To W. J. D.
Feb. 25. 1925

AN

INTRODUCTION

TO

ANATOMY AND PHYSIOLOGY.

FOR THE USE OF

MEDICAL STUDENTS AND MEN OF LETTERS.

BY

THOMAS SANDWITH,

SURGEON.

"In explaining these things, I consider myself as composing a solemn hymn to the Author of our bodily frame; and in this I think there is more true piety, than in offering to him hecatombs of oxen, and burnt offerings of the most costly perfumes." GALEN.

LONDON:

PRINTED FOR

LONGMAN, HURST, REES, ORME, BROWN, AND GREEN,

PATERNOSTER-ROW.

1824.

London:
Printed by A. & R. Spottiswoode,
New-Street-Square.

TO

WILLIAM SPENCE, Esq., F.L.S.

AND

MEMBER OF THE WERNERIAN SOCIETY,
EDINBURGH.

MY DEAR SIR,

In dedicating this work to you, I am conscious that I am conferring an honour upon myself. Your reputation can gain nothing by my acquaintance, but mine will be considerably augmented by this public declaration of our friendship. You have been to me, a Mentor in the pursuits of science; and in commending this trifle to your protection, I am anxious to prove to you, that I am not ungrateful for your instructions.

To expatiate on your merits as a writer on Political Economy and Natural History, or on your virtues as a man, in the bosom of your family, and in the circle of your friends, would, I am aware, with your dislike of ostentation, be offensive rather than acceptable; but in justice to that distinguished naturalist, and truly excellent man, your revered coadjutor, you must permit me to declare, that in the opinion of all competent judges, "The Introduction to Entomology" constitutes an æra in Natural History; no similar work being to compare with it, in comprehensiveness of design, and depth of erudition.

I will only add my best wishes for your health and happiness, and remain,

My Dear Sir,

Your ever obliged,

and faithful friend,

THOMAS SANDWITH.

Beverley,
Nov. 26. 1823.

PREFACE.

The intention of the following Letters being to convey outlines only of Anatomy and Physiology, the descriptions are *throughout* very general. The work is intended to be an introduction to younger students, who require general views of science, to encourage them to encounter the details; and a compendium of all that is interesting in anatomy to general readers. To most of the other sciences, we have excellent introductions *; but anatomy has been hitherto consigned to medical students, although it is not only the most interesting department of natural knowledge, but the only sure foundation on which can be constructed a classification of animals. In spite of his extraordinary genius, owing to his neglect of anatomy, the artificial systems of the great Swedish naturalist are sinking fast into oblivion; serving at present but as scaffoldings for the construction of the more natural methods, which are rising in their stead.

* Conversations on Chemistry, Mineralogy, &c. &c.

Independently of these general considerations, much might be said on the advantages arising from a knowledge of anatomy. To artists, a familiarity with the bones and muscles is indispensable; it may indeed be considered the foundation of their art, and the poet would find the science more available than he imagines. Homer was an anatomist, and a very good one too. There is hardly a page of the Iliad, from which a surgeon may not derive instruction. He describes the course of a wound with the skill of Machaon; and although his heroes are never wounded alike, the wounds are always scientifically mortal. As affording proofs of the being of a God, anatomy has always been the source from whence the theologist has drawn his strongest reasons; and in this respect, it is hoped, the following pages will not be found defective. It was, indeed, the contemplation of the structure and mechanism of the human hand, that produced the sublime apostrophe of Galen, which closes the present work. In another point of view, in which all are equally interested, viz. the preservation of health, the utility of the science cannot be disputed. Salutary cautions are conveyed to the mind by a contemplation of the organs of the body, and a palladium erected against many errors, innocently because ignorantly committed. On this ground, the want of a popular treatise on anatomy the late Dr. Beddoes feelingly deplored, and intended, had he lived, to supply. It is only necessary to observe further, that to the general reader, the means by which nutrition is effected, the aeration and circulation of the blood, the operations of the nervous system, and the theory of generation; the subjects, in short, of the first part of this work, cannot fail to be interesting and instructive; and the description of the voluntary powers in the second will not, we may venture to add, disappoint his expectations.

With respect to the manner of the work, the author has not attempted to describe the indescribable. Words cannot convey to the mind of the reader, the information which is acquired by the eye. Ideas of form, size, and relative position of parts, can only be truly learned by the inspection of the dead subject, or the more agreeable productions of the pencil, which for ordinary readers are a convenient substitute. To the engravings, therefore, which accompany the work, the text is subordinate. The author has avoided tedious verbal descriptions; but by a methodical arrangement has endeavoured to render a subject, otherwise dry and repulsive, plain and familiar. Function is associated with structure, to relieve the tediousness of mere description; and unity of purpose, to which all the subordinate structures and functions are subservient, has been preserved in each letter. By the adoption of the latter principle, the usual formality of anatomical description has been avoided; and the organs will be found arranged, not according to the relation of juxta-position, but the more philosophical and engaging one of natural affinity. The author has studiously kept clear of hard words, and technical phrases are never used but to avoid a periphrasis. He has aimed to be clear and concise; and whenever he is obscure, he trusts the reader will ascribe it to his desire to express himself with brevity.

To the descriptions of individual organs in the human subject, the author has added the deviations which occur in animals, whenever they appeared of importance by their rarity, or served the purpose of illustration. In the discretion which he has used in this part of his work, he has need of the indulgence of the reader. Where the materials were so ample, great judgment was required in the selection; on the one hand to avoid the sin of omission, and on the other not to encumber his work with unnecessary details. And here he must caution the reader not to expect more than was intended. Because he has chosen to enliven the subject by a reference to the most striking features of comparative anatomy, the reader must not be disappointed on finding that the work is not a complete treatise on that delightful science. So far as he has gone, in this respect, he has availed himself of the admirable writings of Macartney, Blumenbach, and Cuvier; which general acknowledgment will, he trusts, save the trouble of frequent reference. As a knowledge of the division of animals by the last of these authors, will render many of the terms which are used in these pages intelligible, a general account of his classification will not be here out of place. Animals then, according to this distinguished naturalist, are divided into two great classes, viz. into those which have *vertebræ* and red blood, and those which are *without vertebræ* with white blood. The former are subdivided into such as have *warm* blood, viz. *mammalia* (animals which suckle their young), and *birds*; and into such as are cold-blooded, to wit, *reptiles* and *fishes*. The *invertebral* animals, again, are subdivided into *mollusca*, animals without skeletons, as snails; *crustacea*, having a hard covering outside, as the crab and lobster; *insects*, *worms*, and *zoophytes*; which last form a connecting link between the animal and vegetable kingdoms. Finally, the author takes leave of the public with a hope, that the worthiness of his design will be received as an atonement for the defects in the execution; and he trusts the professors of "the ungentle craft," will make large allowance for a work composed under every disadvantage. The author has had access to no great library, nor to any museum of comparative anatomy; and his work has been composed amid the distractions of a harassing profession, in those hours which are usually devoted to relaxation or repose.

Beverley, *June* 27. 1823.

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ERRATA.

Page 8. line 8. for *the*, read *most*.
28. — 1. for *saccali*, read *sacculi*.
49. — last but one, for *intercostals*, read *interosseals*.
131. — last, for *became*, read *become*.
181. — 6. for *Fallopia*, read *Fallopian*.
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PART THE FIRST.

ON THE VISCERA.

LETTER I.

ON NUTRITION.

DEAR SIR,

As you are desirous of a knowledge of the Anatomy of the human body, and the acquisition may be useful to others, as well as to yourself, I feel it a duty, and a pleasure to further your design. *Nutrition*, the *circulation* of the blood, the functions of the *nervous* system, and *generation*, are the final purposes of the structure of the human frame; and compose a circle of operations, reciprocally depending on each other. The present letter is on the subject of Nutrition, and the selection has not been made without consideration. This function is common to all animals, and forms a connecting link between this kingdom, and the vegetable. In the structure of the organs, too, a regular gradation is perceivable. In plants, and zoophytes, they are merely tubes. They are not altogether so simple in insects; and in vertebral animals, and man, they consist of a curious, and complicated system of organs, rising in complexity and perfection according to the value of the animal. Again, this function discloses the relationship of man to the earth on which he treads, and of which, like the vegetable, he may almost be considered as a part. And here we cannot help pausing to admire the wisdom, and care of our benevolent Creator. This earth is accommodated to our wants by the intervention of inferior natures, that are the alembics of the Deity, by which inorganic matters are converted into substances proper for nutrition. It has been well observed by Mirbel, "that plants alone are able to convert inorganic matters into food." * Brutes, again, transmute vegetable matter into aliment still more palatable and nutritious; and these humble instruments are rewarded for these, their important labours, by all the gratifications, which, in the absence of mind, the exercise of the instincts, and appetites is able to afford.

