal cuneiform bone, and belonging to the plantar scapho-cuneiform ligament.

|| Interosseous cubo-scaphoid.

has its base turned downward. Moreover, it descends considerably below its fellows, to a level with the tuberosity of the scaphoid, with which it forms a thick marginal prominence, running along the inner side of the tarsus, and deepening the transverse concavity of its plantar aspect. SURFACES. *Posterior.* A triangular, concave surface, wider below than above, and articulated with the innermost and largest of the three anterior facets of the scaphoid. *Anterior.* A semilunar surface, broader above than below, and articulated to the first metatarsal bone. It is curiously twisted, so as to look somewhat more inward above than below. *Superior.* A mere edge, turned upward and outward, representing the sharp border of the wedge, and giving attachment to ligamentous fibres.* *Inferior.* We have already had occasion to notice this aspect, which presents itself on the plantar surface of the foot, as a thick tubercular ridge, often called the *tuberosity* of the internal cuneiform bone. It attaches several ligaments,† gives insertion to two muscles,‡ and origin to a third.§ *Internal.* A broad, quadrilateral, slightly convex surface, directed obliquely upward and inward, presenting at its anterior-inferior corner a smooth facet, over which a tendon‖ turns, elsewhere rough for the attachment of ligaments.¶ *External.* This aspect is skirted by a narrow articular surface, consisting of a horizontal and vertical portion, the former running along its upper, the latter along its posterior margin. The anterior corner of this articular surface is divided by a vertical ridge from its posterior portion, so as to form a little concave facet which meets the inner side of the second metatarsal bone. The remainder of the surface, also slightly concave, and continuous behind with the posterior surface of the bone, articulates with the middle cuneiform. Beneath this articular surface there

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* Belonging to the dorsal scapho-cuneiform, and dorsal intercuneiform ligaments.

† The *outer* side of the tuberosity attaches a ligament passing to the second metatarsal bone, and another extending to the middle cuneiform bone. Its *lower* side (or the inferior surface of the bone, properly so called) attaches plantar ligaments passing backward to the scaphoid, and forward to the first metatarsal bone.

‡ Tibialis anticus, and a slip of the tibialis posticus.

§ Flexor brevis pollicis.

‖ That of the tibialis anticus.

¶ Dorsal ligaments, extending from this bone to the scaphoid, middle cuneiform, and first metatarsal bone.

is a rough space, the upper part of which is opposed to the middle cuneiform bone, and attaches an interosseous ligament;* while its lower portion projects into the plantar region, forming the inner side of the *tuberosity*, and attaching plantar ligaments, in the manner already described.

365. MIDDLE CUNEIFORM BONE. This, the smallest of the three cuneiform bones, is of very regular wedge-like form, but a little wider behind than before. It is inserted between its fellows, with its base upward, in the manner of a keystone. But, by reason of its inferior size, it fills up only a part of the interval between the external and internal cuneiform bones, leaving a wide empty space in front, and another, much narrower, below. The anterior recess lodges the extremity of the second metatarsal bone; the narrow interval below it is occupied merely by a few plantar ligamentous fibres. SURFACES. *Posterior.* A triangular articular surface, alternately concave and convex, corresponding to the sinuously curved triangular facet on the middle of the scaphoid bone. *Anterior.* A triangular sinuous surface, somewhat narrower than the posterior, and directed forward and outward to articulate with the extremity of the second metatarsal bone. *Internal.* Quadrilateral, and skirted along its superior and posterior borders by a slightly convex cartilaginous surface, which presents a horizontal and a vertical portion, in exact correspondence with the marginal surface on the outer aspect of the internal cuneiform, (364) with which it articulates. Below this articular surface is a rough depression for the insertion of a ligament.† *External.* This surface presents, posteriorly, a smooth facet, concave from above downward, and plane in the opposite direction, for articulation with the external cuneiform bone. In front of this is a narrow, rough space, for the insertion of a ligament.‡ *Superior.* A quadrilateral surface, somewhat wider behind than before, forming the base of the bone, and rough for the attachment of ligaments.§ *Inferior.* A narrow,

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* Intercuneiform.

† Interosseous ligament between this bone and the internal cuneiform.

‡ Interosseous ligament extending from this bone to the external cuneiform.

§ Dorsal ligaments passing to the four adjacent bones.

tubercular aspect, almost concealed by the internal and external cuneiform bones, which project below it into the plantar region, approaching each other as they descend. It gives attachment to a ligament.*

366. EXTERNAL CUNEIFORM BONE. Intermediate in size between the other two, and placed like the second with its base upward, this bone occupies a very central position in the tarsus. Thus, it has two cuneiform bones to its inner side, the cuboid bone (which about equals them in bulk) to its outer side, and the middle bone of the metatarsus in front. And, as the second metatarsal bone projects backward into the tarsus, so, on the other hand, does this bone, exceeding the cuboid and middle cuneiform in length, jut forward between the second and fourth bones of the metatarsus; by which alternate projection the tarsus and metatarsus are firmly interlocked, and secured from lateral displacement. SURFACES. *Posterior.* This surface presents a small, slightly convex facet, broader above than below, and directed backward and inward to articulate with the external facet of the scaphoid bone. Below this is a little rough space, to which some ligamentous fibres are attached.† *Anterior.* Triangular, and slightly concave, for articulation with the third metatarsal bone. *Internal.* A quadrilateral surface, presenting two articular facets; a *smaller*, situated at its anterior-superior corner, and articulating with the outer side of the second metatarsal bone; a *larger*, running along its posterior margin,—prolonged, and slightly convex, in the vertical direction — narrow and plane transversely,— directed inward, upward, and a little forward, to articulate with the middle cuneiform bone. Between these facets is a rough depression, for the attachment of a ligament.‡ *External.* This surface, like the last described, presents two articular facets; a *smaller*, situated at its anterior-superior corner, and articulating with the inner side of the fourth metatarsal bone; a *larger*, also posterior, wider above than below, slightly concave, and

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* A short, strong, ligamentous band, extending obliquely backward and inward from this surface to the outer side of the tuberosity of the internal cuneiform bone. (Some anatomists consider this to be part of the interosseous ligament between the internal and middle cuneiform bones.)

† A few fibres running backward and outward to the cuboid bone.

‡ Interosseous ligament between this and the middle cuneiform bone.

directed obliquely outward, backward, and downward, to articulate with the cuboid. The intervening space is rough, and excavated for the attachment of an interosseous ligament.* The cuboidal articular surface just described is an independent facet, having a cartilage proper to itself. But the little metatarsal facet in front of it, and the similar metatarsal facet of the internal aspect, are continuous with the anterior surface of the bone, and covered with a prolongation of the same cartilage. The surface which articulates with the adjacent cuneiform, and the posterior or scaphoidal surface, are in like manner continuous with each other—as indeed are the corresponding surfaces of all the cuneiform bones. (The reason of this continuity is, as we shall presently have occasion to explain, that the scapho-cuneiform and inter-cuneiform articulations are all lined in the recent subject, by a common synovial membrane, presenting but a single cavity.) *Superior.* A quadrilateral surface, representing the base of the wedge, directed upward and outward, and rough for the attachment of ligaments.† *Inferior.* This aspect appears in the plantar region as a tubercular ridge descending lower than the second cuneiform bone, but not so low as the first. It is directed downward and inward, and gives attachment to several ligaments,‡ to a tendinous slip,§ and occasionally to a few muscular fibres.||

OF THE TARSUS IN GENERAL.

367. The seven bones that have now been described compose a region of elongated form, narrow and free behind, where it rests upon the ground, gradually widening towards its anterior extremity, which is supported by the metatarsus. This region, which forms of itself the posterior moiety of the vault of the foot, presents a longitudinal and a transverse curvature; so that it is *convex*

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* Cubo-cuneiform.

† Dorsal ligaments passing hence, in all directions, to the contiguous bones.

‡ Plantar ligaments extending to the cuboid and internal cuneiform bones, also a strong fasciculus, passing transversely to the fifth metatarsal bone, and some fibres running forward to the third metatarsal bone.

§ From the tendon of the tibialis posticus.

|| Of the flexor pollicis brevis.

in both directions above, and *concave* in both directions below. It is also twisted, so to speak, upon itself, in such a manner that its posterior half is most extensive in the *vertical* dimension, and consists of bones piled one upon the other; while its anterior half, on the contrary, is most extensive *transversely*, and consists of bones ranged side by side. Hence, each of the four principal aspects of the tarsus—viz. its superior, inferior, and two lateral aspects—presents a *surface* at one end, narrowing to a *border* at the other. Thus, the *superior* aspect presents, in front, an expanded convex *surface*, formed by the scaphoid, cuboid, and three cuneiform bones; behind this appears the comparatively narrow trochlea of the astragalus; and, still further backward, the upper *border* of the projecting lever of the heel. So, too, the *inferior* view presents in *front*, the wide excavated under-surface of the anterior group of bones; and, behind, only the narrow lower aspect of the lever of calcaneum. Again, the *inner* aspect presents, in front, a *border* formed by the tuberosity of the internal cuneiform and scaphoid bones, and by the neck of the astragalus; and, behind, an expanded *surface* formed by the inner side of the body of the astragalus, and by so much of the corresponding aspect of the calcaneum as lies behind its lesser process. In like manner, the *outer* aspect presents, in front, a *border* formed by the narrow outer side of the cuboid bone, and greater process of the calcaneum; and, behind, an extensive *surface* formed by the bodies of the astragalus and calcaneum. Of these aspects the *inferior* is remarkable for its irregular tubercular appearance. Thus, it presents, posteriorly, the three tubercles of the calcaneum; in front of these, the oblique ridge of the cuboid, and the tubercular lower border of the external cuneiform bone; while further inward, appear the tuberosities of the internal cuneiform and scaphoid bones, which though they appear on the lateral aspect of the tarsus, project downwards also into the plantar region, so as to form a thick ridge along its inner margin. This surface also presents the two principal tendinous grooves of the tarsus, one (sometimes double) on the lesser process of the calcaneum, the other on the cuboid bone. The former is continuous behind with the oblique groove on the posterior extremity of the astragalus; (361) the latter leads externally to the inferior of the two oblique grooves on the outer surface of the calcaneum. (358) The *dorsum* of the tarsus is comparatively smooth and level. It presents, posteriorly, the trochlea of the astragalus (the centre of which surface corresponds with the point of junction between the posterior two-fifths and the anterior three-fifths of this aspect). In front, and a little to the outer side of this articular eminence, appears an excavation of considerable size and depth, which may be called the *dorsal fossa* of the tarsus (in contradistinction to its *plantar* excavation). This fossa is bounded, *below*, by the greater process of the calcaneum ; *behind*, by the body of the astragalus ; and *above* and on the *inner* side, by the neck of the astragalus, which arches over it obliquely forward and inward. In front and externally it is open. It lodges part of the interosseous ligament that connects the astragalus and calcaneum ; it also gives attachment to two other ligaments,* and a muscle.† It is continuous behind with the oblique canal formed by the junction of the grooves of the astragalus and calcaneum ; of which canal, indeed, it may be considered as the expanded extremity. Of the *lateral* aspects of the tarsus, the *internal* is somewhat convex, the *external* nearly flat ; each presents at its upper and posterior part the articular surface for the corresponding malleolus. Below this surface, on the *outer* side, appears the external surface of the body of the calcaneum, with its central *tubercle* for the attachment of a ligament.‡ Further forward may be observed, in succession, the two oblique *grooves* of the calcaneum, with the *tubercle* which separates them,—and the *tuberosity* of the cuboid, with its smooth facet for articulation with the sesamoid bone of a strong tendon.§ Below the malleolar surface, on the *inner* aspect, appears a rough *depression* of the astragalus ; and below this, again, the tubercular extremity of the *lesser process* of the calcaneum ; both attaching internal ligaments of the ankle-joint.||

369. Of the *extremities* of the tarsus, the *posterior* presents only the hinder aspect of the calcaneum, and requires no notice here. The *anterior*, on the contrary,

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* Superior calcaneo-cuboid, and external calcaneo-scaphoid.

† Extensor brevis digitorum.

‡ Middle division of the external lateral ligament of the ankle-joint. § That of the peroneus longus.

|| The astragalus attaches the *deep*, the lesser process of the calcaneum the *superficial* layer, of the internal lateral ligament.

is a very remarkable border, formed by the cuboid and the three cuneiform bones. It is transversely curved so as to present a convexity upward, and it inclines from within obliquely outward and backward, so that its inner extremity (formed by the first cuneiform bone) occupies a position full half an inch in advance of its outer extremity (formed by the cuboid bone). It is rendered uneven by the projection of the internal and external cuneiform beyond the level of the middle cuneiform and cuboid bones. Of this arrangement we shall have occasion to speak more particularly in our description of the metatarsus, with which this border articulates.

MECHANISM OF THE TARSUS.

370. This division of our subject includes, first, a description of the *tibio-tarsal* or *ankle* joint, by which the foot is hinged to the leg; and, secondly, an analysis of the *intertarsal* joints, and of the mechanical arrangements which give *elasticity* and *strength*, together with a considerable degree of *mobility*, to this region of the foot.

371. The articulation of the *ankle* is a *ginglymus* or *hinge-joint* capable of angular motion in the vertical plane, to the extent of about 35°. It is effectually secured from lateral dislocation by the projection of the malleoli, which descend, one on each side of the astragalus, forming a sort of box for its reception; so that luxation on either side is absolutely impossible, except in case of fracture of the corresponding malleolus. Another provision, tending to maintain the bones firmly in their relative position, consists in the shape and adaptation of the opposed surfaces. The trochlea of the astragalus presents a median groove, and two lateral elevations, respectively receiving, and received into, a median ridge, and two lateral depressions on the terminal surface of the tibia. In the median position of the foot, when it rests horizontally on the ground, the astragalus receives the pressure of the tibia at right angles, and none of the ligaments of the ankle-joint are put upon the stretch—a circumstance which may be noted as one of the conditions on which the aptitude of man for the erect posture depends. From this median position the foot is raised, in flexion, about 10° or 15°, and depressed, in extension, between 20° and 25°; the former movement being checked by the posterior, and the latter

by the anterior ligaments of the joint. In *flexion*, the wide anterior extremity of the trochlea of the astragalus is brought between the two malleoli, and completely fills the intervening space; so that, in this attitude, no lateral movements of the joint are possible: but in *extension*, the narrow posterior extremity of the trochlea comes between the malleoli, only partially filling the space bounded by those processes; so that, in this posture, slight lateral, or rather rotatory movements, by which the toes are pointed a little inward or outward, may be performed. And this I take to be the true explanation of the fact that the trochlea of the astragalus is narrower behind than before,—a fact of which anatomical writers have not hitherto pointed out the meaning. Cruveilhier has evidently overlooked it, in asserting, without reference to any particular position of the foot, that lateral movement of the astragalus necessarily involves displacement or fracture of the external malleolus. Bourgery goes to the other extreme, in attributing to the ankle-joint movements of adduction and abduction, by which the sole is turned inward or outward. Each of these movements would involve partial separation of the opposed surfaces; so that the tibia would touch the astragalus on the inner side only, in adduction,—on the outer side only, in abduction. I have satisfied myself, by repeated observation, that the ligaments permit no such separation of the bones; which, even if possible, would probably injure the joint, by causing an undue accumulation of pressure on particular points of its articular surfaces.