As the organs of nutrition are contained in the belly, some description of this cavity is necessary. When the entrails are removed,

* Traité d'Anatomie et de Physiologie Végétales, vol. i. p. 19.

the *abdomen* is the hollow space between the *thorax* and *pelvis*, which, together with a portion of the spine, compose its bony parietés. The cavity of the chest is separated from the abdomen by a sheet of muscle (*diaphragm*), which is peculiar to mammiferous animals; and is an important power in the function of respiration. A strong silvery membrane, the *peritonæum*, lines the cavity of the abdomen, and, covering the tops of the pelvic viscera, forms the floor of the belly. Over each abdominal viscus, the peritonæum is reflected, so that the organs are really outside the cavity. This will be made more intelligible hereafter.

Nutrition is the result of several processes, and the first of them is mastication. The jaws, which are a kind of mill, reduce the food, by the addition of the saliva, into a pulp, which is then swallowed and digested. This latter process is carried on in the stomach, where the pulp is converted into a mass still softer, called chyme.* By the processes of dilution, and

* For an experimental account of the process of digestion, see Dr. Wilson Philips's excellent Treatise on Indigestion (p. 55—74.), which also contains sound information on the prevention and cure of that disease.

purification, in the small intestines, the chyme becomes chyle; the absorption of which completes the business of nutrition.

Mastication is a curious process, and cannot be understood without a reference to the anatomy of the jaws. The upper jaw is moveable in birds, fishes, and reptiles, but it is not so in the human subject, in whom it is furnished with three different kinds of teeth, which are met by corresponding teeth in the lower jaw. In front are the *incisors*, eight in number. The four *canine* come next, two on each side; and beyond them are the *molares*, or grinders, which vary in number, but in general thirty-two teeth completes the set. The first, or milk teeth, are shed about the eighth year, and are replaced by the permanent teeth, which have been gradually coming to maturity, in the sockets of their predecessors. The molares of graminivorous quadrupeds differ from those of man, in having processes of enamel, descending into the substance of the teeth, and the interstices are filled with a peculiar bony substance (*crusta petrosa*). Ruminant animals, again, have no incisors in the upper jaw, and the lower jaw of the cetacea is furnished, instead of teeth, with the peculiar substance called whalebone. In fishes, and reptiles, there are several rows of teeth in each jaw. To return from this digression the nature of our work will render often necessary; by the several motions of the lower jaw, mastication is performed. The food is chopped into pieces by its vertical movements; and the lateral and circular motions, round one condyle, as a fixed point, effect its perfect comminution. The lower jaw of carnivorous animals is incapable of this horizontal motion; so that the complete reduction of their food is left to the solvent powers of the stomach. In the one case, Cuvier observes, the teeth may be compared to scissors; in the other, to the stones of a mill. Various contrivances are subservient to mastication. The tongue, in mammiferous animals, fulfils the office of a trowel, and, as many of our aliments are dry, in order to moisten them, glands, which resemble sponges, perpetually supplied with moisture, pour their secretions into the mouth. The *parotids* are sunk deep behind the ears; beneath the angles of the lower jaw are the *submaxillary*, and underneath the tongue are the *lingual*. These glands are of great size in ruminant animals.

The saliva is composed principally of water, to which is added a little mucus, and some neutral salt. Mastication is a process not absolutely necessary. Birds do not masticate, but then the gizzard, in most of them, performs a function analogous. The food, too, is macerated in the crop before digestion. Fishes, living in the water, have no salivary system, and the invertebral animals, as well as birds, are incapable of mastication. It cannot, however, in the human subject, be neglected with impunity, as the loss of the saliva, in wounds of the cheek, has been known to occasion indigestion.

In order to understand *deglutition*, or the act of swallowing, a previous knowledge of the muscles is required; but as this would lead us into the details of muscular anatomy, you must, for the present, be contented with a general notion of it. The tongue, being drawn towards its root, receives the morsel of food upon its dorsum, which assumes a hollow form. The morsel is then rolled into the isthmus of the fauces, and being caught by the *pharynx*, the entrance of the œsophagus, is urged downwards by the contractions of this organ to the stomach. The œsophagus is a muscular tube lined with cuticle, and lubricated with mucus. Its muscles, which are of great strength in carnivorous animals, are circular and longitudinal. In ruminant animals there are additional fibres, which decussate each other, and ascend from the stomach in a spiral direction. This canal is situated between the stomach and the fauces, and lies close to the spine. The upper end being wider than the rest, and funnel-shaped, is called *pharynx*. In the neck the œsophagus is concealed by the trachea, and in the thorax it lies between the lungs.

Before we enter upon the subject of *digestion*, it will be proper to give you a general idea of the stomach, and its situation. Underneath the diaphragm then, and to the left of the liver, is a pouch, which has been not inaptly compared to a bagpipe. It has four tunics, the peritoneal, in common with the other viscera of the abdomen, the muscular, disposed principally in concentric circles; and the nervous, consisting of cellular tissue, in which the nervous papillæ are embedded; which last is lined with a membrane, puckered up in folds, to increase its extent of surface, and defended with mucus. From this last property it is called the mucous membrane.

The upper part of the stomach, also, as well as the œsophagus, is lined with cuticle. The entrance of the stomach is called *cardia*, the lower opening *pylorus*. The *gastric* fluid, the great agent of digestion, is furnished by the mucous membrane. This unimitated, inimitable liquor, is secreted whenever there is food in the stomach. It is a solvent, which acts upon all matters proper for nutrition, and the vitality of the stomach alone secures it from its corrosive power. Experiment has proved it to be antiseptic. Portions of putrescent meat, having a string attached to each, have been forced down the throats of dogs, and after remaining in the stomach some hours, have been withdrawn perfectly sweet. It is only necessary to inspect the curd in the stomach of a kitten, to learn that the gastric fluid is an acid. But it differs from the acids human chemistry affords, which are caustic, and destroy the textures of the living body. It is, in short, an acid *sui generis*, and like many of the provisions of the Deity, a subject worthy of our admiration, but beyond our knowledge. The notion that digestion is a mechanical or chemical process, is disproved by the following interesting observation: "A serpent swallows an animal larger than itself, which fills its œsophagus as well as stomach, and of which the digestion occupies several days, or even weeks. We open the reptile during this process, and find that part of the animal, which remained in the œsophagus, sound and natural, while the portion which had descended into the stomach, though still retaining its figure, is semiliquified, reduced into so soft a state, as to break down under the slightest pressure." *

As every animal has a stomach, it will not be uninteresting to take a hasty view of their comparative anatomy. The mode in which digestion is effected in birds, we have seen already. Quadrupeds, with cloven hoofs, have no fewer than four stomachs, of which the first is very capacious, and serves as a reservoir for the products of mastication; which are returned into the mouth and chewed a second time. The internal surface of the second stomach is stellated like a honeycomb; the third, or *maniplus*, is furnished with laminæ, arranged like the leaves of a book; and the last resembles the stomach of man. A striking peculiarity in the stomach of the camel, is too interesting to be omitted. The fluid, which

* Lawrence's Comp. Anatomy, p. 37.

is drunk by this animal, is deposited in numerous cells, found in the first and second stomachs, which it can close, and open at pleasure. As these cells are capable of holding several gallons of water, a provision is made for this useful creature in its journeys through the desert, and the thirsty traveller occasionally finds it a salutary supply:—

> " Sweet as the desert fountain's wave
> To lips just cool'd in time to save."

To obtain this treasure, in those burning regions, the animal is often slaughtered. Except in figure, there is nothing very remarkable in the stomachs of fishes, and reptiles. Both mastication and digestion are effected in the stomachs of the crustacea, and of many insects, which are actually furnished with teeth; and zoophytes are little more than stomachs.

With respect to the enquiry, What is the natural food of mankind? the question cannot be settled by experiment; as owing to the imperfection of our instincts, and their flexibility, man is in all climates an omnivorous animal. " In the temperate regions of the globe," observes Mr. Lawrence, " a mixed diet is generally preferred, but as we pass from these middle regions towards the pole, animal matters are more exclusively taken, and towards the equator, fruit and vegetables constitute the greater part of human diet." * In the structure of the organs of mastication and digestion, the human species holds a middle rank, between the herbivorous animals, and the carnivora. The intestinal canal is considerably shorter than that of the former, and longer than that of the latter. The stomach is intermediate between the two, and man is incapable of rumination. If we compare his jaws with each of the two tribes, we find it admits of lateral movements, as in animals which feed on vegetables; while the possession of canine teeth demonstrates his relationship to the carnivora. We may conclude, then, that a mixed diet is natural to the human species; it is that which prevails generally, and our universal fondness for bread arises probably from its approximation to animal food; the gluten of wheat consisting of azot, the basis of flesh.

After digestion the chyme is conveyed to the small intestine, where it is converted into *chyle*. The *small intestine* lies coiled up in the middle of the abdomen, where you observe it is covered

* Lawrence's Natural History of Man, p. 209.

by the *omentum*, a sort of apron, which descends from the larger curvature of the stomach ; and in corpulent subjects is the seat of the superfluous fat. Some of the hybernating animals have also lateral omenta, which, becoming loaded with fat before the period of hybernation, supply them with a species of nourishment during their torpid state. It is remarkable this provision, in these animals, is not universal. The small intestine is divided into three portions, the *duodenum*, the *jejunum*, and the *ilium*. It is six times longer than the body, in the human subject, and has as many tunics as the stomach. The upper portion is the *duodenum*, so called, because it is two ells long, the villous coat of which has fewer villi (*valvulæ conniventes*) and fewer absorbents than the second. In this portion the chyme is purified and diluted. The *jejunum*, which is generally found empty, on the contrary, is highly villous, and abundantly supplied with lacteal absorbents. The reason is obvious. It is here that nutrition is effected. The remainder, the *ilium*, which rests on the bone of that name, urges on the residue to the large intestines, and although not destitute of absorbents, this appears to be its principal office. It has been incidentally observed, that the intestinal canal is shorter in the *carnivora,* than in graminivorous animals; and in the former there is less apparent difference between the small, and large intestines. It is remarkable, that the same rule is universal, applying even to the insect tribes. "Length and complication of the intestinal canal indicate a vegetable nourishment; shortness and thinness, on the contrary, show that the animal is carnivorous."* The whole length of the canal is greatest in the mammalia, and it shortens successively, as we trace it in birds, reptiles, and fishes. In some of the latter animals, it is even shorter than the body. The valvulæ conniventes are most strongly marked in man, and in some of the mammalia they do not exist at all. Examine the upper end of the *duodenum,* and you will perceive an opening, which is the termination of two ducts; the one from the liver, and the other from the pancreas; and through this opening, the bile and pancreatic liquor are conveyed to the chyme. The bile is a thick, viscid, soapy fluid, of a yellow colour, and intensely bitter; but the liquor of the pancreas is insipid, inodorous, and colourless as water: it resembles

* Rees's Cyclopædia (Insects).

indeed the saliva in its chemical properties. The one is obviously a simple diluent, but the other precipitates the feculent matter of the diluted chyme, and by its peculiar stimulus compels the bowel to urge it onward to the large intestine. In the passage of the diluted chyme, the chyle is probably detained by the valvulæ conniventes, where it is absorbed by the lacteals. In this situation the chyle is found beautifully white, like milk, except in birds, where it is transparent as water. Kill a kitten, and you may see the whole process of absorption.

You will now be impatient to have a description of the liver, and the pancreas, the secretions of which are so important in the business of nutrition. The liver is a large, red-coloured, conglobate gland, attached by strong ligaments to the diaphragm, and occupies a considerable portion of the right side of the abdomen, and not a little of the left; as you may see by a simple inspection of the plate. Outwardly it is convex, concave underneath, and having a peritonæal covering; it is beautifully smooth. Near the middle is a cleft, which divides it into two great lobes, and underneath them is a very small one, called *Lobulus Spigelii*, in honour of the anatomist, who first described it. The divisions of the liver are very numerous in the mammalia, for which no satisfactory reason has been assigned. In looking for the *Lobulus Spigelii*, you would perceive a small bag, attached to the under surface of the great right lobe, and full of bile. What then is the office of the gall-bladder? To answer this question satisfactorily, it will be necessary to explain, with some minuteness, the structure of the liver; and in order to understand this subject clearly, a general account of the vascular system must be premised. Now there are two sets of blood-vessels, arteries and veins. The former convey the blood from the heart, to every part of the frame, and the latter return the superfluous blood to the heart. These vessels, in short, accomplish the circulation of the blood. Like the other organs of the body, the liver is supplied with an artery; but its small size, when compared with the great bulk of the liver, has led anatomists to believe, that it is put there only to keep the organ in repair. How then, you will ask, is the bile secreted? All the arteries of the abdomen terminate in veins. From minute ramifications, as they approach the heart, they become considerable trunks, which eventually compose one large vein, the vena portæ. In the liver, this great vein, contrary to expectation, branches out again into minute ramifications, some of which unite with innumerable pores (*pori biliarii*), and are thus employed in the secretion of bile; and others; inosculating with the proper hepatic veins, convey the blood to the inferior cava. * The pori biliarii become ducts, and eventually terminate in a large duct, the *ductus hepaticus*. If the bile flows into this duct, and this again conducts it to the *duodenum*, of what use is the gall-bladder? The question is a very natural one. The mechanism of the *gall-ducts* is highly interesting, and will require your whole attention. Attend, then, and mark the common duct (*ductus communis choledochus*), into which you perceive the hepatic and cystic ducts terminate.

* It would appear from the case related by Mr. Abernethy, in the Phil. Trans. for 1793, that the hepatic artery occasionally performs the double function of nutrition and secretion. The subject was a child, perfectly well nourished, in which the vena portæ terminated at once in the vena cava inferior, without approaching the liver. On dissection, bile was found both in the intestines and gall-bladder. The hepatic artery was larger than usual. It is a singular circumstance, that a fine injection may be made to pass from the artery into the biliary ducts.

Now, if the bile, in its passage through the common duct, were to meet with any impediment at the entrance of the bowel, the duct would be distended, and the bile would flow back again. There is an obstacle. The diameter of the aperture in the duodenum is considerably smaller, than the diameter of the duct itself; and the orifice being muscular, it only permits the bile, which is hurried through the duct, to pass into the bowel drop by drop. Imagine a canal so placed, as to arise from the middle of the duct, and lead to a receptacle, the bile impeded at the entrance of the duodenum would find its way into the receptacle prepared for it. This is precisely what happens. The cystic duct communicates with the common duct, and the returning bile is conveyed to the gall-bladder. Here it is reserved for the occasion that demands its use, which occurs whenever the stomach is distended with chyme. The pressure caused by this distention compresses the gall-bladder, and squeezes the bile into the ductus communis, from whence it drops into the duodenum, and mingles with the chyme as it passes the pylorus. It is worthy of remark, that in animals which do not fast long, as the horse, for example, there is no gall-bladder. According to Cuvier, indeed, this organ is peculiar to carnivorous animals. Many birds, as the pigeon, parrot, &c. have no gall-bladder; hence probably the expression of Hamlet:

> "Sure I am pigeon-liver'd, and lack gall
> To make oppression bitter."

A few words more on the subject of the bile. As it passes from the liver, this fluid is sweet to the taste; were it otherwise, indeed, the livers of animals could not be used as articles of food. But the bile in the gall-bladder is intensely bitter; it is also much more viscid, and of a deeper colour. It is evident, therefore, that the bile acquires new properties in the gall-bladder. It does so, not by the addition of any new matter, but by the absorption of its more fluid particles. Bitter matters resist fermentation in vegetables, and putrefaction in animal matter. A barrel of ale affords us a familiar illustration of this power. But for the hops, the infusion of malt would speedily become vinegar. In the same manner, the bile prevents the corruption of the contents of the digestive cistern, which, being in a warm situation, would be otherwise speedily decomposed.

What other use the bile is of, in the business of nutrition, is unknown, but from the magnitude of the liver in fishes, and the small quantity of this fluid that is found in the intestines, it is supposed, that the bile assists in the conversion of chyme into chyle; in performing which, it is itself decomposed, and disposed of. This opinion is countenanced by the disproportionate size of the liver in the fœtus, and by the great emaciation, that attends an interruption of the biliary secretion. It may be observed too, that the liver, or a provision analogous to it, exists in all animals, excepting worms and zoophytes.

The *pancreas*, or sweet-bread, needs not an elaborate description. It is a conglomerate gland, which exists in all mammiferous animals, and in birds, and reptiles; oval, white, and crosses the spine behind the stomach. Open it lengthwise, and you will find a duct, which runs through it, and conveys the pancreatic liquor to the duodenum. This duct was discovered by an Italian anatomist, of the name of Wirsing, a discovery which caused so much envy, as to procure his assassination.* It is worthy of remark, that in

* Boerhaave's Method of studying Physic, p. 219.

birds the pancreas consists of two distinct glands, and it is only found in two genera of fishes — the ray and the shark. In your search for the pancreas, your attention would be caught by an organ, dark-coloured, like the liver, full six inches long, and attached to the greater curvature of the stomach. This is the *spleen*, which is consequently situated on the left side, under the false ribs, and exists in most animals. The location of this organ among the viscera of the belly, its size, and glandular appearance, render it probable, that it is in some way subservient to the process of nutrition. It has no excretory duct, and secretes no peculiar fluid; peculiarities which have rendered the function of the spleen an interesting subject of enquiry. Haller imagined it was in some way, or other, subservient to the formation of bile in the liver. He supposed that the blood, in its passage through this organ, acquired some property, which fitted it for its further changes in the liver. This hypothesis, however, is not supported by experiment. Dr. Haighton removed the spleen from a dog, and not only did the liver secrete the bile as usual, but this fluid, when subjected to chemical analysis, differed in no respect from the ordinary secretion.* Sir Everard Home imagined, that he had discovered a communication between the spleen and the kidnies, and concluded, that the office of the spleen was to carry off superfluous water from the stomach, by a route infinitely quicker than the ordinary course of absorption. "But," as Mr. Lawrence observes, "it exists in reptiles, and fishes, where neither the figure of the stomach, nor the known habits of the animal, in respect to food and digestion, admits of this explanation. In the camel, which retains the water in the stomach, and in the horse where it passes very rapidly into the cæcum, the spleen is as large as in other animals. In beasts of prey, which hardly drink at all, it is as large and cellular as in the herbivorous ruminant animals. Its size and its cells are particularly conspicuous in the latter; yet the fluids, which they swallow, go into the paunch, and not into the true digestive stomach."† The most rational theory, beyond all question, is that of Dr. Haighton. He supposes, that the spleen is a reservoir of blood, for the use of the stomach, in the process of

* Saunders on the Liver, p. 49.