The proximity of the ankle-joint to the heel is an important feature in the organization of the limb. It not only determines the leverage of the extensors of the foot, and the proportions of velocity and force in the motions which they produce, but it enables us, by simply elevating or depressing the knee, to modify the character and properties of the support which the foot affords to the leg. In the former posture, when only the anterior extremity of the sole touches the ground, force is transmitted very indirectly, and by the intervention of a long spring in the tibia: in the latter position, on the contrary, when the heel rests on the ground, a comparatively direct and rigid support is afforded to the leg. The first-described attitude is employed to distribute the force of sudden *concussion* (that of a jump, for example); the second posture is assumed when the foot is required to sustain some heavy continuous *pressure* (that of the trunk, for instance, augmented, as it often is, by the addition of a ponderous burden).

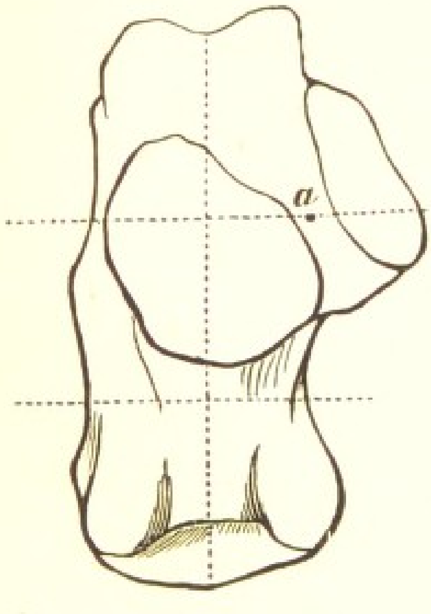
This explanation may be confirmed, and the advantage of the existing arrangement illustrated, by considering the effect of a different structure.

If the trochlea were situated at a greater than its actual distance from the heel—if, for example, the tibia were supported on the *centre* of the pedal arch—the aptitude of the limb to sustain pressure and concussion would be diminished. Sudden shocks on the anterior extremity of the sole, being received by a shorter spring, would pass more abruptly to the leg; and continuous pressure, finding its way less directly to the ground, would strain more severely the bony and ligamentous structure of the foot. If facts are required in further corroboration of these views, we may refer, on the one hand, to the violent concussion of the whole body, occasioned by a fall upon the heel; and, on the other, to the strain on the plantar ligaments, resulting from an attempt to support a heavy burden while the heel is elevated from the ground.

372. The mechanism of the *intertarsal* articulations may be considered with reference, first, to mobility, and, secondly, to elasticity. The astragalo-calcanean, astragalo-scaphoid, and calcaneo-cuboid joints, are capable of comparatively extensive movements, by which the attitude and direction of the foot are visibly changed. The remaining articulations, including the three scapho-cuneiform, the two intercuneiform, and the cubo-cuneiform joints, together with the cubo-scaphoid (when it exists) are susceptible only of very limited movements, contributing to the general flexibility and elasticity of the tarsus, but producing no sensible alteration in its posture.

The seven last-mentioned joints are, in the recent subject, all lined by a common synovial membrane, which covers the front of the scaphoid, and the posterior surfaces of the three cuneiform bones, sending prolongations between them, as well as into the cubo-scaphoid joint (when it exists), and from thence into the cubo-cuneiform. The calcaneo-cuboid joint has a separate synovial membrane; as also has that portion of the astragalo-calcanean joint which lies to the outer side of the astrago-calcanean oblique canal. That part of the astragalo-calcanean joint, however, which lies on the *inner* side of the canal, is lined by a continuation of the same synovial membrane, which covers the surfaces of the astrago-scaphoid articulation. The two joints, indeed, appear at first sight to be perfectly distinct; the lesser process of the calcaneum being separated, in the skeleton, from the scaphoid bone by a triangular interval through which part of the articular under-surface of the head of the astragalus appears in the plantar region. In the recent subject, however, a strong ligament stretches across the interval from the lesser process of the calcaneum to the scaphoid bone, furnishing the head of the astragalus with a flexible, yielding support, and presenting a surface along which the synovial membrane is reflected continuously from one bone to the other. Thus, though there are ten joints in the tarsus, there are only four separate synovial cavities.* The shape and curvature of the opposed surfaces in these joints having been already described, I shall proceed at once to consider the direction and effect of their several movements, of which no full and satisfactory account has hitherto been published.

373. The calcaneum performs upon the astragalus a movement of rotation, the axis of which is the middle of the astragalo-calcanean interosseous ligament. The position of this axis is shown at *a*, in the annexed diagram. It lies between the body and lesser process of the bone, at the junction of the two posterior thirds with the anterior third of its length. In rotating on this centre, the body of the calcaneum advances beneath the body of the astragalus, while its lesser process recedes beneath the neck of that bone. The advance, however, is more extensive than the recession, because the centre of motion is further from the middle of the body than from the middle of the lesser process. Hence the relative

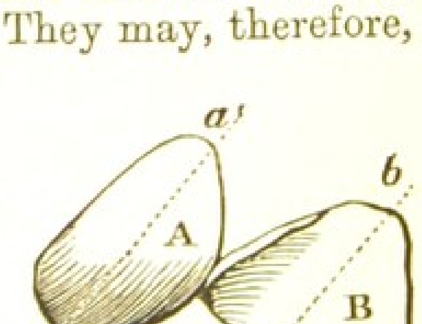


* Sometimes the synovial cavity in front of the scaphoid communicates (through the cubo-scaphoid joint) with that which lies behind the scaphoid, in which case the number of separate synovial cavities in the tarsus is reduced to three.

position of the neck of the astragalus and the lesser process is comparatively little changed; but the body of the calcaneum advances nearly a quarter of an inch. But, again, as the body of the calcaneum articulates by a *convex* surface directed upward and forward, with a *concavity* on the astragalus having an opposite aspect, it cannot glide straight forward, as it might upon a plane surface horizontally disposed, but is compelled to *descend* a little in advancing. This descent is from one-eighth to three-sixteenths of an inch in extent. A converse adaptation of surfaces compels the lesser process to ascend a little as it recedes. Moreover, as the body of the calcaneum advances by rotation on a centre situated at its inner side, its advance must be accompanied by a motion of its anterior extremity *inward* (and, of course, of its posterior extremity in the opposite direction).

The effect of this compound movement of the calcaneum upon the anterior region of the foot is easily traced. The calcaneum articulates in front with the cuboid bone, which supports the *outer* side of the metatarsus and phalanges; while the head of the astragalus is connected, by the intervention of the scaphoid and cuneiform bones, with the *inner* side of those regions. The effect of *advancing* the body of the calcaneum, while the astragalus remains fixed on the tibia, is, therefore, to push forward the outer side of the foot, and to point the toes inward. And the effect of *lowering* the body of the calcaneum, while the astragalus remains stationary, is to depress the outer border of the foot, and to give the sole a direction obliquely downward and inward. To this latter effect the *inward* motion of the anterior extremity of the calcaneum slightly contributes.

The astragalo-scaphoid and calcaneo-cuboid joints are nearly on a line with each other, and their motions are always simultaneously performed. They may, therefore, both be examined at once, as forming a double articulation, by which the anterior and posterior moieties of the tarsus are moveably jointed together. The oval, convex head of the astragalus, and the sinuously concave anterior surface of the calcaneum, are represented respectively at A and B, in the annexed diagram (taken, as the student will observe, from the left foot). The concavity of the calcaneum repre-

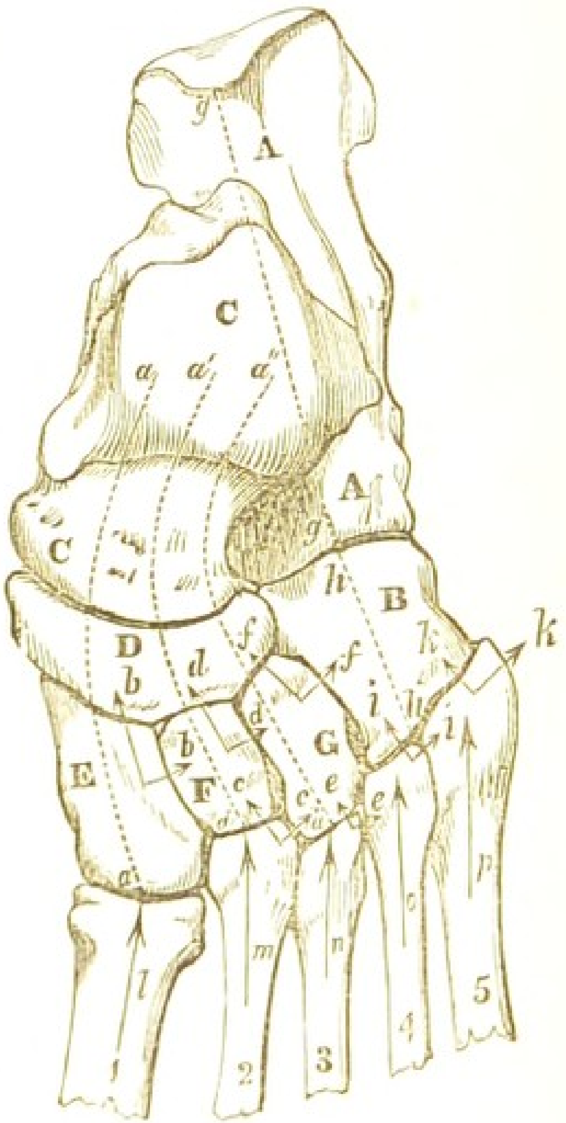


sents a shallow groove, running obliquely downward and inward, in the direction *b b*, parallel to the long diameter *a a* of the head of the astragalus. The scaphoid bone descends obliquely inward upon the head of the astragalus, in the direction of its long diameter, *a a*. The cuboid performs a parallel movement on the calcaneum —gliding in the direction *b b* of its shallow groove. But the cuboid descends further than the scaphoid; whence it follows that the latter bone executes a *rotatory* movement on the head of the astragalus, in addition to its descent, or flexion, thereon. Further, the head of the astragalus being convex, inclines obliquely backward below its centre, so that the scaphoid, in descending upon it, also *recedes* a little. The effect of the oblique descent of the scaphoid bone, and of its recession, is to increase the convexity of the antero-posterior arch of the foot, and to point the toes inward. The rotatory motion occasioned by the cuboid descending further than the scaphoid bone, has for its effect to depress the *outer* and to raise the *inner* border of the foot; so that the sole is turned obliquely inward.

When these movements of the two last-described joints are performed concurrently with those of the astragalo-calcanean articulation, the posture of the foot undergoes a considerable change. The toes move inward from their median position, describing an arc of about 25 degrees, and the outer border of the foot is brought into a plane about an inch and a-half below the level of the inner border. The opposite movements restore the foot to its median position; and may be continued further, so as to turn the toes and the plantar surface outward. This action, however, is less extensive than the former. The outward range of the toes does not exceed ten degrees, and the elevation of the outer border is small in proportion.

374. Having thus examined the more extensive motions of the tarsus, we may next consider the obscure, but not less important movements upon which (so far as the bones are concerned) the primary and essential quality of this region, viz., its *elasticity*, depends. To facilitate this analysis, which has not hitherto been attempted by anatomists, I have made use of the method previously employed in determining the complicated motions of the carpal bones; (280) a method which consists in tracing the course and distribution of concussions transmitted along each of the five terminal columns of the limb.

When we alight, in jumping, upon the anterior extremity of the pedal arch, part of the force of impact bends the ankle-joint, depresses the heel, and tells upon the muscles of the calf, which yield to it in the manner of a spring, while another portion, which increases as the foot is pointed more directly downward during the concussion, passes longitudinally through the tarsus to the tibia. It is with this latter portion that we are at present concerned; and its distribution will be readily understood by the aid of the subjoined diagram, which represents the tarsus and the posterior part of the metatarsus, as seen from above. *A A* is the calcaneum, *B* the cuboid, *C C* the astragalus, *D* the scaphoid, *E*, *F*, and *G*, the internal, middle, and external cuneiform bones; while the figures 1, 2, 3, 4, 5 are placed each upon the metatarsal bone of which it is the numerical appellation. The arrows *l*, *m*, *n*, *o*, and *p*, show the direction in which the force arrives; and the smaller arrows, *b b*, *c c*, *d d*, *e e*, *f f*, *i i*, *k k*, indicate its subsequent distribution.



The three cuneiform bones (*E F G*), run obliquely forward and *outward* from the scaphoid bone; while the three first metatarsal bones (1, 2, 3), which they respectively support, run obliquely forward and *inward*. Thus each cuneiform bone forms, with the corresponding metatarsal bone, an obtuse angle having its apex directed outward. From this arrangement it results, that concussion transmitted through the first metatarsal to the internal cuneiform bone, is divided in the manner indicated by the arrows *b b*, a portion passing on to the scaphoid (*D*), while the remainder tells obliquely upon the middle cuneiform bone (*F*). A shock passing through the second metatarsal bone (2), is divided, first, between the middle and external cuneiform bones (*F* and *G*), as shown by the arrows *c c*, and again between the scaphoid and external cuneiform bones (*D* and *G*), as represented by the arrows *d d*. In like manner, the force of a blow upon the third metatarsal bone is divided, first between the external cuneiform and fourth metatarsal bones (*G* and *H*), as shown by the arrows *e e*, and again between the scaphoid and cuboid bones (*D* and *B*), in the manner represented by the arrows *f f*.

Thus, longitudinal concussion of the first three metatarsal bones is partially converted, in the tarsus, into a lateral force, tending to thrust outward the cuboid bone. And it is, I think, for the more effectual resistance of this pressure, that the base of that pyramidal bone is turned inwards toward the cuneiform bones, instead of appearing above on the convex surface of the tarsus.