† Lawrence's Physiological Lectures, p. 89.

digestion, and his arguments render it highly probable. He infers it, in the first place, from the great size of the splenic artery, when compared with the hepatic, which is merely nutrient; while the liver is many times larger than the spleen. Then, the size of the gastric arteries bears no proportion to the quantity of gastric fluid secreted in the stomach. These probabilities are strengthened by the anatomical fact, that the gastric and splenic arteries inosculate, and are derived from one common trunk, the cœliac artery. Again, before the arteries, within the spleen, terminate in veins, there are cells interposed, which are capable of retaining a considerable quantity of blood, and when the organ is distended, the pressure of a full stomach must force an additional quantity of blood into the gastric arteries. Finally, when animals are deprived of the spleen, digestion is impaired; they become dyspeptic, and die of atrophy.

You will now be curious to hear something concerning the *lacteals*. If you take hold of a piece of small intestine, you find attached to it, the whole length, a membrane, which hangs it to the spine. This membrane is the mesentery, and in it you can trace the absorbents, passing through the lacteal glands; except in birds, which have no mesenteric glands, and converging towards the spine. In an animal recently killed, the lacteals are full of chyle, which is seen beautifully ascending. The mouth of each vessel communicates with the small intestine, where they are found lurking behind the valvulæ conniventes, and like myriads of leeches imbibing the chyle. The lacteals, like the veins, are furnished with valves. Close upon the spine is the thoracic duct, the entrance of which is called the receptaculum chyli. It is about the thickness of a quill, and conveys the chyle to a vein in the neck (the left *subclavian*), from whence it is conveyed by the vena cava to the heart, and this completes the process of nutrition. Birds have two thoracic ducts, which terminate in the two jugular veins, and insects have no absorbents. — While on the subject of absorption, it will be proper to observe, that the whole body, in vertebral animals, is every where furnished with absorbents, which containing a transparent fluid, are called lymphatics. These, in the mammalia, and birds, pass through numerous glands, and also terminate in the thoracic duct. The lymphatics perform many important offices in the system. Parts which require renewal, and this must hourly happen in a growing body, are removed, and room made for the deposition of new matter. This explains the growth, and perpetual renovation of the frame. In a pathological point of view they are indispensable. By their agency morbid structures are removed, and the frame preserved from the natural consequences of disease. In this way all swellings are reduced. To them we are indebted for the cure of an enlarged liver, and the dropsy. As the matters they convey are excrementitious, but for the provision of sewers for their reception, and expulsion, the blood would be constantly impure. The principal emunctories are the kidnies, which will be described in a future letter. In the annexed plate you may see them in the loins, where you will instantly recognize them by their well known figure. Like the veins, the lymphatics are furnished with valves, except in fishes, in which animals, also, there are no lymphatic glands.

We remarked, that the residue of the chyle was conveyed to the *large intestine*, which exists in all vertebral animals. Where the small intestine ends the large one begins, the calibre of which is much greater. To see it fairly, the coil of small intestines should be cut away. The beginning of the large intestine occupies the right groin; and is called cæcum or caput coli. This portion of the intestine is very small in the carnivora; so that the presence of a large one shews, that the animal feeds on vegetables. There is an appendix (*vermiformis*) attached to the cæcum, which is wanting in all the simiæ, except the orang outang. Most birds have two cæca, and the large intestine in fishes is so short, as to represent that portion which in other animals is called the rectum. The *colon* arises from the cæcum, and crossing the stomach, descends on the opposite side, and making a sigmoid flexure, ends in the rectum. This terminates the whole, except in birds, where the rectum ends in a part called the cloaca; together with the ureters, and organs of generation. The large intestine is composed of four tunics, like the rest, but the muscular coat consists of longitudinal, as well as concentric fibres, and as the former are shorter than the bowel, it is drawn into saccali, where the fæces are figured prior to their expulsion.

I cannot conclude this letter better, than in the words of the Athenian sage. "Is it not," he says, in his incomparable dialogues, after expatiating on the mechanism of the eyes and ears, "a wonderful providence, that the fore-teeth are proper to cut the food, and those on the sides of the mouth to grind it? That the mouth, which is the entrance for the nourishment of all animals, is near the eyes and nose, that we may the better judge of the things that enter into the body? And because the excrements are disagreeable, that an averted direction is given to the canal, which conveys them from the body; by which means they are removed as remotely as possible from the senses? These things being disposed with so much apparent foresight, can you hesitate to determine, whether they are the effects of chance or of providence?"*

Farewell.

* Xenophon's Memorabilia.

LETTER II.

ON THE CIRCULATION OF THE BLOOD.

DEAR SIR,

To an enquiring mind like yours, the subject of the present letter will have peculiar attractions. The circulation of the blood, and the function of respiration, which raise us a step higher in the scale of being, must have oftentimes excited your curiosity and wonder. In our last, the organs, which attach us to the earth, were examined; the viscera of the thorax will now be displayed, those organs, which connect us with the air, by which we may be said to live, move, and have our being. — A perfect circulating system is peculiar to warm blooded animals; and with respect to respiration, although it is carried on in all animals, the organs vary considerably. In the warm-blooded vertebral animals, the chief organ of this function is the lungs; the same obtains in serpents, but in fishes it is performed by the gills.

Insects are aerated by means of tracheæ, which cover their whole surface, and worms and zoophytes by analogous, but at the same time very different parts. The leaves are supposed by some physiologists to be the lungs of plants, but this theory is entirely conjectural.

The ancients supposed the air was an elementary substance, and the opinion was universal, until the eighteenth century, when the discoveries, in pneumatic chemistry, threw full light upon the subject; and by detecting the composition of the atmosphere, and the proportions of its component parts, gave an impulse to science, as great as the discovery of the circulation of the blood. Dr. Black led the way. While he was subjecting chalk, and magnesia, to experiment, in order to discover a solvent for the stone; he found these substances became lighter by the action of fire, and that a short exposure to the air restored the weight they had lost. The inference was irresistible: these bodies contain air in combination, and the proposition was confirmed by the fact, that air is extricated from them by the action of acids. The gas, thus disembodied, was next collected, and it was found to have peculiar properties.

It extinguished flame, and deprived animals of life. As it was solidified in chalk and marble, he called it fixed air; and as these substances, when deprived of it, regained it by exposure, it was plain, that the atmosphere was a compound body, and fixed air (*carbonic acid gas*) one of its component parts. Other chemists, following in the same track, in a short time, made out the other constituents of the atmosphere. Cavendish discovered hydrogen; Rutherford, nitrogen, or azot; and the brilliant discovery of oxygen was reserved for Dr. Priestley.* The exact composition of the atmosphere is as follows:

Nitrogen gas, 78 parts;
Oxygen 22.
Carbonic acid gas, the fixed air of

* "To Dr. Priestley we owe that beautiful discovery of the mutual support, which the animal and vegetable creation afford to each other; viz. that animals whilst dissolving and putrifying after death, set loose in the atmosphere a great quantity of nitrogen gas, which if augmented beyond its due proportion would tend to destroy those that still live; but that this gas is greedily absorbed by growing vegetables, which retain and fix its basis as a part of their substance, whilst they give out in exchange a quantity of vital air that in its turn is necessary to the maintenance of respiration and animal life."

Curry's Obs. on Apparent Death, p. 118.

Black, in a very small proportion; and hydrogen is an accidental combination. To what extent these worthies were anticipated by Hooke, Mayow, and Boyle, the chemists must determine.

Before we describe the changes effected in the blood by the process of respiration, some account of the thorax, and its contents, must be premised. The form of the chest is a truncated cone, somewhat flattened behind, and before. Its sides are formed by two rows of ribs, twelve on each side; all of which are articulated obliquely to the spine, and in front, seven are united by the intervention of cartilages, to each side of the sternum. This bone, and the spine, afford great strength to the thorax, and serve as fulcra for the ribs; as they ascend, and descend in the process of respiration. The diaphragm, the floor of the chest, has been mentioned already, and will be more particularly described hereafter. Within, the thorax is lined with a membrane (*pleura*), analogous to the peritonæum, which also is reflected over the several viscera; so that the heart and lungs are really outside the pleura. This is demonstrable by putting two inflated bladders side by side, and then reflecting each bladder, when punctured, over the hands. The union of the pleuræ leaves a hollow beneath the sternum, and upon the spine, and thus forms the anterior and posterior mediastinum; in the former of which, is a gland (*thymus*), of great size in the fœtus, the use of which is unknown, and the latter contains the principal vital nerves, the aorta, vena azygos, œsophagus, and the thoracic duct. When the sternum, and the cartilages of the ribs are removed, the contents of the chest are displayed. — The form of the chest in vertebral animals is not essentially different, and it has been remarked already, that birds and fishes have no diaphragm.

The *heart* is a hollow muscle of a well known figure, placed underneath the sternum, its apex pointing to the left side; where you may feel its pulsations. It is seen, contained in a bag (*pericardium*), which exists in all red blooded animals, and is moistened by a halitus or vapour, that after death becomes a fluid. This fact is interesting, as it accounts for the circumstance of blood and water issuing from the side of our Saviour, when it was pierced by the Roman soldier. In a species of fish, the lamprey, the pericardium is composed of firm cartilage, embedded in the liver, from which structure Macartney concludes, that the bag does not alter its figure with the contraction and dilatation of the heart; and hence the necessity of a greater quantity of fluid in this cavity, than in the other cavities of the body.—The heart is divided into two compartments, one before, the other behind; and these are improperly called the right, and left sides of the heart. Each chamber consists of a veinous looking cavity above (the *auricle*), and below it, a muscular cavity called *ventricle*. The left ventricle is less capacious, but much more substantial than the right. In the septum, or partition, which divides the auricles, are the traces of an opening (*foramen ovale*), which is pervious in the fœtus, and closed in after life. This opening is supposed to be pervious in amphibious animals, but Cuvier found it closed in the porpoise, the dolphin, and the seal; and the observations of Blumenbach warrant the same conclusion. The heart is nourished by the coronary arteries, the first branches of the aorta.

So much for the heart—we must now proceed with the circulation of the blood. The right auricle, so called from a little ear-like appendage, receives the contents of the venæ cavæ, and pours them into the right ventricle. Now there are certain valves, or floodgates (*valvulæ tricuspides*), in the ventricle, which originate in its margin, and lie close to its sides. In this situation they do not impede the entrance of the blood, but when the ventricle is full, they are floated, and prevent its refluence. Lest the contraction of the ventricle upon the blood should force these valves back into the auricle, they are detained by strings (*chordæ tendineæ*). Of the use of the valve of Eustachius, physiologists are not agreed. Haller supposes it prevents the return of the blood into the cavæ *, an opinion which is strongly countenanced by the structure and function of this valve in birds. It is remarkable, that the Eustachian valve does not exist in the lion, the bear, and the porcupine. From the upper corner of the right ventricle, you perceive a considerable artery arises. This is the pulmonary artery, which abruptly splitting into two divisions, conveys the veinous blood, by ramifications almost without end, into the lungs; indeed, the lungs are principally composed of the

* Haller's first Lines, p. 38

branches of the pulmonary artery. When the root of this vessel is laid open, you see three semilunar valves, placed there to prevent the regurgitation of the blood upon the heart. Nothing in anatomy is more beautiful than this contrivance. How simple, yet how effective! But for the semilunar valves, any impediment to the free transmission of the blood, through the lungs, would overwhelm the heart. The first fit of coughing would be mortal! There is a remarkable peculiarity in the structure of the right side of the heart of birds, deserving your attention. Instead of the tricuspid valve, the right ventricle is furnished with a triangular muscle of great strength. Taken in connection with the structure of the lungs, and the extent of the air cells, as you will perceive presently, the utility of this deviation is apparent. In the human subject the alternate collapse and expansion of the lungs facilitates the transmission of the blood to the left side of the heart; but the lungs of birds are in a state of permanent expansion.

To return from this digression, each side of the thorax is occupied, and filled with two light spongy bodies, divided into lobes, and in size and figure corresponding to the cavities allotted them. These are the lungs, which are alike in all quadrupeds. Outwardly, they are covered with the pleura, and within they consist of innumerable cells, which have communication with the air. Through each cell a ramule of the pulmonary artery passes; and as the coat of the vessel is thin, the air, in this manner, comes in contact with the blood.—In front of the throat, is a tube, the *trachea*, consisting of cartilages disposed in rings. Near the top of the sternum it divides into the two bronchiæ, which subdivide in the substance of the lungs, and convey the air to the air cells. On the forepart of the trachea, and on each side, is a gland (*thyroid*), the use of which has not yet been discovered, although it exists in man and the mammalia only. The most remarkable deviations in the structure of the lungs occur in birds and fishes. In the former, the cells of the lungs communicate with numerous air cells, throughout the body; and in most birds, a considerable portion of the skeleton, as well as the wings, is formed into receptacles for air, which supplies the place of marrow. The lungs too, adhere to the thorax, which renders them incapable of alternate collapse and expansion, and are only covered by the pleura, on their under surface. They are also furnished with muscles. Instead of lungs, fishes and the crustacea are furnished with gills (*branchiæ*), behind the neck, on both sides, and these animals receive their oxygen from the air contained in the water. The swimming bladder of fishes is probably analogous to the air cells of birds, and the air vesicles, in aquatic insects, evidently resemble them. Amphibious animals are remarkable for the great size of their air cells, and in serpents, for the most part, there is but one lung, which is an elongated bag. You will not wonder at the amazing irritability of insects, when you are informed, that their air vessels communicate with every part of their bodies. They are aerated by means of *tracheæ*, which ramify over the whole surface.

Before we proceed with the process of respiration, it is necessary to observe, that at the top of the trachea is a complicated instrument, the *larynx*, which is indeed the organ of voice. It is a kind of portal, which admits the air into the trachea, and employs it in its return in the production of sound; and is an admirable instance of the economy displayed in the works of the

Creator. In front, it is formed by a cartilage, which from its resemblance to a shield is called *thyroid;* and this stands upon a circular one, the *cricoid*. Behind, two more are so formed and situated, as to leave only a small chink, the *glottis*, for the entrance of the air. The arytenoid cartilages being moveable, and furnished with ligaments (*chordæ vocales*), and muscles, increase and diminish the size of the glottis, and thus modulate the voice. To prevent any thing from falling into the trachea in the act of deglutition, a little valve (*epiglottis*) is attached to the root of the tongue, to which the larynx ascends, when we swallow, and closes the glottis. Birds have two larynxes, one at the top, and the other at the bottom of the trachea; but no epiglottis. The inferior glottis corresponds to the reed of a hautboy or clarionet, and produces the tone or simple sound; while the superior larynx gives it utterance, as the holes of the instrument. The strength, and body of the note, depends on the extent and capacity of the trachea. The neighing of the horse, and the braying of the ass, are produced by a ligament, which crosses the larynx. As might be expected, fishes and insects have no organs of voice, and all the amphibia want the epiglottis.

Respiration consists of two actions, inspiration and expiration. Atmospheric air, after being admitted into the lungs, returns charged with nearly ten per cent. of carbonic acid gas. Dr. Henry observes, that "when the state of the expired air is examined, a quantity of oxygen is found to have disappeared, equal to the volume of the carbonic acid which has been formed. Now as carbonic acid has been proved to contain its own bulk of oxygen gas, it follows, that all the oxygen, which disappears in respiration, must have been expended in forming this acid? *" The blood then is decarbonized in the process of respiration, and hence it is, that arterial blood is of a bright vermillion colour, while the blood in the veins is almost black. The effect of atmospheric air upon the blood may be seen by a simple experiment. Fill a moistened bladder with veinous blood, and expose it to the air. In a little time the surface of the blood will become of a bright scarlet colour, while the middle

* Henry's Chemistry, vol. II. p. 354.

of the mass, that portion to which the air has had no access, will retain its livid hue. In the following experiment of Godwin, the process of respiration is represented to the naked eye. Having opened the thorax of a living dog, he exposed the lungs and heart to view. It was a striking spectacle to observe the black blood, in its return from the lungs, and in its passage to the heart, change to a bright vermillion colour. As the dog became exhausted, it was found necessary to inflate the lungs by artificial means. When this was omitted, the blood received from the heart was black, and in a little time its action ceased. But when the lungs were again made to collapse and distend by the inflation of common air, the blood in the pulmonary vessels regained its former crimson colour, and the action of the heart and arteries was excited anew." Respiration is not only essential to life, for death ensues when an animal is deprived of the air, but it is the principal cause of animal heat. In the union of the oxygen of the atmosphere with the carbon of the blood, heat is evolved, which the arterial blood immediately absorbs, and retains in a latent state, and as veinous blood has been found by experiment to have less capacity for heat than arterial, in passing from the arterial to the veinous state, the blood parts with a portion of caloric, which during the circulation is diffused through every part of the frame. Recent experiments, however, assign some share in the production of animal heat to the nerves. "We have evidence" says Mr. Brodie, "that when the brain ceases to exercise its functions, although those of the heart and lungs continue to be performed, the animal loses the power of generating heat." Dr. Wilson Philip has also shewn, that a destruction of any considerable portion of the spinal marrow lessens the temperature of the animal.* The nerves too, probably contribute to that equable temperature, which the animal body preserves amidst all the changes of the surrounding medium. This is peculiarly the property of living matter. All other bodies have the same degree of heat with the substance in contact with them, but man preserves an uniform temperature in the icy regions of the pole, and amid the fervours of