That portion of the force of impact which passes from the cuneiform bones to the scaphoid, proceeds thence through the astragalus (*G G*) to the tibia. In its progress through the tarsus, it traverses a bend formed by the obliquity in opposite directions of the cuneiform bones and the neck of the astragalus. This bend would be angular if the head of the astragalus were brought immediately into contact with the cuneiform bones; by the interposition of the scaphoid bone it is rounded into a gradual curve, the convexity of which is turned inward, as shown in the diagram by the lines $a\,a$, $a'\,a'$, and $a''\,a''$. This curve yields beneath concussion, its convexity increasing during the passage of the force, and being restored immediately afterwards (by the action of the ligaments and tendons) to its previous condition.

This curvilinear arrangement of the inner division of the tarsus is analogous in its effects to the double inclination of the scaphoid bone in the corresponding division of the carpus, and susceptible (as I shall presently endeavour to show) of a similar explanation.

The outer division of the tarsus presents a more massive structure, less elastic, but in an equivalent degree more rigid than the inner. The two bones of which it consists are large, and placed nearly in a right line with each other, as shown in the diagram by the lines *g g* and *h h*, representing respectively the longitudinal axis of the calcaneum and cuboid bones. Shocks transmitted along the fourth and fifth metatarsal bones, which this division of the tarsus supports, pass almost directly through the cuboid to the calcaneum; the only distribution of their force being that which takes place at the oblique cubo-metatarsal articulation (see the arrow heads *i i* and *k k*).

The explanation of this difference in the mechanical construction of the opposite sides of the tarsus is obvious. It is upon the ball of the great toe and the adjacent portions of the sole that we usually alight in jumping and similar actions: it is therefore by the inner division of the tarsus that the most numerous and most violent concussions are sustained, and that elasticity is chiefly required. Hence the advantage of its numerous obliquely-jointed bones, and its *curvilinear* arrangement. The outer division, on the other hand, acts principally as a lever stretching backward from the metatarsus, beneath the astragalus, to receive the insertion of the great tendon of the heel. To this purpose it is adapted by its comparative rigidity, and by the almost *rectilinear* disposition of its bones; while its inferior elasticity involves no additional liability to fracture, first, for the reason, already mentioned, that this side of the tarsus receives fewer and less violent concussions than the other; secondly, because it does not, like the inner division, articulate directly with the tibia.

Thus, then (to recapitulate these facts), we find in the tarsus three distinct curvatures: one in the antero-posterior vertical plane, another in the transverse vertical plane, a third in the horizontal plane. The two *vertical* curvatures present their convexities upward, and serve the double purpose of increasing the strength and elasticity of the tarsus in the vertical sense, and of forming a plantar excavation, in which the nerves, vessels, and muscles of the sole are lodged in security from pressure. The *horizontal* curvature is confined to the inner side of the tarsus, its convexity is directed inward, and its use is to promote the *longitudinal* elasticity of that part of the region in which it occurs. Though it has hitherto escaped the attention of anatomists, I regard it as a feature of essential importance in the mechanical construction of this region; and its existence in strong contrast with the rectilinearity of the outer side of the tarsus has suggested the longitudinal division adopted in the foregoing descriptions. And I would propose this plan of classifying the tarsal bones, for general use, as preferable to the old division into two transverse ranges like the horizontal rows of the carpus, because this latter method, though sanctioned by high authority, has the inconvenience of leaving the scaphoid bone to be assigned to the *anterior* or to the *posterior* row, or to be taken separately as the vestige of a *third* range immediate between the other two, according to the particular views of individual anatomists.

375. The *strength* of the tarsus, taken to imply its power of sustaining concussion without rupture of the arch, or dislocation of its several parts, depends partly on the provisions for elasticity already described, partly upon the tenacity and suitable arrangement of the tarsal ligaments; concerning which I shall have some observations to offer on another occasion. Its *strength*, considered with reference to the resistance which each particular bone is capable of offering to direct pressure, depends chiefly upon the distribution of the cancellous tissue, which Bourgery has very accurately described and figured (*Anatomie de l'Homme*, tom. i. p. 129, pl. 43). He has shown that the direction of the principal fibres of the cancellous tissue in these bones is by no means indeterminate, but has a uniform relation to the nature and direction of the strain which each is required to support. Thus, for example, a vertical section of the calcaneum from end to end exhibits the principal fibres radiating from the astragalar articulating surface—some horizontally backward to receive the transverse strain of the great extensors of the foot,—a considerable number obliquely downward and backward, to transmit, through the tubercles of the heel to the ground, the pressure received from the astragalus, while a third set run forward, diverging from each other as they advance, to strengthen the greater process. As, however, this bone is subject to no directly vertical pressure, nor to any strain which directly vertical fibres would help to resist, so we find no such fibres in the cancellous structure, but in their place (between the fibres that descend obliquely *backward* and those which descend obliquely *forward*) an empty triangular interval. The same economical distribution of materials is observed in all the tarsal bones; and it accounts for the great resisting power which they possess in proportion to their weight.

OF THE METATARSUS.

376. The metatarsus presents a series of five bones, of the cylindrical class, separated by four interosseous spaces. The bones diverge a little from each other at their anterior extremities, which rest upon the ground and articulate with the toes; they are elevated at an angle of from 25 to 30 degrees posteriorly, where they articulate with each other and with the tarsus. Like the corresponding bones in the hand, they are distinguished by numerical appellations, as the first, second, third, fourth, and fifth, counting from within outward. The interosseous spaces (which are numbered in the same manner) diminish in extent from the first to the fourth. They lodge several small muscles, of the same name, arranged in a dorsal and a plantar series.

COMMON CHARACTERS OF THE METATARSAL BONES.

377. The *posterior extremity* of each metatarsal bone is wedge-shaped,* and offers a *terminal* surface, smooth for articulation with the tarsus; a *dorsal* and a *plantar* aspect, rough for the attachment of ligaments, and two *lateral* aspects, presenting smooth cartilaginous facets,† and rough ligamentous impressions, for articulation with contiguous bones. The *anterior extremity*, or *head*, has a *terminal* articular convexity, received into the cup-like depression of the corresponding phalanx; and extending further backward below than above; two *lateral* aspects, each presenting a *depression*, surmounted by a *tubercle* for the attachment of ligaments: a *superior* aspect marked with a transverse *groove* also for ligamentous insertion; and an *inferior* aspect presenting in the middle a small semilunar *depression*, which corresponds to the flexor tendon, and is bounded on each side by a small articular *eminence*, continuous with, and prolonged backward from, the terminal convexity. These elevations, of which the external is the more prominent, may be called, to facilitate reference, the *condyloid eminences* of the head. The *shaft* is curved longitudinally, so as to present a convexity upward--a concavity on the plantar

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* Except that of the fourth, which is cuboidal.

† Except the first, which has no lateral articular facets; and the fifth, which has none on the outer side.

aspect; it tapers gradually from the tarsal extremity to the head. In the metatarsal bones of the great and little toe, or first and fifth of the series, it is always distinctly prismatic. In the three intervening bones its form, though usually prismatic, varies considerably in different subjects, being sometimes almost cylindrical, sometimes transversely flattened so as to present a mere border above and below.

DIFFERENTIAL CHARACTERS OF THE METATARSAL BONES.

378. The metatarsal bones differ from each other in size. The second is the longest of the series; the third, fourth, and fifth follow in succession; the first is the shortest of all. On the other hand, the first is greatly superior in breadth and thickness to all the rest, and, in point of weight, nearly equals any other two of the series. The dorsal aspect of the first metatarsal bone is directed upward and *inward;* the corresponding surfaces of the other bones look upward and *outward,* and the obliquity of their inclination increases from the second to the fifth. The three middle metatarsal bones differ little in form; the first and fifth are distinguished by several peculiarities from them, and from each other.

379. FIRST METATARSAL BONE. The *tarsal* extremity of this bone is distinguished by the absence of lateral articulate facets; its terminal surface is semilunar, or kidney-shaped, for articulation with the internal cuneiform bone; it looks backward, upward, and *outward* (whereas the corresponding surface of the other four bones is directed backward and upward, and more or less *inward*). The circumference of this extremity is marked with a groove for the attachment of ligaments.* Its inferior angle is prolonged downward and outward, forming a rough tuberosity for the insertion of a tendon.† Its outer side gives origin to part of a small muscle.‡ The *head* of this bone is remarkable for its breadth, and presents, underneath, a median smooth *ridge,* separating two lateral *depressions* which glide on the sesamoid bones of the great toe. The *shaft* is very strong, and its prismatic form well marked. Its *dorsal* surface is smooth, convex, subcutaneous, and directed obliquely upward and inward;

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* Tarso-metatarsal.

† That of the peroneus longus.

‡ Inner head of the first dorsal interosseous.

its *plantar* aspect is concave longitudinally, plane transversely, wide and directed obliquely inward behind, narrower and directed downward in front, while in its whole length it is covered by a muscle and a tendon.* Lastly, its *external* surface is concave longitudinally, plane in the opposite direction, much wider behind than before, and covered by a muscle,† to the fibres of which, however, it does not give origin. Of the *borders* by which these surfaces are separated, the *external* (also *inferior*) extends from the tuberosity of the tarsal extremity to the outer condyloid eminence of the head; the *superior* runs from the upper angle of the tarsal extremity to the external lateral tubercle of the head, and the *internal* passes from the inner angle of the tarsal extremity to the inner condyloid eminence of the head. The course of these borders along the shaft requires no particular notice. They are all prominent. The external is deeply concave; the superior corresponds in the recent subject to a tendon.‡

380. Second metatarsal bone. The superior length of this bone depends chiefly upon its prolongation backward into the cuneiform recess of the tarsus. Its *tarsal* extremity is wide above, narrow and tubercular below. The *terminal* surface of this extremity is smooth and triangular for articulation with the middle cuneiform bone. Its *inner* side presents, at its upper part, a smooth facet for articulation with the internal cuneiform bone, and, inferiorly, a rough space for ligamentous attachment. Its *outer* side presents a superior and an inferior articular surface, separated by a rough ligamentous depression, and each subdivided by a vertical elevation into an anterior and a posterior facet. Of the four facets thus formed, the two anterior are directed outward and *forward*, to articulate with the third metatarsal bone: the two posterior (which are sometimes joined together so as to form a vertical linear surface) look outward and *backward* to articulate with the external cuneiform bone. The *head* agrees, in every particular, with the common description already given. It is more or less flattened from side to side, so that its vertical exceeds its transverse diameter. Its lateral tubercles are prominent, and its upper surface presents a *transverse ridge* for ligamentous attachment. The *shaft* of this bone, in well-

* Flexor brevis pollicis, and tendon of the flexor longus pollicis.
† First dorsal interosseous. ‡ Extensor proprius pollicis.

marked specimens, presents an inferior and two lateral *lines*, separating a superior and two lateral *surfaces*. The *lateral lines* commence, posteriorly, one on each side of the dorsal aspect of the tarsal extremity; approach one another as they advance; and diverge again, near the head, to terminate each at the corresponding lateral tubercle. The *inferior* line commences at the lower border of the tarsal extremity, runs along the shaft, keeping to the outer side of its median line, and bifurcates in front to terminate at the two condyloid eminences on the under surface of the head. From the course of these lines the shape of the intervening surfaces may be inferred. The *superior* surface is narrow in the middle, where the lines approach each other, and expands a little at each extremity in consequence of their divergence. It looks upward and a little outward, and corresponds to the second extensor tendon. The *lateral* surfaces are separated above by the width of the aspect just described, but they meet below at the inferior border. As this border lies to the outer side of the median line of the shaft, the *internal* lateral surface extends further round the bone, inferiorly, than the *external*. (The lower part of the internal surface, indeed, looks so much downward that it is sometimes described separately as a *plantar* aspect.) By its lateral surfaces, and by the under side of its tarsal extremity and of its head, this bone gives partial attachment to three muscles.*

381. THIRD METATARSAL BONE. The *tarsal* extremity of the bone articulates, by a triangular terminal surface with the external cuneiform bone, by two facets on its *inner* side with the second metatarsal bone, and by a single facet on its *outer* side with the third metatarsal bone. The *shaft* and *head* exactly resemble those of the bone just described. It gives partial attachment to five muscles.†

* The internal lateral surface gives origin to the outer fibres of the first dorsal interosseous, and the external lateral surface to the inner fibres of the second dorsal interosseous; a tendinous slip of each of these muscles arises from the under border of the tarsal extremity; and a fasciculus of the transversus pedis from the under aspect of the head.

† By its lateral surfaces to the outer fibres of the second, and inner fibres of the third, dorsal interosseous muscle; by the under aspect of its tarsal extremity to the first plantar interosseous muscle, and a few fibres of the abductor obliquus pollicis; by the under aspect of its head to a slip of the transversus pedis.

382. Fourth metatarsal bone. Closely resembles the two preceding ones, except at its *tarsal* extremity, which is of a cuboidal form, and presents, *posteriorly*, a quadrilateral surface for articulation with the cuboid bone—on the *inner* side a smooth surface, divided into an *anterior* facet which articulates with the third metatarsal bone, and a *posterior* narrower facet, which articulates with the external cuneiform,—and lastly, on the *outer* side, another facet for articulation with the fifth metatarsal bone. It gives partial attachment to five muscles.*

383. Fifth metatarsal bone. The *tarsal* extremity of this bone articulates, *behind*, by a triangular oblique surface, with the cuboid bone, and *internally*, by a flat facet, with the fourth metatarsal bone. Its *outer* side presents a tubercular prolongation, called the *tuberosity* of the fifth metatarsal bone, which gives insertion to two tendons.† Its *upper* and *lower* surfaces are remarkably wide. The *shaft* of this bone is very wide posteriorly, but tapers and curves outward as it approaches the head. Instead of being flattened transversely, like the three preceding bones, it is flattened from above downward; so that, whereas they present wide *lateral* surfaces, and a prominent border, on the *plantar* aspect—this bone, on the contrary, presents wide surfaces *above* and *below*, and a prominent border on the *outer side*. The *head* is turned somewhat outward, in consequence of the curvature of the shaft, and has an irregular tubercular appearance. This bone gives partial attachment to six muscles.‡

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* By its lateral surfaces to the outer fibres of the third, and the inner fibres of the fourth dorsal interosseous; by the under surface of its tarsal extremity, to the second plantar interosseous, to a tendinous slip of the third dorsal interosseous, and to a few fibres of the abductor obliquus pollicis; and by the under surface of its head, to a fasciculus of the transversus pedis.

† To the peroneus brevis, and below that to a slip of the abductor minimi digiti.