* Philip on Vital Functions, exp. 58, 59 and 60.

the torrid zone. In the human body the temperature varies only a few degrees from 96° Fahrenheit, whether it be exposed to a cold many degrees below the freezing point, or is surrounded by an atmosphere little short of the heat of boiling water. Birds possess a higher degree of temperature than all other animals. Camper states it to vary from 104 to 107 degrees of Fahrenheit's scale. Before we proceed with the circulation of the blood, it will be proper to notice the properties of this important fluid. When first drawn, the blood is apparently homogeneous, but it soon coagulates, and separates into a fluid (*serum*), and a solid (*crassamentum*). The serum consists of water, colouring matter, common salt, and, according to the experiments of Dr. Bostock, mucus* ; and the crassamentum is composed of gelatine, and oxyd of iron. It contains, in short, the elementary principles of the frame, and is thus fitted for its perpetual renovation; the distribution of life and warmth, and the production of the several secretions. It is conjectured by

* Med. Chir. Trans. vol. i. p. 46.

Haller, that the whole mass of circulating fluid, in the human body, amounts to fitfy pounds, of which one-fifth is red blood.

When the blood has been aerated, in its passage through the lungs, it is conveyed by the pulmonary veins to the left chamber of the heart. These veins, which originate in the ultimate ramifications of the pulmonary artery, end in four trunks, and communicate with the left auricle. As in the right ventricle, in the left there are valves (*mitral*) for a similar purpose. — We have now traced the course of the blood from the right chamber of the heart to the left, and this constitutes the lesser circulation, which was understood by Cæsalpinus, and clearly described by Servetus, a century before Harvey came forward with his discoveries. He says, " the communication between the two sides of the heart is not effected through the partition which separates the ventricles, as is generally supposed, but by a great mechanism. The blood is carried from the right ventricle to the lungs, by the vena arteriosa (pulmonary artery) and from it by the arteria venosa (pulmonary veins). The air insinuates itself into these vessels, and mixes with the blood, which in its turn throws off by the same way, the gross humours with which it may be charged. The blood thus mixed with the air, is attracted by the left ventricle, which dilates to receive it more readily." This great man fell the victim of religious bigotry, and was burnt alive at Geneva, by the Protestants, for denying the Trinity. A. D. 1553.

When the left ventricle, which is very strong and muscular, contracts upon its contents, the blood is forced into the aorta, the branches of which (*the arteries*) convey it to every corner of the body; and it is returned to the right ventricle again, having its losses repaired by the addition of the chyle, by the veins. These vessels are the terminations of the arteries, and, as was observed, in a former letter, from minute ramifications become considerable trunks, and end in the venæ cavæ, the connection of which with the right auricle has been described already: and this constitutes the *greater circulation*, the discovery of which, in the 17th century, has rendered the name of Harvey immortal. — Like the fate of every great genius, this illustrious discovery brought unmerited persecutions upon its author. We will not drag their names from oblivion, but merely subjoin the following specimen of Harvey's method of dealing with his adversaries, which contrasts the temper of the contending parties. " It cannot be helped, but that dogs will bark, and cynics pretend to mix with philosophers; but I shall take special care, that they do not bite, and destroy with their dogs' teeth, the very marrow of truth. They rail against me, because I do not answer the surfeits they eructate. Detractors, mimics of men, let them know that I never intend to read works, that can have nothing of solid sense in them; much less shall I esteem them worthy of an answer. It would be unworthy of me to return opprobrious language for theirs. I shall do better, for I will overcome opposition by truth; and if they will consider with me the anatomy of the vilest insect, they will find a God equally in the humbler, as in the higher works of creation."

The account we have given of the circulation is capable of being illustrated by the facts of pathology. From the rapid progress of morbid anatomy it now appears, that malformation of the heart, once considered a great rarity, occurs so frequently as to create a difficulty in classing its varieties. They are, however, of two kinds: malformation mingling black with red blood, and those which only impede the circulation of the blood. We have already contended for the aeration of the blood being a a principal source of animal heat, and a review of the symptoms of malformation of the heart confirms that opinion. Along with dyspnœa, palpitation, faintness, and other distressing symptoms, a blue child is generally colder than others. This phenomenon is owing to veinous blood having a less capacity for heat than arterial, and also to its being more easily deprived of it, by whatever favours the reduction of animal temperature. The opinion also advocated in these pages, that the nervous system participates in the important function of regulating animal heat, is demonstrable by the same species of proof. Cases of malformation, throwing an extreme impediment in the way of the blood's aeration, are on record, where a degree of sensible heat pervaded the internal surfaces of the body, greater than can be explained on the hypothesis of respiration being its only source. For the details I must refer you to the writings of Farre and Corvisart.

Instruction rather than amusement is our purpose, otherwise, were we disposed to study effect, there is no single subject in the whole province of physiology, on which the imagination dwells with so much wonder, as the circulation of the blood. Dr. Paley has judiciously heightened the impression it is well fitted to produce, by contrasting the circulation in man, and still larger animals. "Consider" says he, "what an affair this is, when we come to very large animals. The aorta of a whale is larger in the bore than the main-pipe of the water-works at London bridge; and the water roaring in its passage through that pipe is inferior in impetus and velocity, to the blood gushing from the whale's heart." Generally speaking, the circulation in the warm-blooded vertebral animals resembles the same process in the human subject, but in the other classes the deviations are considerable. Thus, in the turtle, the two ventricles communicate, and the passage is only closed by a valve; so that the blood can reach the left ventricle, without performing the lesser circulation. The aorta, too, arises from the right ventricle. These peculiarities are obviously adapted to the amphibious nature of the animal. Fishes, and reptiles, have but one auricle and ventricle, and insects have neither lungs, heart, nor blood-vessels; unless the canal, which runs along the spine, can be considered one. There are three hearts in the cuttle-fish, two pulmonary, and one aortic; but the other mollusca have an aortic heart, consisting of an auricle and ventricle.

A magnificent arterial arch, the *aorta*, arises from the top of the left ventricle. In the annexed plate, you see it bestriding the pulmonary artery: and, as in that artery, valves are placed at its root. The *head* is supplied by two large arteries (*carotids*), which arise from the arch of the aorta, and course along the neck, on each side the trachea; and by the vertebral arteries which spring from the *subclavians*. These again originate in the arch of the aorta, or a trunk which springs from it, (the *arteria innominata*), and supply the upper extremities. Beyond the axilla, they are called brachials, and course down the inside of the arm, where of course they are out of the way of accidents. At the bend of the arm, the brachial artery subdivides into the *radial* and *ulnar*, from whence originate the *intercostals;* and in the hands they compose two arches (*superficialis* and *profunda*), beneath the palmar fascia, which send two vessels to each finger.—The thorax and abdomen receive their supply of blood from the descending *aorta*, which in its passage through the chest supplies the several viscera; and gives off a series of arteries, (the *intercostals*), on each side, one of which runs between every two ribs. Having passed the diaphragm, the aorta gives off the phrenic arteries to that muscle, and the *celiac* artery, by the branches of which the stomach, liver, and spleen, are nourished. The two *mesenterics* are next given off, and these are distributed to the small and large intestines. They are succeeded by the *renal* and *spermatic*, the former of which proceed to the kidnies, and the latter to the testes or ovaria; and the last in the series are the *lumbales*, which encircle the loins. At the end of the vertebral column, the aorta splits into the two iliacs, which subdividing, the one is distributed to the viscera of the pelvis, and the other proceeds to the lower extremity. The branches of the *internal* iliac are the *ilio lumbales*, *sacro-laterales hypogastrica*, which last supplies the bladder; *obturator*, *glutea*, and *is chiatica*, which play around the hip-joint, and the *internal pudic*, which supplies the pudenda.

In the groin you find the continuation of the external iliac, where it receives the name of *femoral*, which having given off the profunda, and the circumflex arteries to inosculate with the branches of the internal iliac; about the middle of the thigh sinks into the ham, and then becomes the *popliteal artery*. At the bend of the knee, this great vessel divides into the three arteries of the leg; the two tibials and the peronæal, from which sources the toes are as bountifully supplied with blood as the fingers.

The distribution of the arteries, in the other classes of vertebral animals, does not differ essentially from the description we have given of the arteries of the human subject. The mode, however, in which the aorta is formed in fishes, and reptiles, renders it impossible for the heart to communicate its impulse to the arterial system. The circulation of the blood, therefore, in these animals, is carried on slowly and without pulse; and the arteries have no middle coat as in warm-blooded animals. The retiform structure of the arteries, in the extremities of tardigrade animals, is interesting, as it accounts for their inactive habits, and is analogous to a similar distribution of the arteries at the basis of the brain (rete mirabile) in the mammalia. The middle coat of an artery is muscular, the contraction of which drives on the blood. The inferiority of this power in the veins * is in some measure compensated, except in cold-blooded animals, by the addition of valves in their course. Owing to the contraction of the arteries, they are found empty after death, from which observation the ancients concluded they were air tubes; hence the name of artery. This error was first exposed by Galen. The inosculation of the branches, which a great artery gives off in its course, with those previously dispatched; an example of whichwe have noticed in the description of the internal iliac and femoral arteries; is a beautiful provision of nature for the preservation of the limbs. By this contrivance, the destruction of the main trunk of an artery does not destroy the circulation in the member it supplies. Of this extraordinary provision English surgery has availed

* Haller and others confine the muscularity of the veins to the great trunks near the heart. But Verschuir and Dr. Hastings have proved that this power resides in the whole veinous system, although in a less degree than in the arterial.

itself, and English surgeons are in the daily practice of tying a thread round the trunks of the great arteries with perfect security. That distinguished surgeon Sir Astley Cooper has even ventured to tie the aorta itself, an operation which is perfectly successful in the inferior animals.

In our last letter, we shewed the necessity of some contrivance for the purification of the blood, and pointed out the causes of its impurity. The principal sewers, or excretories of the body, are the kidnies, which carry off the grosser impurities. Carbon and superfluous water are conveyed out of the system by the lungs and skin, in the forms of vapor and perspiration. And here we must remark on the œconomy displayed in the works of nature. While the skin carries off redundant moisture, and it is only excited to do so when the body is too hot, the perspiration is the vehicle of the superfluous caloric; so that the skin is the grand cooler of the body, and preserves it from any accumulation of heat that would hinder its organization. In fevers it does not act, and hence the painful and frequently fatal accumulation of heat in the body. The skin likewise, where it covers the extremities, is an organ of sense.

The structure of the kidnies is highly curious. Cut one into halves, and the internal structure is apparent. To the extent of half an inch, from without, you perceive a reddish substance. This is the cortical matter of the kidney, and consists of arteries and veins. What change the blood undergoes in this part of the organ is unknown. It is probably a mere receptacle. The matter more internal is not red: it is pale; and, if you examine it minutely, you may see myriads of capillary tubes, converging to the centre, in which is a cavity called pelvis. In this part of the kidney the urine is strained from the blood. The uriniferous matter ends in papillæ, each of which distils the urine into a little receptacle (*infundibulum*), from whence it flows into the pelvis. This latter cavity does not exist in cold-blooded animals. Two canals (*ureters*) convey the urine to the bladder, the structure of which is simple. It is a membranous sac, within the pelvis, under the peritonæum, which adheres to its upper surface, and has three tunics, muscular, nervous, and villous. The neck of the bladder is surrounded by a gland (*prostate*), about the size of a chesnut, and its waste-pipe, (which will be more fully described hereafter,) is called the urethra. Two remarkable membranous receptacles, which communicate with the excretory duct of the testis, and with the urethra, you will find at the bottom of the bladder: but the consideration of these parts will be resumed, when we come to describe the urethra, as an organ of generation. Birds, some fishes, and reptiles, have no bladder; and in many of the mammalia the kidney resembles a bunch of grapes.

The *skin* is composed of three layers; the innermost of which (*cutis*) is covered with a mucous sort of net-work (*rete mucosum*), which contains the colouring matter of the skin. Between these laminæ you find the papillæ or sentient extremities of the nerves, the skin being also an organ of sense, which are most abundant in the lips, and in the tips of the fingers and toes. The *cuticle*, or scarf-skin, covers all, and is abundantly supplied with pores, for the escape of the fluid of perspiration. The other secretions of the skin are worthy of attention. To secure it from the effects of moisture, an unctuous matter is constantly exuding. In the ears it assumes the form of an unguent of a peculiar odor, which probably protects these organs from the incursions of insects, as effectually as the tears wash them from the eyes. Another property of the skin are the hairs, which in the higher latitudes preserve animals from the effects of cold. In this enumeration we must not omit the nails, that cover the tips of the fingers, and the hoofs which protect the feet of quadrupeds; but these, as well as the plumage of birds, and the scaly armour of fishes and reptiles, are the province of the natural historian. In our next, we shall describe the viscera of the head and spine, and their functions, which elevate us from the low scale of vegetable existence, and connect us with the external world. Farewell.

LETTER III.

ON THE NERVOUS SYSTEM.

DEAR SIR,

CONTRARY to what happens in the thorax and abdomen, the receptacles of the brain and spinal marrow, the two great sources of nervous power, are of a complicated structure. This complexity has no connexion with the functions of the organs they contain, but depends on other circumstances. As far as the brain is concerned, the cranium may be regarded as an osseous sphere, hollow within, and perforated at the basis with various holes, for the transmission of the nerves; and the vertebral column is a hollow cylinder, perforated laterally, in like manner, and for a similar purpose. The reason why the skull consists of several bones, connected by sutures, is the impossibility of the growth of a continuous sphere of bone, with a rapidity proportionate to the speedy expansion of the brain; and the spine is composed of a series of vertebræ connected by ligaments, because the various movements of the frame render its flexibility essential. In describing these receptacles, it is not necessary, at present, to enter minutely into osteology. We shall direct your attention to those parts only, which are concerned in the course of the nerves. If you remove the upper half of the skull, and look into the cavity beneath; the first thing that strikes the eye is the division of the base into three hollows, one lower than the other. The foremost, which is the shallowest, supports the fore lobes of the cerebrum, and gives exit to the olfactory and optic nerves. Below it is a deeper cavity, protected laterally by the temples, for the reception of the middle lobes, and the transmission of the nerves belonging to the muscular apparatus of the eyes; and to the jaws and ears. The organ of hearing is also found in this situation. Last of all is a deeper hollow still, for the reception of the cerebellum, which gives out the par vagum, the suboccipitals, and the lingual nerves; and is provided with a large hole *(foramen magnum)*, for the passage of the spinal marrow. With respect to the vertebral column, or spine, there are, as Paley observes, " three views in which it ought to be regarded, and in all of which it cannot fail to excite our admiration. These views relate to its articulations, its ligaments, and its perforations; and to the corresponding advantages which the body derives from it, for action, for strength, and for that which is essential to every part, a secure communication with the brain."* The one which more particularly interests us, at present, is its perforations, which are twenty-four in number, and are situated on each side of the spine. Through these the spinal nerves are transmitted.

The brain and spinal marrow are further protected by their membranes; the outermost of which, the *dura mater*, is a membrane of great strength, and adheres firmly to their bony parietes. It forms two processes, one of which, *the tentorium*, separates the hollow, which holds the cerebrum from the cavity, which contains the cerebellum. The other, called the *falx*, extends from the roof of the nostrils to the basis of the skull, and divides the cerebrum and cerebellum into two hemispheres. The use of these parts is obvious. They prevent the concussion of the several portions of the brain, in the more

* Paley's Natural Theology, p. 104.

violent actions of the body; and, in animals swift of foot, are actually composed of bone. The *pia mater* is a membrane of great delicacy, and covers the convolutions of the brain, and spinal chord; and is itself covered by a membrane still finer, called *tunica arachnoides*, from its resemblance to a spider's web.

The mechanical functions of the body result from the structure of the parts concerned. The same may be said of the secretions, but between the sensorial functions, and the structure of the brain and nerves, there is no obvious connection; indeed their relation as cause and effect has been ascertained by negative evidence alone. As we have observed already, the brain consists of two parts; the *cerebrum* and the *cerebellum*. The former is divided into two hemispheres, and these again into lobes. When pared down horizontally, the cerebrum is seen to consist of two substances; the cortical matter without, and the medullary within. The former is reddish and vascular; the latter pale, and of a nervous texture. This part of the brain is remarkable for three cavities, or ventricles, which communicate with each other, and with another ventricle in the cerebellum. When the two hemispheres of the cerebrum are held asunder, a white substance is exposed (*corpus callosum*), which is the roof of the two lateral ventricles. The septum, which divides them, passes down perpendicularly from the under surface of the corpus callosum. The opening of the ventricles exposes two grey substances (*corpora striata*), and the *thalami* of the optic nerves, between which is a white line in relief (*tænia semicircularis*); and a vascular substance called the *choroid plexus*. Each lateral ventricle has three sinusses, of which the two posterior leave elevations of the medullary matter; the *hippocampus major* and *minor*. The *septum lucidum* adheres to the *fornix*, the roof of the third ventricle, behind which are four bodies (*corpora quadrigemina*), on which stands a curious little substance, the *pineal gland*, covered by a process of pia matter, called the *velum interpositum*. The pineal gland is of a greyish color, about the size of a pea, and contains a gritty matter like sand. Descartes supposed it was the seat of the soul! The fourth ventricle is situated still deeper, between the cerebellum, and the medulla oblongata; the beginning of the spinal chord. It is worthy of remark, that the corpus callosum, fornix, and a part to be next described, *pons varolii*, are peculiar to the mammalia. The circumstances worthy of note, at the basis of the brain, are the union of the two crura cerebri, and crura cerebelli (*pons varolii*), before which are two little white bodies (*corpora albicantia*), and the *medulla oblongata*, or root of the spinal marrow, on which are two eminences, the *corpora oliviria*, and *pyramidalia*.