‡ By its internal surface, to the outer fibres of the fourth dorsal interosseous muscle; by the under surface of the tarsal extremity, to a few fibres of the flexor brevis minimi digiti, to the third plantar interosseous muscle, and to a tendinous slip of the fourth dorsal; by the tuberosity, to the peroneus brevis, and to a slip of the abductor minimi digiti; and, by the head, to a fasciculus of the transverse pedis.

OF THE METATARSUS IN GENERAL.

384. The five bones that have now been described compose a quadrilateral region, rather wider before than behind, convex transversely, and more slightly so in the longitudinal sense also, *above;* concave, in both directions, *below.* Of its *borders,* the *internal,* formed by the first metatarsal bone, is thick and straight; the *external,* formed by the fifth metatarsal bone, is thin and concave; the *anterior,* represented by the line of heads, is convex: the *posterior* presenting the range of tarsal extremities, is rendered uneven by the projections of the second, fourth, and fifth bones, beyond the line of the first and third. The MECHANISM of the metatarsus is very simple. The tarso-metatarsal and intermetatarsal articulations are gliding joints, the motions of which, though limited by strong dorsal, plantar, and interosseous ligaments, give considerable flexibility to this region, enabling it to mould and adapt itself to the inequalities of the surface on which it rests. The mutual interlocking of these joints tends evidently to secure the bones, both of the tarsus and of the metatarsus, from lateral displacement. The great strength of the first metatarsal bone is explained by the fact, already pointed out, that concussions are usually received by the ball of the foot, and pass along its inner side to the tibia. And lastly, the concavity of the under surface of this region, together with the similar excavation of the tarsus, affords room for the secure lodgment of the plantar nerves and vessels. STRUCTURE. Resembles, on a reduced scale, that of the humerus, and other large bones of the cylindrical class. DEVELOPMENT. By two points of ossification, one for the body, the other for the head, with the exception only of the first metatarsal bone, which (like the corresponding bone of the metacarpus) has the second ossific point at its *tarsal* extremity—a character by which, as we shall presently find, it is assimilated to the phalanges.

OF THE PHALANGES.

385. The phalanges of the foot resemble, in number and general arrangement, the corresponding bones of the hand, already described. The toes, like the fingers, are five in number, each consisting of three phalanges, with the exception only of the great toe, in which the middle

phalanx is deficient, and the first articulates immediately with the third. Thus, viewed collectively, the toes present a series of fourteen phalanges, disposed in three rows, of which the first and third contain five bones each, the second only four. The phalanges of each of these rows exactly resemble those of the corresponding range in the hand—with the exception of certain modifications of form, depending evidently upon imperfect development. Thus, the two phalanges of the great toe, which are large and fully developed, are exact repetitions of the two phalanges of the thumb; and between the remaining fingers and toes the only notable difference is, that these latter are of comparatively diminutive size—their first phalanges disproportionately slender—their second and third phalanges mere rudimentary nodules of bone, such as either phalanx of a finger would appear, if its shaft were deficient, and its two extremities joined together. We shall, therefore, to avoid unnecessary repetition, refer the student, for further information concerning these bones, to paragraphs 303—8 inclusive: wherein are described, first, the common characters of all the phalanges, and, secondly, the particular characters of each row.* As to the precise identification of individual phalanges, they are only distinguished among their fellows of the same row by their relative size—which diminishes from the first to the last in succession.

386. In point of *structure*, also, these bones resemble those of the fingers. Their *movements* are of a similar kind, but, with one exception, more limited in range. The excepted movement is that of *extension*, which can be carried a little farther in the toes than in the fingers. They are *developed* by two points each, one for the body and one for the metatarsal extremity. That of the body appears early in fœtal life; that of the terminal epiphysis appears, in the different phalanges, at various periods between the fourth and seventh year after birth. The union of the two parts does not take place till the seven-

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* In applying these descriptions to the foot, the student will find two or three verbal alterations necessary. Thus, the word metacarpal must be read *metatarsal*, and the word palmar *plantar*, &c. It must also be remembered that the hand hangs *vertically*, with its dorsum looking backward; whereas the foot rests in a *horizontal* position, with the toes pointed forward, and the dorsal surface directed upward.

teenth or eighteenth year. All the phalanges give attachment to muscles;* those of the great and little toe have special motors. Their *use* in the mechanism of the lower extremity seems to be inconsiderable, and is evidently diminished by the custom of wearing shoes. However, when their action is unimpeded, they extend the surface for the support of the leg, and by grasping the little inequalities with which they meet, give it a firmer hold upon the soil. They continue to the latest moment the pressure of the backward foot against the ground, in the various actions of progression. They also increase the elasticity of this region when opposed, as a spring, to concussion; and, when the body inclines too much forward, assist in restoring its equilibrium, and preventing its fall.

OF THE FOOT IN GENERAL.

387. The general configuration of the foot has been noticed in the introductory paragraph of the foregoing description (353); and the strength, mobility, and elasticity of its structure, so far as they depend on the arrangement of the bones, have been fully explained in the paragraphs on the mechanism of its several regions (370—5, 384, 386). Its uses as an organ of support and locomotion have also been noticed incidentally; and its analogies to the hand, which we have already referred to in general terms, will be more exactly analysed in the following chapter.

388. I have observed a curious fact respecting the

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* The attachment of these muscles are as follows:—*Extensors.* The *extensor longus digitorum* is attached to the dorsal surface of the second and third phalanges of the last four toes. The *extensor brevis digitorum* is attached to the dorsal surface of the first phalanx of the great toe, and of the third phalanges of the second, third, and fourth toes. The *extensor proprius pollicis* is inserted into the dorsal surface of the terminal phalanx of the great toe. *Flexors.* The *flexor longus digitorum* is inserted into the plantar surface of the terminal phalanx of the last four toes. The *flexor brevis digitorum* is inserted into the lateral border of the second phalanges of the four last toes. The *flexor brevis pollicis* is inserted into the plantar surface of the terminal phalanx of the great toe. The *adductor* and the two (*abductors oblique* and *transverse*) of the great toe are attached respectively to the inner and outer side of its first phalanx, which also gives insertion underneath (by the intervention of the sesamoid bones and capsular ligament of the metatarso-phalangeal joint) to the *flexor brevis pollicis*. A special *abductor* and *flexor* are also attached to the first phalanx of the little toe.

course of the medullary canals in the hand and foot, which, as it tends more closely to assimilate the two organs, and may throw light upon a disputed point concerning the analogies of certain of their bones, deserves a brief mention in this place. The medullary foramen of the first metatarsal bone enters the shaft obliquely towards its *phalangeal* extremity; whereas in the other four metatarsal bones it runs in the opposite direction, *i.e.* towards the *tarsal* extremity. An exactly similar difference in direction is observed between the medullary foramina of the first, and four succeeding bones of the metacarpal region of the hand. In the *phalanges*, both of the hands and feet, the medullary foramen, when it exists, runs in the same direction as that of the first metacarpal (or metatarsal) bone, viz., towards the *distal* extremity. Thus a new analogy is established between the bones that support the thumb and the great toe on the one hand, and the phalanges on the other. And the constant and exact correspondence of the hand and foot in this particular is rendered the more remarkable by the fact that an equally constant *difference* exists between the two limbs with respect to the course of the medullary foramina in their remaining cylindrical bones—those of the humerus, radius, and ulna, all running *towards* the elbow, while those of the femur, tibia, and fibula, all run *from* the knee. The reader will find a circumstance of a similar nature recorded at note ‡, page 138 *supra*, with respect to the nutrient foramina of the ribs; and the questions, appended to that note, concerning the purpose and meaning of the arrangement therein described, apply with equal force to the perplexing facts at present under review. The whole subject is extremely interesting, and its investigation might throw light on the analogies of the bones, and on the laws of their development and nutrition. The first and principal object of such an inquiry should be, to discover whether the course of the nutrient canals bears any constant relation to the form or structure of the bones, to their mode of development, or to any other determinate circumstance.

OF THE SESAMOID BONES.

383*. These are little rounded nodules, cartilaginous in childhood, bony in the adult, occurring in the substance of certain tendons, at points where they come in contact with the bones. They are observed in various regions of the upper and lower extremities, but chiefly in the hands and feet. They are enveloped in fibrous tissue on all sides but one, which is more or less flattened, and presents a free articular facet. They increase in number with advancing age, and are said to be more numerous in the male than in the female, and in vigorous and active individuals than in the feeble and comparatively inert. They may be divided into two classes; first, those which rest on the articular extremities of bones, and enter into the composition of *joints;* and, secondly, those which are contiguous to cartilaginous facets on the tubercular *apophyses* of bones. The sesamoid bones of both classes serve to improve the leverage of the tendons in which they occur, by increasing their angle of insertion. Those of the *first* class also equalize the distribution of external *pressure* on the convexities with which they articulate, and present a surface on which *gliding movements* of considerable extent are performed. Those of the *second* class, on the contrary, are not subject to external pressure, nor to gliding movements of any notable extent. Indeed, they are not found at the places where the tendons rub most against the bones (as for instance, behind the malleoli), but at points near their insertions, where friction, if it occur at all, is reduced to a minimum. For this reason, I dissent from M. Bourgery's opinion that these bones are developed in the tendons and ligaments, "*dans tous les points où ils exercent des frottemens durs sur les os.*"

389. Sesamoid bones of the joints. Of these, in the foot, two are constantly observed beneath the metatarso-phalangeal joint of the great toe, and another (sometimes two) of much smaller size, at its inter-phalangeal joint. One is sometimes found at the metatarso-phalangeal joint of the second toe; another, more rarely, at that of the little toe; and, still less frequently, rudiments of a similar development occur in the fibrous tissue beneath the third and fourth metatarso-phalangeal articulations. The two first are the most important. They are elongated and curved so as to fit the grooves on the head of the first metatarsal bone, which glides smoothly upon them. They are enveloped in a mass of fibrous tissue, formed partly by the capsule of the joint, partly by several small tendons.*

* The two tendons of the flexor brevis pollicis, and that of the transversus pedis.

In the hand a similar arrangement is observed. There are always two sesamoid bones on the palmar side of the metacarpo-phalangeal joint of the thumb, and sometimes one of smaller size at its inter-phalangeal articulation. One or two are occasionally observed at the metacarpo-phalangeal joint of the fore-finger; another at that of the little finger; and others, more rarely still, at the corresponding articulations of the middle and ring fingers.

The patella, considered with reference to the great extensor tendon of the leg, resembles the sesamoid bones of this class; but, viewed in its relation to the tibia, it is evidently analogous to the olecranon process of the ulna. It may, therefore, be regarded as a bone of intermediate character, establishing a transition between the sesamoid bones on the one hand, and the epiphyses of the long bones on the other. This view of its analogies is confirmed by the fact, that the olecranon process sometimes continues through life a separate bone, connected with the shaft of the ulna only by a fibrous band obviously resembling the ligamentum patellæ; a variety of which Rosenmüller has recorded an example, (261)

390. Sesamoid bones of the apophyses. Of these, one is observed, resting on the tuberosity of the cuboid bone, in a tendon* that lies in its oblique groove; another appears, in old age, opposed to a smooth facet of the internal cuneiform bone (304), in the substance of a tendon† to which that bone gives insertion; and a third is usually found at the inner side of the astragalus, in a tendon‡ which passes forward to reach the tuberosity of the scaphoid bone. To this class of sesamoid bones may also be referred the osseo-cartilaginous thickenings which are occasionally found, in old subjects, opposite the tuberosity of the radius,§ the trochanter major of the femur,‖ and at various other points with which tendons come in contact.

391. Structure. Of very light cancellous tissue, enveloped in a thin layer of compact. Development. The ossification of these bones takes place by a single point for each. It commences late, and is not fully completed till the period of adult age.

* That of the peroneus longus. † That of the tibialis anticus.
‡ That of the tibialis posticus.
§ In the tendon of the biceps flexor cubiti.
‖ In the tendon of the gluteus maximus.

CHAPTER VI.

OF THE SKELETON IN GENERAL.

392. The human skeleton represents a column, larger and heavier above than below, and standing erect on a comparatively small base. On the circumstance of its upright position many peculiarities of its structure depend; while the necessity of keeping an elevated centre of gravity within a narrow basis of support gives rise to several of its most characteristic movements.

393. The contrast between the thoracic and pelvic extremities in man, is, perhaps, the most obvious and striking indication of his essential aptitude for the erect posture. The former are manifestly organs of tact and prehension only; the latter are, as evidently, adapted exclusively for locomotion and support. The arched and massive foot, resting horizontally on the ground, articulating at right angles with the leg, furnished with very small digital appendages, but prolonged into a strong lever at the heel, is as well calculated for the base of a column of support as it is incapable of grasping, or performing rapid movements; while the hand, with its long fingers, its opposed, divergent thumb, and its narrow carpus articulated in a right line with the bones of the forearm, is, on the contrary, a perfect tactile and prehensile organ, but altogether unsuited to sustain or propel the trunk, in the ordinary modes of progression. In the quadrupeds and quadrumana these organs present no such contrast, but more or less closely resemble each other; the quadrupeds being adapted for progression on all fours by conversion of the *hands* into *feet;* while the quadrumana are fitted for their climbing habits by a contrary transformation of the *feet* into *hands.* It may further be observed upon this point that in none of the mammalia do the feet present so extensive a surface to the ground as in man. In digitated quadrupeds, such as the dog, the carpus and tarsus are considerably elevated, so that the body is supported entirely by the toes; and in animals having solid hoofs, as for example, the horse, the foot assumes an almost vertical position, so that only the third phalanges rest upon the ground.

A similar contrast in point of structure, indicating a corresponding diversity of function, may be traced in the other regions of the limbs. The pelvis, for example, is a massive, rigid, hoop of bone, forming a strong foundation for the spine, and resting, by deeply hollowed sockets, on the heads of the thigh-bones. The shoulder, on the contrary, is a light and extremely moveable apparatus, presenting but shallow sockets for articulation with the arms, which hence derive greater freedom from motion, but withal less security from dislocation. The bones of the thigh and leg are equally superior to those of the arm and forearm in point of bulk—equally inferior in point of mobility. The forearm and hand can be rotated on the pivot-joint of the radius to the extent of 90° in all positions of the limb; whereas the rotation of the tibia and foot on the femur, is only possible during flexion of the knee, and even then, is limited to between 30° and 40° of angular extent. Again, all the joints of the upper extremity bend in the same direction, so that the limb forms an arched line in flexion, by which the hands are brought forward into a convenient position with respect to the range of vision, and the arms are enabled readily to encircle any object in their embrace. In the lower extremity, on the other hand, the articulations bend in opposite directions, so as to form a zigzag line in flexion; the knee-joint pointing *forward*, the hip and ankle-joints *backward;* by which the limb is better adapted to shorten and extend for the propulsion of the body, and to yield, in the manner of a twice-bent spring, to concussion; but at the same time is rendered still more inferior, in point of mobility, to the upper extremity. This inferiority, indeed, is so marked, that whilst the sole of the foot cannot, by any action of the leg, be brought into contact with the trunk, there is, on the contrary, no spot on the surface of the body to which the hand may not more or less easily be applied, as well by its dorsal as by its palmar surface.

In quadrupeds all these parts are assimilated by a more equal distribution of bulk, weight, and mobility, between the thoracic and pelvic limbs. The scapulæ are so disposed that the glenoid cavities look downward; and, in consequence of the absence of clavicles, and the narrow keel-like form of the thorax, they come into much closer proximity than in man; so that the thoracic extremities, in these animals, stand vertically under the forepart of the trunk, supporting its weight effectually, but enjoying little lateral motion. Lastly, the joints corresponding in the fore-leg of quadrupeds to the human elbow and wrist, as well as those of their hind leg, which answer to our knee and ankle-joints, bend in opposite directions, so as to take a zigzag line in flexion; and all their limbs are alike deficient in the free rotatory action that distinguishes the forearm in man.

394. The spinal columns of man and of the inferior mammalia present differences of form and function, equally striking, and not less obviously related to the difference in their habitual attitude. In quadrupeds, that portion of the spine which extends horizontally from the pelvis to the root of the neck, usually forms one continuous elliptic arch, which, being kept bent by strong ligaments (as a bow is kept bent by the bow-string), and bearing at its extremities on the fore and hinder limbs, is well adapted to sustain the constant weight of the viscera that are suspended from it, as well as the occasional (and often severer) pressure of burdens laid upon the back. In man, that portion only of the spine which enters into the composition of the thorax, presents a dorsal convexity; the lumbar region, like the cervical, bends in the opposite direction, giving to the column a triple curvature, by which it is adapted to break the force of longitudinal concussions consequent upon its perpendicular position. In quadrupeds, again, the weight of the skull, bearing at right angles on the extremity of the horizontal neck, and increased, in many instances, by the growth of massive horns, antlers, or tusks, requires for its support, that the cervical vertebræ should be proportionately enlarged; that the spinous processes of the lower cervical and upper dorsal vertebræ, from which the great muscles of the neck arise, should be exceedingly prominent, so as to compensate in some measure for the disadvantageous position of the weight, by rendering the application of the moving power more direct; and lastly, that a strong elastic fibrous cord (the *ligamentum nuchæ*) should be extended from the occiput to the prominent vertebræ, in order to assist, in the manner of a *bearing-rein*, in bracing up the head; in man, these provisions are not required; the neck is vertical, the occipital condyles are horizontal, and situated vertically under the centre of gravity of the head, which thus rests of itself in exact equipoise on the

summit of the spine.* Hence, in the human subject, the diminutive proportions of the vertebræ of the neck; the comparative shortness, and the imbricated disposition of the lowest cervical, and adjacent dorsal vertebræ; and the rudimentary condition of the *ligamentum nuchæ*, which is reduced to a mere fibrous slip, prolonged upward from the supra-spinous ligament of the back and loins. We have already, in treating of Daubenton's angle (p. 101), had occasion to point out the difference which exists between the human skull and the brute skull, with respect to the position and direction of the foramen magnum and the occipital condyles. We may here mention, as an additional characteristic of the human skull, that the plane of the axes of the orbits is parallel to the plane of the jaw, and also, in the erect attitude, to the plane of the horizon; a disposition which affords to vision a free horizontal range in the upright posture of the head, but which would evidently have the effect of directing the eyes vertically downwards, and so preventing horizontal vision, if the head were carried in the posture natural to quadrupeds. In these latter, accordingly, no such parallelism is observed, the plane of the orbit forms an angle with that of the jaw; which, in its turn, is more or less inclined to the plane of the horizon.

395. The *basis* on which the human frame stands is a space, bounded laterally by the outer edges of the soles of the feet; behind by a line extending from heel to heel, and in front by a similar line joining the toes.

396. The *centre of gravity*, in the erect attitude, must lie somewhere in the median plane of the body. It must also lie somewhere in the transverse vertical plane passing through the centres of the heads of the thigh-bones, on which the trunk is balanced. It must, therefore, lie somewhere in the vertical line in which these two planes intersect each other. To find the position of this line of intersection, Weber first ascertained, by a pair of plumb-lines, let fall, one on each side of an erect living

* The preponderance of the anterior segment of the macerated skull depends chiefly on the uncompensated weight of the lower jaw. Weber found that a recent head with its encephalon and integuments complete, would stand in equilibrium on its condyles alone, when the face was directed forward and slightly upward.

man, opposite the middle of the trochanter major, the points on the outer surface of the body which the above-mentioned transverse plane would intersect. These he found to be opposite the mastoid processes above, and the centres of the knee and ankle-joints below. By subsequent observation of a skeleton, he found that a plane intersecting these points would also intersect both ends of the spine, passing, at the upper extremity of the column, through the atlanto-occipital joint, and at its lower extremity through the sacro-lumbar articulation. But the spinal column is bisected in its whole length by the median plane; so that the required line of intersection, containing the centre of gravity, passes vertically through both the above-mentioned joints, and falls below between the feet. Thus much having been determined, it only remained to ascertain the horizontal plane of the centre of gravity; for which purpose Weber balanced a plank across a horizontal edge, stretched on this plank the body of a living man, and brought the whole mass to equilibrium (employing, to neutralize errors, the well-known method of double-weighing). It being now certain, according to the laws of equilibrium, that the centre of gravity lay directly over the line of support, the distance of its horizontal plane below the vertex was found by measuring, on the edge of the plank, the distance from the line of support to a line let fall from the vertex. This distance, subtracted from the total length of the body, gave the distance of the centre of gravity above the soles of the feet; and by subtracting from this again, first, the height of the transverse axis of the hip-joints, and afterwards that of the promontory of the sacrum, the height of the centre of gravity above those two points respectively was ascertained. The following Table exhibits the results of these measurements in millimetres; which I have reduced, for the convenience of the English reader, into inches, and decimal parts of an inch.

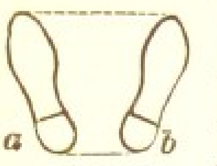
POSITION OF THE CENTRE OF GRAVITY WITH RESPECT TO THE VERTICAL DIMENSIONS OF THE BODY.

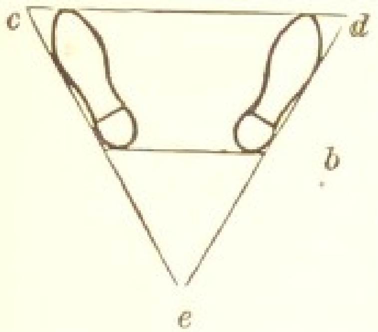
	Millimet.	Inches.
Total length of the body . .	1669·2	65·30853
Distance of the centre of gravity below the vertex . .	721·5	28·406455
Distance above the sole . .	947·7	37·310949
Distance above the transverse axis of the hip-joints . .	87·7	3·454729
Distance above the promontory of the sacrum . . .	8·7	0·341519

Hence it appears that the horizontal plane of the centre of gravity lies only a fraction of an inch above the promontory of the sacrum; so that, in fact, it traverses the sacro-lumbar articulation; which, being traversed also, as we have seen, by the median plane, and by the transverse vertical plane, contains the common point of intersection of all three planes; that is, contains the centre of gravity of the body in well-proportioned individuals, while standing erect.

397. The position of the centre of gravity, however, varies more or less with every change in the relative position of the parts of the body, ascending if the arms are raised, advancing or receding as they are thrown backward or forward, and following in like manner the various movements and inclinations of the head, trunk, and lower extremities. In all these postures, it is essential to the stability of the column represented by the trunk, that a line dropped vertically from its centre of gravity for the time being, should fall on some point within its basis. For the fulfilment of this indispensable condition, we stand habitually with the feet so disposed as to furnish the most extensive area of support that can be maintained without fatigue, or an inconvenient separation of the legs. Supposing the outside points *a* and *b* of the heels to coincide, the greatest supporting area would be obtained by turning out the toes till the feet formed a right angle with one another. But as these points can never in

reality coincide, but must always be separated by at least double the width of the heel, the feet never require to be turned apart so far as to form a right angle. When the feet are so disposed, that the distance a b between the outside points of the heels exactly equals the length of the foot, the greatest area of support will be obtained by turning the feet at an inclination of 60° to each other; that is, in other words, by turning them so that the lines, c a and d b, if produced to meet in e, shall make the triangle c e d an equilateral triangle. And I think it may be said, that the feet are unconsciously, and as it were instinctively, placed at or about this angle, when it is desired to plant the body firmly in the upright posture.





398. In standing on one foot, the supporting area is of course reduced to the extent of the sole which remains upon the ground, and the difficulty of balancing the body becomes proportionably greater. This difficulty is increased to its maximum when, as in opera-dancing, the heel is raised from the ground, and the body rests entirely on the toes of a single foot. In these positions of difficult equilibrium, the least displacement of any one portion of the frame requires to be compensated by a precisely equivalent movement of some other part in the opposite direction, without which the centre of gravity would be carried beyond the area of support, and the body would of necessity be overthrown. It is on the degree of readiness and self-possession with which these compensating movements are executed, and on the choice of easy and appropriate attitudes for this nice adjustment of the weight of the body over a constantly varying and often extremely narrow basis, that what is called *grace* of mien and deportment mainly depends; and it is in the conception of attitudes not only graceful in themselves, but really natural to different kinds of actions, and suited in each case to maintain the equilibrium of the figure, that the skill of the sculptor in a great measure consists. Professor Moseley, in his treatise on "Mechanics applied to the Arts" (to which useful work I am indebted for several of the preceding observations), has introduced, as an illustration of the compensating movements by which the body

is balanced, a sketch of the celebrated statue of the flying Mercury, by Juan di Bologna. The god, being in the act of springing from the earth, rests only on the extremity of the right foot; the body and the left arm are thrown forward, and with them the centre of gravity is advanced beyond the vertical line passing through the contracted basis of support. To bring it into that vertical again, so as to restore the equipoise of the figure, the sculptor has represented the left leg and the right arm as thrown backward far enough to counterbalance the weight in front; and it is evidently by just such an action that the equilibrium of the human body would really, in similar circumstances, be maintained.

399. The difficulty of restoring the equipoise of the body when disturbed, may be increased not only by thus diminishing the extent of the supporting area, but conversely, by increasing the superincumbent mass while the basis remains the same. Hence corpulent persons stand less firmly against violence than others. Hence, too, the addition of a heavy burden renders it more difficult to restore the equilibrium of the body when it has in any way been thrown off its balance. In this latter case the body, and the load which it supports, form, in a mechanical point of view, or so far as the question of equilibrium is concerned, a single mass, having a common centre of gravity. This common centre of gravity lies at some point in a line joining the centre of gravity of the man to the centre of gravity of the burden sustained. If the weight of the burden is precisely equal to that of the body, the common centre of gravity will be found in the middle of the line of junction, equidistant from each separate centre of gravity. If the weight of either mass exceed that of the other, the common centre of gravity will approximate the heavier of the two, more closely in proportion as the excess of weight is greater. It is to bring this new centre of gravity vertically over the middle point of the basis, that we vary the posture of the body in bearing a load; inclining *forward* if the weight is fastened, like a pedlar's pack, behind the shoulders; throwing the head and the upper part of the trunk *backward*, if, on the contrary, it hangs in front, as an applewoman's basket, a protuberant belly, and the like; bending *laterally*, if it is applied on one side, as in carrying a single pail of water; and lastly, keeping the body strictly upright, if the pressure acts directly in the median line, as

when a tray is borne upon the head, or a pair of pails upon a yoke across the shoulders.

400. The power of thus swaying and inclining the body in every direction, depends partly on the mobility of the trunk, on the hip-joints, partly on the flexibility of the vertebral column itself. The direction and extent of the movements due to the hip-joints have already been described. (324) The general flexibility of the vertebral column, and the relative proportions which the cervical, dorsal, and lumbar regions respectively contribute to its total amount, have been accurately determined by Weber; who states, as the mean result of his observations on two subjects, that the whole range of the head, in approaching the pelvis before and behind, by the utmost flexion and extension of which the intervertebral, sacro-lumbar, and atlanto-occipital joints are susceptible, equals 245°; of which amount nearly two-thirds are due to the joints of the cervical vertebræ with each other and with the head, one-third to the joints of the lumbar vertebræ with each other and with the sacrum, and the small remainder only to the joints of the dorsal region. This difference of flexibility depends, in a great measure, on the different shape and aspect of the articular processes in the three regions. In the back they form joints calculated to allow a movement of torsion, but to oppose movements from before backward; in the loins they permit bending motions of a certain extent in every direction, but entirely prevent *torsion;* while in the neck their structure is such as to offer little or no impediment to motion of any kind. All the movements of which the vertebral column is thus susceptible, are brought into play by turns, when the body is balanced in postures of difficult equilibrium.

401. The cases of difficult equilibrium which we have hitherto considered, depend on a change in the normal proportion between the bulk of the supported mass and the extent of the area on which it stands; whether occasioned by enlargement of the former, or by diminution of the latter. We have next to notice a kind of disturbance, still more dangerous to the stability of the body, and requiring for its compensation a superior degree of skill and agility, only to be attained by much practice; a sort of disturbance, in fact, to which, for this very reason, most of the falls that actually happen are due. I allude to sudden irregular motions, communicated from without, either to the column itself, or to the surface on which it

rests. Pressure, or percussion, applied directly to the body—as in wrestling, boxing, and similar athletic sports —disturbs the equilibrium, by forcibly removing the centre of gravity from above the basis. Motions impressed upon the supporting surface, such, for instance, as the tossing and rolling of a ship at sea, while one stands upon its deck—have the converse, but precisely equivalent effect, of withdrawing the area of support from beneath the centre of gravity. We usually oppose the tendency to fall, thus occasioned, by putting forth one leg (and so extending the basis of the column) in the direction *towards* which the body is propelled, or *from* which the supporting surface is withdrawn. When, however, the direction of the disturbing motion is foreseen, and its extent inconsiderable, it may often be counteracted by a judicious inclination of the spine (in the manner just described), without enlargement, or other modification, of the basis of the body. It is in this manner, doubtless, that a tumbler, standing erect on the back of a running horse, keeps his footing, when endangered by the casual swerving of the animal to either side; there being evidently no room, in this case, to make compensation by extending the basis of the column laterally.

402. We need hardly dwell at length upon the disturbance of equilibrium which occurs when, after the body and the supporting surface have for some time moved on together at an equal rate, the motion of one is accelerated, retarded, or stopped, while that of the other continues unchanged. In this case, as in the last, the loss of equipoise evidently depends on a change in the normal relative position of the centre of gravity and the centre of the supporting area; and its restoration, in like manner, is to be effected only in one of two modes; viz., either by bringing the former point once more vertically above the latter, or by replacing the latter in its proper position beneath the former.

403. The liability of the body to be overthrown by either of these causes, is greatly diminished in the *sitting* posture; first, by the enlargement of the basis on which the trunk rests; and, secondly, by the reduction of the height of the centre of gravity above the supporting surface. Hence, in sitting, not only are the lower extremities relaxed, but the vertebral column itself is held erect with less exertion than usual; for which reason we find this posture one of comparative repose. Even sitting, how-

ever, if long continued, ultimately produces fatigue; perfect rest being only possible when the centre of gravity is so placed, that the force of gravitation tends to *maintain*, not to *alter*, its position; a condition which for a jointed framework, such as the human body, can only be fulfilled in the *horizontal* or *recumbent* posture.

404. Such are the principal conditions (so far as the skeleton is concerned) upon which the erect attitude of the human body, and the maintenance of its equipoise on the narrow basis of the feet, depend. We may, in the next place, still confining ourselves to the osteological point of view, analyse in a similar manner the several modes of *progression* natural to man; such as walking, running, leaping, and the like; tracing, in each case, the relations which subsist between the action accomplished, and the organ, or system of organs, by which it is performed.

405. In standing, the limbs are employed only to *support* and *balance* the body; in progression, besides performing these functions, they have also to act as *propellers* and *springs*.

These four conditions of locomotion depend for their fulfilment upon certain actions of the limbs, which, though subject in each kind of progression to partial modifications, are in all cases *essentially* the same.

Thus, as, in progression, the trunk is always carried at a level below its full height, the condition of *support* always depends on the power we possess of stiffening the limbs when *flexed*, as well as when *extended*. We shall presently find it a general rule, that the body is supported at a lower level, in proportion as its rate of progress becomes more swift.

Again, the *equipoise* of the body, in progression, is always maintained by *inclining* it more or less obliquely in the direction of its advance; the trunk being, in fact, carried and poised on the heads of the thigh-bones, as a staff is carried and balanced, when it rests, by one end, on a hand moving more or less rapidly forward. If the staff were balanced vertically, as when standing still, its lower end only would advance with the hand; its centre of gravity could neither be at first set in motion, nor afterwards kept moving against the resistance of the air. Hence, the more rapidly the balance staff is to be urged forward, and the greater the external resistance (that of a contrary wind, for example), against which its motion is to be maintained, the more obliquely must it be carried. So likewise, and for the same reason, the swifter the motion of the trunk, and the denser the medium, or the stronger the current, by which its advance is opposed, the more oblique is its position of equipoise on the thigh-heads.

Propulsion, again, invariably depends upon the power we possess of shortening the limbs by flexion of the joints, and afterwards elongating them again, by a more or less rapid and forcible extension, while applied against a resisting surface. This action may be compared to that by which a boat is propelled with a pole. The pole rests in an inclined position on the bottom of the river, forming, with the upright body of the man, an acute angle. The man then gradually inclines himself, so as to bring the pole and his body more and more into a straight line; elongating thus the *limb* which the two may be conceived to represent, by extension of the sort of *joint* which they form at their angle.

A similar uniformity is observed in the actions by which, in all modes of progression, the condition of *elasticity* is fufilled. The *impact* of the foot on the ground is always accompanied by a more or less extensive flexion of the joints of the planted limb; which yields thus beneath the concussion, and causes the force to be delivered gradually, instead of passing with abrupt and accumulated violence to the trunk. This yielding, however, differs from that of an ordinary spring, in two respects, viz.—

First, that it does not *diminish in extent* as the amount of compression increases;

Secondly, that it is not necessarily attended with *recoil*.

These distinctions, to which few physiologists, I believe, have hitherto directed attention, involve several consequences of considerable importance, both in a mechanical and physiological point of view; the consideration of which, however, would be inconsistent with the plan of this work, and will form the subject of a separate paper on the mechanism of the skeleton.

406. There are six principal modes of progression; viz., walking, running, jumping, creeping, swimming, and climbing; of which the two first are adapted for ordinary and *continuous*, and the remaining four for *occasional* use. Each of these modes of progression possesses cer-

tain characters, capable of exact definition, by which it may be distinguished, amidst all its modifications, from the rest; while, on the other hand, each alike requires, for its secure and perfect accomplishment, the concurrence of the four above-mentioned conditions. In each, however, some one or two of these necessary conditions obtains more, or less, than its usual degree of prominence. Thus, in jumping, *propulsion* and *elasticity* are particularly remarkable; the former at the beginning, the latter at the end, of the action. In walking, on the contrary, comparatively little *elasticity* is required, on account of the small force of *impact* at each tread. In running, the movements by which the *equilibrium* is preserved, are strongly marked; and *propulsion* becomes again, as in jumping, a prominent feature. In creeping, on the other hand, the actions by which the *equilibrium* is usually maintained, are, for the most part, rendered unnecessary by the enlargement of the basis on which the body rests. And, in swimming, the organic provisions for *support*, and for the prevention of injurious *concussion*, are, in a great measure, superseded by the properties of the medium in which the body floats. Climbing, however, is an irregular mode of progression, in which the relative predominance of the four conditions varies with every change in the nature of the obstacles to be surmounted. It is, however, sufficiently distinguished, as we shall presently find, by a *fifth* constant condition, peculiar to itself.

407. In all modes of progression, we may distinguish the moving body into an *active* and a *passive* portion—*i.e.*, into the organs carrying, and the burden carried. Thus, in walking, running, and jumping, the lower extremities are the actuating instruments, while the head, trunk, and arms, constitute the passive mass on which they act. In creeping, climbing, and swimming, the *upper* extremities become also active organs of locomotion, the head and trunk only remaining inactive. This division, however, must be understood in a comparative, not an absolute sense. No part of the body is ever strictly inactive in progression. The arms when not employed directly to support or propel the trunk, nevertheless assist in maintaining its *equilibrium*;—performing for this purpose, as we shall presently explain, certain uniform motions, in a regular order of succession. The preservation of the *equilibrium* moreover requires in many instances certain changes in the position and inclination of the head and

trunk, by which the vertebræ of the neck and loins are necessarily brought into play. On the other hand, it may be observed that in all modes of progression the organs of locomotion, usually distinguished as *active*, are relaxed at certain intervals, and themselves become passive masses, adding their weight to that of the burden sustained. With these reservations, however, the division in question may be adopted without danger of error or misunderstanding;—and it will be useful in suggesting some well-marked distinctions between the several modes of progression.

408. Thus, in walking and running, each leg is *alternately* active and passive—one swinging, relaxed from the trunk, which at the same time carries it forward, while the other is actively engaged in successively fulfilling the four conditions of progression; viz., at the moment of impact, in imparting the required elasticity to the tread; subsequently in balancing and supporting the body on the narrow basis of the planted foot; and, lastly, towards the end of the step, in pressing backward against the ground, so as to urge the whole mass forward.

In *jumping*, on the contrary, no such alternation is observed. In this mode of progression the legs are simultaneously active, first, as propellers, to give the body a projectile motion, subsequently as springs to break its fall; and they are simultaneously passive and relaxed, during their flight with the body through the air.

In *swimming*, as in jumping, the legs move together; and their action is, moreover, simultaneous with that of the arms; the preparation for a stroke, and the act of striking itself, being performed by the four members at once.

Creeping resembles in this respect, the progression of quadrupeds. The motion of each pair of limbs, considered separately, is alternate, like that of the legs in walking. The motion of either thoracic limb also alternates with that of the pelvic extremity of the same side —the former being advanced to take a new step, while the latter is stretched backward in propulsion. The motion of each thoracic limb is neither alternate, nor yet strictly simultaneous, with that of the opposite pelvic limb; each action of the former slightly preceding the similar action of the latter; the object being to rest as long as possible in each step on three limbs. That kind of creeping in which the belly rests upon the ground has in this respect considerable analogy with swimming, that the trunk is, in both instances, in *immediate contact* with the sustaining surface, the *earth* affording it in the one case that direct support which in the other it derives from the *water*.

Climbing is in this respect (as indeed in almost every other) a variable mode of progression; being performed by motions of the limbs which are either alternate, or simultaneous, or wholly irregular, as circumstances may require. Climbing, however, is essentially characterized by the *prehensile* action of the hands, and the general substitution, in the upper extremities, of *traction* for *propulsion*, that is, of the *shortening* of the limbs by flexion for their *elongation* by extension, as a means of advancing the body. The lower extremities may, or may not, be used in climbing; but one cannot be said to *climb* unless some fixed object be from time to time *grasped* with one or both hands; and the body be wholly, or in part, *suspended from*, or *drawn towards*, the point of resistance so obtained. Provided that this condition be fulfilled, *climbing* takes place, whether the body move upward or downward, as in ascending or descending a tree, or horizontally, as along a rope stretched in that direction;—whether the actions of the limbs be irregular, as in the first-mentioned case, or equally uniform with those of walking, as when we go up a ladder or the shrouds of a ship. (Hence, in mounting an easy staircase, without using the bannisters, one is said to *walk* or *run* up; but in ascending a steep and difficult flight, when one partly also advances by *grasping* and *drawing* with the hands and arms, the mode of progression, though in other respects unaltered, is converted into *climbing*.)

409. The four last-mentioned modes of progression which we have distinguished as *occasional*, are considered, with justice, of less importance than walking and running: nevertheless they claim a share of our attention, because, though suited only to circumstances which, with us, are comparatively rare and exceptional, they are in constant requisition among uncivilized races of men, who are compelled, by the wildness of the regions they inhabit, their warlike and predatory habits, and their dependence for food upon the chase, to adopt by turns every possible kind of locomotion.

410. And this leads us to observe that it is possible to advance by certain secondary or *intermediate* modes of progression, each partaking of the characters of some two of the six above mentioned. Thus, the motions of the diver, who propels himself by means of the *ground*, deriving at the same time his principal *support* from the pressure of the water, constitute a mode of progression evidently intermediate between *walking* and *swimming*. There is also, as we shall presently find, a pace (called the *storming-pace*) exactly intermediate between *walking* and *running*. So again, when we ascend a steep hill on all-fours, using the upper extremities partly as *prehensile* and *tactile* organs, partly in the manner of legs for ordinary *propulsion*, our progression evidently partakes in an equal degree of the characters of *creeping* and *climbing*. And lastly, the act of gliding over level ice (considered separately from the *run* by which impetus is previously acquired) may be regarded as a sort of transition between *standing* and *progression;* all parts of the body being *stationary* in relation to each other, but in a state of rapid *motion* with respect to the supporting surface.

411. All these modes of progression, whether primary or compound, may be assisted, with respect to one or more of the four essential conditions, by *artificial aids*.

Thus, to diminish the labour of supporting the body, the walker may use a *staff* or *crutch*. So, too, the swimmer may avail himself of a floating plank, or other buoyant object, to compensate for the difference in specific gravity between his body and the water. *Stilts* quicken the pace by lengthening the legs, and giving them a wider span over the ground. The *leaping-pole*, again, is a sort of artificial limb, which supports the leaper's body during its flight through the air, and lengthens considerably the range of his leap. The *velocipede* is, to the runner, what the plank on which he floats is to the swimmer; both assist progression by relieving the limbs from the labour of *supporting* weight, and by enabling them to throw so much the more force into the actions of *propulsion*.

The smooth irons fastened to the feet, by the use of which *sliding* is converted into *skating*, are artificial aids to locomotion not analogous in their mode of action to any of those above mentioned. The practical utility and important capabilities of the singular mode of progression in which they are employed, appear to have been much underrated by physiologists; who, while they have taken the pains to analyse the actions of jumping and swimming, with several others of minor significance, have entirely overlooked skating. Yet, in cold countries, this art is employed not merely as an agreeable exercise, but as an ordinary means of travelling from place to place; and there can be no doubt that, under favourable circumstances, it is, of all modes of transit resulting from the direct application of the human locomotive organs, the simplest, the easiest, and the most expeditious.

412. If, now, instead of the more or less perfect artificial fulfilment of one or two of the essential conditions of locomotion, we conceive a complete realization of all the four by adventitious aids, if, for instance, we conceive the velocipede of the runner not only to *support* his body, but also to be itself rendered *elastic* with springs, kept in *equipoise* by additional wheels, and *propelled* by the application of some external power; we pass the boundary between active and passive locomotion, and arrive at the notion of *riding*. The case of riding, thus understood, is beyond the province of physiology; the person so conveyed being, with reference to progression, equivalent only to a mass of inanimate matter. *Riding*, however, *on the back of a horse or other animal*, is a case of mixed progression, in which the rider is partly active, partly passive, with respect to the conditions of *support*, *equipoise*, and *elasticity;* while the fourth condition, that namely of *propulsion*, is entirely fulfilled by the animal. If, indeed, we consider the horse and his rider collectively, as forming one moving body, we shall perceive that the fulfilment of all these conditions is exclusively due to the former. But if, on the other hand, we attend separately to the rider, we observe that he is by no means passive, but engaged in the execution of a series of movements, varying with every change of the animal's pace, yet having for their common object to maintain the *equilibrium* of the body, to preserve it by *elastic* yielding from concussion, and to *support* it at an angle of inclination proportionate to the speed of the motion. When, indeed, these exertions of the rider have to encounter the contrary efforts of the animal to relieve himself from his burden, this mode of progression becomes even more

fatiguing than walking or running. It is more usual, however, to find the motions of the horse and man in perfect accordance; as when, for instance, in turning a corner at a rapid pace, they both incline, instinctively and simultaneously, towards the centre of the curve described, for the purpose of counteracting the centrifugal force by which their common equilibrium would otherwise be endangered.

413. It is evident that the steps of the transition by which *running* thus finally passes into *riding*, have an exact counterpart in those by which *swimming* passes into *sailing;* the supporting plank, somewhat widened and hollowed, becoming a *canoe*, which may be *poised* by ballast, and *propelled* by the wind. In each case *organic* action is gradually superseded by the progressive introduction of *mechanical* aid.

414. Lastly, as the various modes of progression are thus, in many cases, facilitated by the employment of artificial *aids*, so their difficulties are sometimes intentionally increased by the introduction of artificial *impediments.* This happens in many athletic sports and trials of agility or skill. Sometimes, for example, we refrain purposely from the use of one or more of our limbs; as in hopping with one leg, swimming with one hand, and the like. Or we may reverse the proper functions of the limbs; as in walking on the hands, while the legs, extended in the air, are employed to balance the body. Or again, we may, in running, pass a cord between the feet and the ground at each step, as in the exercise of *skipping.* Or we may whirl round as we advance, still maintaining the equilibrium of the body, as in *waltzing;* or move in a prescribed figure, executing at the same time particular evolutions with the feet, as in the several varieties of *dancing.* None of these exercises are uninteresting to the physiologist, who discovers in them all more or less striking evidence of the varied capabilities of the body, and of the precision of action to which the limbs may be trained.

415. In this rapid but comprehensive review of the subject of progression, we have noticed, first, the four necessary conditions common to all its varieties; secondly, the leading characteristics of its six principal modes, and of the combinations and modifications of which they are susceptible; and finally, the artificial aids and impediments, by the gradual introduction of which the loco-

motive organs come at last to be exerted, on the one hand in the *minimum*, and on the other, in the *maximum* degree; *natural progression* passing, by the former transition, into *artificial conveyance;* by the latter, into (equally *artificial*) *athletic sports.* Furnished with this useful preliminary knowledge, we may next proceed (still confining our attention to the skeleton) to analyse more in detail the complicated actions of progression; and especially those by which its two most important modes—viz., *walking* and *running*, are performed; and for this purpose we shall constantly avail ourselves of the valuable experimental and theoretical investigations of W. and E. Weber, to whose work (entitled *Mechanik der Menschlichen Gehwerk-zeuge*) we have already several times referred.

416. The object, in walking, is to keep the body moving, at a *rate* as nearly as possible *uniform*, in a line as nearly as possible *horizontal*. In order to understand how this object is accomplished, we must consider, first, the series of movements performed by the locomotive organs at each step, and the direction in which the force they exert is applied to the trunk; and secondly, the external forces which act on the body in walking, and concur with the muscular force in the production of the observed effect.

417. Each leg is planted on the ground during one step, and swings in the air during the next; so that, to trace its entire action, we must follow it through two consecutive steps. As, however, one leg is in the act of swinging in the air, while the other is resting on the ground, the two together exemplify the whole series of movements in each single step.

418. The leg that we set forward in taking a step, advances at its upper extremity, by turning below on the planted foot, first at the ankle-joint, and afterwards on the ball of the great toe; in which advance the trunk, resting on its upper end, necessarily participates. During this action there is an instant when the direction of the limb (represented by a line drawn from the centre of the head of the femur to the centre of the surface which, for the time being, touches the ground) is exactly vertical;—that is to say, when the head of the advancing femur arrives directly over the planted foot. During the period which precedes this moment, the foot is in advance of the body, and the direction of the leg is from the trunk downward and *forward;* during the subsequent period, the foot

is left behind by the trunk in its advance, and the direction of the leg is downward and *backward*. If, throughout these two periods of the advance, the knee-joint remained in a posture of extension, and the length of the limb underwent no change, its upper end would describe a curve, rising during the first period, descending during the second. In a leg of ordinary length, and in walking at a moderate rate, this alternate rise and fall would amount to upwards of two inches—through which space therefore the trunk would have to be lifted at every step; to the great waste of muscular force, and the unnecessary fatigue of the walker. The means of obviating such an evil, and of rendering the advance of the trunk perfectly horizontal, consist in simply flexing the joints so as to shorten the limb, during the first period of its advance (or while approaching the vertical position); and lengthening it again (by extension of the joints previously flexed) during the second period of its advance (or while passing further and further beyond the vertical). This alternate shortening and lengthening of the limb really takes place; so that the body of a good walker, advancing at a medium rate, moves nearly in a horizontal line. The slight rise and fall actually observed at each step, depend chiefly, I think, on a certain yielding of the planted leg at the moment of impact necessary to give lightness and elasticity to the tread.*

419. During the first period, or before arriving at the vertical position, the leg offers to the trunk a resistance, the direction of which is obliquely upward and backward; so that, while it opposes the fall of the trunk, it also acts in a certain degree as an obstacle to its advance. At the moment of reaching the vertical, the leg sustains the whole weight of the trunk, and ceases to oppose its horizontal advance. In passing the vertical position, and entering on its second period, the leg begins to propel. The more the leg shortens during the first period, the more will it lengthen during the second, and the more

* The advantage of this yielding, and the amount of concussion from which it saves the trunk, is illustrated by the vibration which is communicated to the floor of a room if one walks across it with an inelastic tread. And the comparative ease which we feel in walking on turf, arises, doubtless, in a great measure, from the *springiness* which it imparts to the tread, and the proportionably *smoother* carriage of the trunk.

propelling force will it thus be able to exert. Again, the more obliquely the leg is stretched backward from the trunk, while propelling, the more effectively will its force be applied in accelerating the motion of the body. These two principal conditions of swift walking, themselves, depend (other things being equal) on the level at which the body is carried. In ordinary walking the body is carried at twenty-five millimetres (Weber), or nearly an inch, below its level in the erect attitude. It is evident that the greater this depression of the trunk becomes, the more must the leg be bent while standing vertically under it, and the more must the position of the limb approach the horizontal when it is stretched backward at its full length in propulsion.

420. Such are the movements of the leg which is planted in advance. While they are performed, the leg which remained behind at the beginning of the step, also executes certain movements, which come next to be considered.

421. During the first period, while the advanced leg is preparing, by gradual flexion, to propel, the hinder leg remains in contact with the ground. Precisely at the moment when the advanced leg reaches the vertical, and is able to sustain the whole weight of the body, the hinder leg quits the ground, and becomes a passive appendant to the trunk. Immediately afterwards, as the advanced leg, having past the vertical, begins to propel, the hinder leg begins to swing forward, turning, like a pendulum, at the hip-joint, and partaking at the same time in the movement of translation of the body in general. Before the advanced leg has completed its second period and ceased to propel, the hinder leg has swung far enough forward to be planted in advance; forming thus the commencement of a new step, during which it executes, in its turn, the first described series of movements.

422. Propulsion is thus kept up without intermission in walking, the hinder leg in each step not ceasing to urge the body on, till the leg planted forward has reached the vertical, and (having completed its retarding period) is ready to take up, in its turn, the propelling action. Hence we learn that there is a certain period of each step, in walking, during which the body is in connexion with the ground by two legs at once, one lengthening and propelling, the other shortening and preparing to propel; the former tending to accelerate the body, the latter

offering a resistance which constitutes the principal check to its progress. But though for a part of each step both legs are at once *on the ground*, there is no period in walking during which they are both at once *in the air*. In running it is just the reverse; there is a period in each step, during which both legs are at once in the air; but no period in which they simultaneously touch the ground. This constitutes the essential difference between walking and running. As we quicken our space, in walking, the period during which both legs touch the ground at once, gradually becomes shorter, till at the quickest walking one leg is taken up almost as soon as the other is set down. Again, as we slacken our pace, in running, the period during which both legs are off the ground at once, and the body moves, like a projectile unsupported through the air, gradually shortens, till at the slowest running its length is scarcely appreciable. Thus walking and running gradually approximate in character, as the latter becomes slower, and the former more swift. There is a pace in which one leg is taken up at the very instant the other is set down; which pace, possessing thus neither the period peculiar to walking, nor that which is characteristic of running, must be regarded as a transitional pace exactly intermediate between these two modes of progression. By the least slackening, this pace passes into walking; one leg being taken up a little *after* the other is set down; so that a period of appreciable length, in which both touch the ground together, again exists. On the other hand, by the least quickening, this pace is converted into running —one leg being taken up a little *before* the other is set down; so that the period in which both are simultaneously in the air, re-appears. In this pace, which we have already alluded to as the *storming-pace*, (and which, I believe, is called, in pedestrian matches, walking *toe-and-heel*,) the trunk is carried in a very inclined position, and considerably below its ordinary level: the leg is set down vertically, in a posture of demi-flexion, so as to be ready to begin to support and propel the trunk directly it touches the ground. And it stretches further backward in propulsion, on account of the lower level of the trunk, so as to span over a greater distance than in walking. It is also lengthened more rapidly, by a quicker and more forcible action of the extensors; so that while the *space* traversed at each step is increased, the *time* occupied in the transit is diminished. (It is a curious fact, equally true for walking and running, that the *duration* of our steps always diminishes as their *length* increases; so that as we advance faster, we take a greater number of steps, as well as traverse a greater distance, in a given time.)

423. The propelling force, at whatever pace we walk, acts on the trunk in a direction more or less obliquely forward and upward. In order to understand how a force so applied can produce and maintain horizontal progression, we must consider the other influences which act on the body in walking, and ascertain the precise manner and degree in which they affect its motion.

424. Five influences act on the body in walking, independently of the force of the propelling limb; viz., first, its own previously-acquired *momentum*, which would keep it moving at a uniform rate in the same direction for ever, without further propulsion, if there were no retarding or disturbing influences; 2ndly, the force of *gravitation*, tending to draw it vertically downward; 3rdly, the *resistance* of the *advanced limb* during its first or retarding period; 4thly, the *resistance* of the *air;* and, 5thly, the *gliding-friction* of the joints, and the *rolling-friction* of the sole of the foot against the ground. The retarding influence of friction is, in all modes of progression, comparatively so insignificant, that it need not be taken into account. The resistance of the air in ordinary walking requires a constant expenditure of force about equal to that of a pound weight, moving at the rate of six or seven feet per second; which, in reference to the whole amount of resistance overcome in walking, is also quite inconsiderable; and may, therefore, like the friction, be for the present disregarded. We have here, therefore, only to consider the operation of *gravity*, of *momentum*, and of the *retarding leg*. The *gravity* of the trunk is opposed, during the period in which both legs touch the ground, by their conjoint action, the support afforded by the advanced limb being combined with a retarding influence, that of the hinder limb with a propelling action. At the beginning of this period of the step, the propelling force exerted is rather less than the resistance; so that the body, at the same time that it is supported, is also retarded a little. At the instant when the leg reaches the vertical position, the body is supported without either acceleration or retardation. When the leg passes the vertical, the action is entirely changed. The hinder leg being now lifted, the body is supported entirely

on one leg, which stretches obliquely downward and backward, lengthening meanwhile so as to urge the body in the opposite direction. At each instant of this period the force of gravity, and the previously acquired momentum of the body, acting at right angles to each other (the former downward, the latter forward), give the trunk a tendency to move, not in the direction of either separate influence, but in that of their diagonal resultant; represented by a line drawn obliquely downward and forward from the centre of gravity to the ground, at an angle varying with the speed of progression.* But as the body, thus tending at each moment to move obliquely *downward and forward*, receives also, at each moment, from the propelling leg, an impulse obliquely *upward and forward*, it will obey both these forces conjointly, by moving in the direction of their diagonal resultant; that is to say, *horizontally forward.* The propelling action, during this period of the step, meets with no other resistance than that of friction, and of the air; and as it greatly exceeds these, it accelerates the motion of the body, till the swinging leg is planted forward; when the retarding operation begins again, and the whole series of actions just described is repeated. Thus, as the motion of the body is not perfectly horizontal, so neither is its rate strictly uniform, in walking; it rises and falls a little, and it also undergoes alternate acceleration and retardation, at each step.

425. Such is the series of movements by which, in walking, the conditions of *support*, *propulsion*, and *elasticity* are fulfilled. The motions by which the *equipoise* of the body is maintained are easily understood. As each foot alternately becomes the basis of support, the vertical line of the centre of gravity must be made to fall within its area, either by a swaying of the trunk to one side; or by a contrary inclination of the foot, in the act of stepping, towards the median plane; or by a combination of both these movements. Skilful walkers adopt the last-men-

* The body would, if really suffered to fall to the ground in walking, describe a parabolic curve in its descent, because gravitation is an accelerating force. But its *tendency*, before actually beginning to fall, is to move in a tangent to the first point of such a curve; and this *tendency*, with which alone we are here concerned (as the body in walking never actually falls to the ground) is accurately represented by a straight line drawn diagonally in the direction mentioned in the text.

tioned method, in which, while the foot is not moved inwards inconveniently on the one hand, the lateral motion of the trunk is not awkwardly extensive on the other. Sailors, in consequence of their habit of walking the deck with their legs separated, so as to be prepared for the tossing of the ship, learn to balance themselves almost entirely by swaying the body from side to side—whence their clumsy, *rolling* gait.

426. The motions of the arms in walking are perfectly regular and uniform; and their purpose becomes obvious when they are considered in connexion with the action of the legs. While the right leg swings forward, the right arm is swung backward and the left forward. While the left leg swings forward the left arm is swung backward and the right forward. The effect of swinging the right leg forward would be to cause the trunk to rotate horizontally on the head of the femur of the supporting leg, so that the right side of the body would advance beyond the left. By swinging the right arm backward and the left arm forward, the trunk acquires a tendency to rotate on the planted leg in exactly the opposite direction. This tendency neutralizes the other; and the result is, that both sides of the trunk advance together, when walking is skilfully performed, at an equal rate; neither side passing forward, at any time, beyond the other.

427. Since, in walking, one leg is always set down before the other is taken up, the length of our steps in this mode of progression has a natural fixed limit, determined by the span of the legs. The object of *running*, which we may next proceed to consider, is to enable us to traverse at each step a space not thus limited by the span of the legs, but depending only, as to its extent, on the degree of propelling force which the limbs are able to exert. This object is attained by giving the body a projectile motion for a certain part of each step; during which period both legs are suspended freely on the trunk, and accompany it in its flight through the air. The length of the running-step exceeds that of the walking-step by the horizontal distance through which the body is thus projected during the period in which neither leg touches the ground. This distance differs according to the speed with which we run. Our steps, in running, are on an average double as long as in walking, and they are also more rapidly executed, in the proportion of three to two; so that, in a given

time, one may run about three times as far as one can walk. The exertion required to maintain this speed is, of course, directly as the resistance to be overcome; and this depends more on the air, and less on the retarding action of the advanced leg, than in walking. At the fastest pace that a good runner can keep up for any length of time, the working force constantly expended in overcoming the resistance of the air is equal to about four pounds, moving at the rate of twenty feet per second; a considerable exertion even for a robust man. And as this resistance varies nearly at the cube of the velocity,* it is easy to understand why swift running is so laborious; and why a small acceleration, when a rapid pace has already been attained, adds to our fatigue in a degree apparently so disproportionate to the slight increase of speed. Hence quick running is an advantageous mode of progression, only when the distance to be traversed is small, and the time to be occupied in the transit short. When the time and the distance are both lengthened, we find our advantage in walking.

428. Weber has entered into a very elaborate calculation of the motion of the swinging leg, in walking and running, founded on the hypothesis that the leg swings entirely by its own weight, without assistance from the muscles, and that its motion is consequently governed by the general laws of oscillating bodies. I have not as yet had any opportunity of testing this theory experimentally; but I am rather disposed to doubt the assertion, that the muscles do not contribute in *any* degree to swing the leg forward in natural progression. However, according to Weber's supposition, the leg oscillates in the same time in all paces, from the slowest walking to the fastest running; and the duration of a step is greater or less, as the swinging of the leg is interrupted, by setting foot to ground, when it has traversed a greater or

* The amount of atmospheric resistance depends chiefly on the *quantity* of air displaced in a given time, and the *rate* at which its particles are moved; which quantity, and rate of motion, *both* increasing directly as the velocity of the projectile, would make the resistance vary as the *square* of the velocity. But the resistance is further increased by the condensation of the fluid in front of the moving body, by the partial vacuum formed behind it, and by several other circumstances, which, added to the former, make the resistance vary nearly as the *cube* of the velocity, according to the statement in the text.

less proportion of its arc. Thus, in the storming-pace, the limb is planted as soon as it has swung through half its arc, and arrived vertically under the trunk: in walking, as each step occupies more time, so the swinging leg describes more than half its arc, and passes beyond the vertical position before it is planted; and this so much the more as the pace is slower, and the duration of each step consequently longer. In the quickest running, each leg must, as in the storming-pace, perform at least half an oscillation (so as to hang vertically beneath the trunk) before it can be planted; but the steps, in running, can nevertheless follow each other more rapidly than in the storming-pace; because, as both legs are suspended in the air at once, during part of each step, they swing forward *simultaneously* through a portion of their respective arcs, and, by this saving of time, can be planted in quicker succession than when they are swinging separately, one after the other.

429. This account of walking and running is so far calculated to elucidate, in their more important particulars, the four *occasional* modes of progression, that it will not be necessary to dwell on these latter at any great length.

430. In *jumping*, the body is projected into the air by a simultaneous extension of both legs, performed with remarkable rapidity and force. In jumping, forward, backward, or to either side, the body describes in its flight a parabolic curve; in jumping upward, it moves in a right line; in all cases it obeys the ordinary laws of projectiles. Thus, for example, the period of its fall is nearly equal to that of its ascent; and its rate of motion, at each point of its descent, is exactly equal to its rate of motion at the corresponding point of its ascent. If the act of springing forward be preceded by a run, the body acquires an impetus, which concurs with the propelling action of the limbs, and increases the horizontal extent of the leap. In like manner, by swinging the arms, at the moment of springing, in the direction in which the body is projected, their inertia is made to aid, instead of impeding, its flight through the air.

431. The progression of the body through the water, in *swimming*, depends on the principle that action and reaction are equal and contrary. The *action*, in swimming, consists in displacing a considerable quantity of water, and urging it backward, by certain movements of the

hands and feet. By the necessary reaction of the water on the body, this latter is displaced and urged forward with a momentum precisely equivalent to that of the water moved in the opposite direction. Some swimmers render the body specifically lighter than the water, by keeping the chest more than usually full of air, so that no muscular power is required to keep them from sinking. More usually, however, it is necessary to urge the water somewhat downward as well as backward, with the hands and feet, in order to keep the breathing apertures free above the surface of the fluid. Swimming is not susceptible of so much diversity in point of speed as progression on dry land through the air, on account of the greater resistance opposed by the water to the motion of the body. This resistance (varying, like that of air, nearly as the cube of the velocity) soon renders it impossible for the swimmer to accelerate his motion without an additional amount of exertion, too fatiguing, and too disproportionate to the small advantage gained, to be long or usefully continued. In all modes of progression, indeed, whether through water or air, there is a certain average velocity, adapted to the powers of the body and easily attainable, but which cannot be much surpassed without excessive exertion. This depends on the resistance of the medium increasing so much more rapidly than the speed of the body which moves through it; and it accounts for the fact, that the difference in the speed of runners, swimmers, &c., is so much less than the difference in their strength would at first sight lead us to expect. In reality, to outstrip a swift runner, though but by a little, requires a very considerable superiority of strength.

432. The stature, weight, and proportions, of the skeleton vary much in different individuals and races of men, as well as in the opposite sexes, and at different periods of life. Many of these diversities have been noticed incidentally in the preceding chapters. Thus, we have had occasion to refer to the remarkable weight and density of the bones in the negro as compared with the European skeleton; to the superior dimensions of the female pelvis as contrasted with that of the male; to the disproportionate size of the head in the child as compared to the adult; and to the inferior relative capacity of the anterior segment of the cranium in several barbarian tribes, as compared to more civilized races of men.

The average stature of the adult male human skeleton (taking into consideration the shorter as well as the taller varieties of the species) is five feet six inches. This is increased, in the living subject, by the muscles and integuments, to about five feet seven inches. Variations in height of more than nine or ten inches above or below this medium standard are anomalous; that is to say, at four feet nine inches a man's stature may be considered dwarfish, while at six feet five inches he becomes a giant. Bourgery cites, as extreme instances of dwarfish and giant stature, a Congo negro, nine feet high, seen by Vanderbroeck; and a dwarf, aged thirty-seven years, sixteen inches high, mentioned by Birch. The average height of the adult European male skeleton (to which, in this work, our attention has been principally directed) is five feet eight inches, or, with the integuments, five feet nine inches. In a man of this stature the total height of the body is eight times that of the head. In all varieties of the species, whether tall or short, barbarous or civilized, the height of the female is, on an average, inferior by about 1-11th to that of the male. Varieties of height usually depend in a greater degree on the limbs than on the trunk; for which reason it is that tall and short persons, when sitting, often appear of nearly equal height. Vitruvius mentions some curious facts with reference to the proportions of the human body. If the body be laid on a flat surface, with the legs extended, as in the erect posture, and the arms stretched out at right angles on either side; and if then a parallelogram be formed, by drawing two lines parallel to the median plane, one on each side, touching the tips of the fingers, and meeting these at right angles by two transverse lines, one in contact with the crown of the head, the other with the soles of the feet; this parallelogram, thus exactly including the body, will, in a well-proportioned individual, be found to be a perfect square. If the arms be now raised till the tips of the fingers are in a line with the top of the head, and if the legs be separated till they would form, with a line joining the feet, an equilateral triangle; then, around the navel as a centre, a circle may be described, which shall touch the tips of the fingers above and the soles of the feet below, thus including the body exactly within its circumference. Mr. Joseph Bonomi, sculptor, in conjunction with myself, tried the truth of these rules on two individuals of ordinary proportions, and we found them verified with surprising accuracy. It is difficult to believe that these constant simple relations of the human figure to the square, and to the circle, can be accidental; on the other hand, we have no grounds for asserting positively that other proportions would not answer the purpose equally well; nor are we aware of any particular inconvenience occasioned by small deviations from the ascertained law.

433. The analogies of form, number, and connection, traceable in the several bones and regions of the skeleton, constitute a subject of the highest philosophical interest, which has given rise of late years to keen controversy between naturalists of distinguished ability; so that it remains up to the present day an undecided question in physiology. According to Carus, and the transcendental anatomists, there are two simple modes of development, and two simple primary forms (the *diconic* and the *spherical*), which are repeated throughout the skeleton, and which, with particular modifications (depending on certain laws of *antagonism*, and *polar evolution*), give rise to all the diversified forms actually presented by the bones. These views are opposed by Cuvier and his school, who, in accordance with the simple theory of the Conditions of existence, seek only, in studying the phenomena of organized beings, to trace in each instance, the relations which subsist between the form and structure of organs on one hand, and their functions on the other, or (as Blainville has expressed it) between the *static* and *dynamic* conditions of life. To discover these relations, and this constant mutual interdependence, and to reduce them by degrees to their simplest and most comprehensive terms, so as to arrive at laws of the utmost possible scope, and generality, is, according to these philosophers, the proper end of physiology; an end not promoted (as they say) by fanciful theories of development, or speculations on the analogous geometric construction and essential similarity of organs evidently diverse as well in point of number and connection, as in shape. The necessary length of such a discussion precludes its admission into this work, which has indeed already extended itself far beyond the limits originally proposed. We shall here, therefore, confine our attention to those more obvious analogies between the upper and lower extremity, and between the bones of the cranium and of the vertebral column, which are now universally admitted by physiologists; observing

only with reference to the two theories in question, that each appears to possess a philosophical value peculiar to itself, and adapted to corresponding necessities of the science; while, on the other hand, their essential principles are in fact less contradictory than they at first sight appear.

434. In order to conceive the cranium as a prolongation of the spine, and to trace in its bones the essential elements of vertebræ, it must be borne in mind that each vertebra consists of a body and an arch, the former being part of a *column* of support, the latter of a *canal* or *tube* for the reception of a nervous cord. The relative development of these two parts varies in particular vertebræ, according as the column is required to be stronger, or the cavity more capacious. In the sacrum, which serves as a foundation for the spine, the supporting column is required to be massive and strong; but, as the contained parts are here at a low point of development, the protecting cavity becomes a feature of less importance. Here accordingly the *bodies* of the vertebræ form a large consolidated mass, while the arches are small, and, in the lower sacral vertebræ, even altogether deficient. In the cranium a contrary development takes place. The contained nervous column, swelling out at its upper extremity to form the cerebrum and cerebellum, requires, for its reception, that the arches of the containing vertebræ should here be remarkably broad and capacious; while, on the other hand, their bodies are reduced to mere vestiges, either in accordance with the law of antagonism (as the transcendental philosophers would say), or simply because a column of support is here not wanted (as the opposite school would affirm).

435. Bearing these facts in mind, we may trace in the cranium three separate zones, each presenting, more or less distinctly, the principal elements of a vertebra. The first of these cranial vertebræ is the occipital bone; the second is formed above by the parietal bones, below by the greater wings of the sphenoid bone, and by the larger portion of its body; the third is composed of the ethmoid and frontal bones, together with the lesser wings of the sphenoid and that part of its body by which they are supported. The temporal bones are said, by some anatomists, to belong to the second or middle cranial vertebra: by others they are regarded as parts of a separate,

imperfect vertebra, possessing rudiments of laminæ in the Wormian bones which intervene frequently between the parietal and occipital bones (and which, in many instances, attain a considerable size, *vide* par. 57). We shall not, however, in this place discuss the doubtful or disputed analogies of the anterior and middle zones of the cranium, but shall confine our attention to the occipital bone, referring the reader to the writings of Professor Owen on transcendental anatomy for fuller information.

436. In the occipital vertebra of the cranium, the *basilar process* represents the *body*, and the broad *hinder plate* of the bone forms an expanded and capacious *arch;* while the *foramen magnum*, included between these parts, is evidently analogous to the *vertebral hole.* Again, the *occipital condyles* are true *inferior articular* processes, and the *jugular processes* may be regarded, I think, as vestiges of the *superior articular processes.* The *transverse processes* are represented by the rough portions of bone which lie to the outer side of the condyles, and give attachment to the lateral recti muscles; while the *exterior occipital crest* and *tuberosity* constitute a rudimentary *spinous process.*

437. The student, in examining the forms of the bones, must have already been struck with the analogies, which assimilate the shoulder to the pelvis, the upper arm to the thigh, the forearm to the leg, and the three regions of the hand, respectively, to the corresponding divisions of the foot. The flat iliac portion of the os innominatum corresponds, both in form and position, to the ala of the scapula, and its internal and external fossæ represent the dorsal and ventral depressions of the shoulder-blade. The acetabulum answers to the glenoid cavity, and the ischium to the coracoid process; while the pubes, stretching horizontally inward, is recognised as the analogue of the clavicle. The head and neck of the humerus answer to those of the femur; and the larger and smaller tuberosities of the former bone correspond to the larger and smaller trochanters of the latter. The lower extremity of both bones presents a trochlear surface with lateral tubercles for muscular and ligamentous insertion; while the patella of the knee-joint and the olecranon process of the elbow are, in general respects, strikingly analogous. Thus, each is developed by a separate point of ossification, and presents the structure common to

short bones; each gives attachment and improved leverage to a mass of extensors; and each protects a joint, which would otherwise be exposed during flexion. When the olecranon remains separate from the ulna, and forms an independent short bone (as in an instance recorded by Rosenmüller), this analogy is rendered complete. The analogies between the forearm and the leg are, in several respects, more uncertain than those between the upper arm and thigh. The leg is indeed, like the forearm, composed of two parallel prismatic bones, articulated together above and below, and having their shafts connected by an interosseous membrane. But, with respect to the precise analogies of these two bones, different opinions are entertained by anatomists, the tibia being compared by some to the ulna, and by others to the radius. At its upper extremity the tibia certainly resembles the ulna; because it is in a line with the inner side of the bone above, and because moreover it possesses, in the patella, an appendage analogous to the olecranon. At its lower extremity, on the contrary, the tibia resembles the radius, first, because it contributes more than the fibula to the ankle-joint, as the radius contributes more than the ulna to the wrist; secondly, and chiefly, because it is in a line with the great toe, as the radius is with the thumb. Here, therefore, it must be admitted that the analogy of the two limbs is somewhat obscure. It is, however, impossible to dispute the resemblance between the malleoli of the ankle-joint and the styloid processes of the wrist; between the cuboid bones of the tarsus and those of the carpus; between the cylindrical bones of the metatarsus and those of the metacarpus; and, finally, between the phalanges of the fingers and toes.

438. If these strong analogies between the upper and lower extremities compel us to admit that they are formed in a common type, their numerous and important differences are, on the other hand, sufficient to prove that that type has undergone considerable modifications, to adapt it in each case to particular functions. This is a point on which we have already had occasion to dwell (393); and we need here, therefore, only remind the student (by way of recapitulation,) that the bones of the arm, in which freedom, swiftness, and delicacy of motion, are the principal requisites, present slender shafts, shallow articulations, and short processes for the attachment

of muscles: while in the leg, which is designed to sustain a heavy pressure, and to perform motions of limited range, and rather forcible than rapid, we find more massive and heavier columns, longer processes of leverage, and, of the joints, some entirely done away with, others but slightly moveable, and the remainder rendered more secure by increase of depth, or expansion of surface.

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