The cerebellum is of the same texture as the cerebrum; only when it is cut across, the cortical matter, except in fishes, resembles the arborescence of a tree; and hence it is called the *arbor vitæ*. The texture of the spinal marrow resembles the medullary matter of the brain. Generally speaking, except in figure, the brain and spinal marrow are alike in vertebral animals; and it is observed by Blumenbach, that in nothing is the gradation of animals so clearly seen, as in their conformation. If these organs exist at all in zoophytes, they are interwoven with their texture. Insects and vermes have merely a nervous chord somewhat enlarged at one end; the mollusca have a brain placed near the œsophagus, with a variable number of ganglia, from both of which arise the nerves; but in vertebral animals, both cold and warm-blooded, they constitute the complicated structures we have just described. Before we conclude the description of the brain, it is proper to advert to certain contrivances, destined to secure the organ from pressure. The brain is supplied with blood, (as was observed in a former letter,) by the carotids, and vertebral arteries; and the blood is returned to the vena cava by the jugular veins. As, however, the state of the circulation within the head varies hourly from the emotions of the mind, a set of reservoirs for the reception of the blood, are provided, additional to the veins. These are the *sinusses*, which differ from the veins in being elastic. They are numerous, but an inspection of the *longitudinal* and *lateral sinusses* will give you an idea of their nature and utility. With respect to the functions of the brain and medulla spinalis, physiologists regard them as glands, the blood supplying them with the raw material. The secreted principle eludes the grasp of the senses, but is visible in its effects, and is conducted to every part of the frame by the nerves; enabling the internal organs to furnish their secretions, giving power to the senses, and rendering the members obedient to the mind. Ten pairs of nerves originate in the brain, and thirty in the spinal marrow.

The cerebral nerves are—

	NAME.	ORIGIN.	DISTRIBUTION.
1st pair.	Olfactory.	Corpora Striata.	Nose.
2d	Optic.	Thal. Nervi Optici.	Eyes.
3d	Motores oculi.	Crura Cerebri.	Muscles of the eye.
4th	Trochleares.	Valvula Cerebri.	Trochlearis muscle.
5th	Trigemini.	Pons Varolii.	Face.

These last are the *orbital*, *superior*, and *inferior* maxillary. The *first* reaches the face by the *supra orbitar foramen*; it sends a branch to the orbit, where it unites with the third pair to form the ophthalmic ganglion, and to the nostrils, and lachrymal gland. The *second* sends a branch to the face, which passes through the *infra orbitar foramen*, and the remainder supplies the palate and fauces. The *third* sends a branch to the tongue, (the true gustatory nerve) and, penetrating the lower jaw, supplies the teeth. It reaches the outside of the jaw, by the *foramen mentale*.

6th pair.	Abducent.	Pons Varolii.	Muscles of the eye.
7th	Auditory & Facial.	4th Ventricle. Crura Cerebelli.	Ears and face.

The *portio mollis* goes to the ear, and the *portio dura*, the respiratory nerve of Mr. Charles Bell, having given off the chorda tympani, penetrates the parotid gland, and forms, in the cheek, the *pes anserinus.* This nerve is very small in birds. Mr. Shaw, whose researches have thrown much light on the functions of this nerve in animals, states the proportion of the facial respiratory nerve to the fifth pair to be greater in man than in any other animal; that it is diminished in the monkey, though more complicated in that animal than in the dog, or any of the carnivora. From the lion, the dog, and the cat, we descend to the horse, ass, and cow. In the gazelle, sheep, and deer, it is still more simple, while in the camel it is intermediate between that of carnivorous and graminivorous animals. In the various classes of birds again its distribution is analogous to what occurs in the different tribes of quadrupeds. The nerve in question he shews clearly to be subservient to the muscles of expression.*

8th pair.	Par Vagum.	Medulla Obligata.	Viscera.
9th	Lingual.	Corpora Pyramidala.	Muscles of the tongue.

* Vide London Medical & Surgical Journal, No. 292.

The spinal nerves are—

8 pair of	Cervical.
12 ——	Dorsal.
5 ——	Lumbar.
5 ——	Sacral.

We have here to erect a monument to the genius of Mr. Charles Bell, to whom belongs the singular and sole merit (at one time erroneously ascribed to M. Majendee) of a brilliant discovery in one of the most obscure departments of anatomical science. He divides the nerves into two classes, the *Regular* and *Irregular*. The former he has ascertained to have a double origin, and a compound function. Voluntary power is connected with their anterior origin, and sensation with the posterior filaments, while a division of the trunk of the nerve annihilates both functions. But we shall give Mr. Bell's arrangement of the nerves in the words of Mr. Shaw, his able and zealous advocate.

" The principal arrangement is this: — there is an obvious division of the Medulla Spinalis, corresponding to the Cerebrum and Cerebellum: every *regular nerve* has two roots, one from the anterior of these columns, and another from the posterior. Such are the fifth pair; the sub-occipital; the seven servical; the twelve dorsal; the five lumbar; and the six sacral; viz. thirty-two perfect, regular, or double nerves. They are common to all animals, from the worm up to man, and are for the purposes of common sensation, motion, or volition. They run out laterally to the regular divisions of the body, and never take a course longitudinal to the body.

"The remaining nerves are called *Irregular* nerves. These are distinguished by a simple fasciculus, or single root; that is, a root from one column. These are *simple* in their origin, *irregular* in their distribution, and *deficient* in that symmetry which characterizes the first class. They are superadded to the original class, and correspond to the number and complication of the superadded organs. Of these there are the third, fourth, and sixth to the eye; the seventh to the face; the ninth to the tongue; the glosso-pharyngeal to the pharynx; the vagus to the larynx, heart, lungs, and stomach; the phrenic to the diaphragm; the spinal-accessory to the muscles of the shoulder;

the external respiratory to the muscles of the chest. This seeming confusion in the irregular nerves is owing to the complication of the super-added apparatus of respiration, and the variety of offices, which this apparatus has to perform in the higher animals." *

1. The conductors of nervous power to the organs, whose functions have been the subjects of our former letters, and to the pelvic viscera which remain to be described; or, according to others, the media by which the several vital organs are associated in their functions, are the *par vagum* and the *great sympathetics*. These last are formed by the union of a branch of the sixth pair, and a twig from the superior maxillary branch of the fifth. Having left the cranium, these nerves course along the neck, by the sides of the carotid arteries; and, in this situation, distribute branches to the trachea, œsophagus, and tongue. In the thorax, they frame the cardiac and pulmonary plexusses; and, having reached the cavity of the abdomen, form the great semilunar ganglion, which is the origin of the various plexusses, that supply the

* Shaw's Manual of Anatomy, p. 434.

organs of nutrition and generation. In its descent, the great sympathetic receives two branches from each of the thirty spinal nerves, and in the chest forms the great splanchnic nerves. In the neck, it gives off three ganglions, which seem to be "secondary centres of nervous influence, receiving supplies from all parts of the brain, and spinal marrow, and conveying to certain organs the influence of all those parts*," thus connecting important viscera with the brain and spinal marrow. Before the par vagum leaves the cranium, it unites with a spinal nerve (*nervus accessorius*), which enters the skull to join it. The sympathetic nerves are not found in animals without a bony spine, and, according to Cuvier, their ganglia are larger and more numerous in proportion as the principal brain is less. To this remark, however, fishes afford an exception. In these animals, their sympathetic nerves are large in proportion to the brain, and have no ganglions.

2. The organs of nutrition require the co-existence of the senses, without which the

* Philip on Vital Functions.

cravings of hunger and thirst would be the infliction of torture and death. The brain may be regarded as the parent of the senses, which, generally speaking, are alike in all vertebral animals. Eyes she has planted in the orbits to enable us to see; and as the senses are intended to warn us of danger, as well as to be subservient to our appetites, the mobility of the eyes enables us to see in all directions except one. Subservient to the eyes, therefore, which cannot see behind, the ears are placed on each side the temples of the head, with the conchæ so disposed, that we can hear sounds behind. To this remark birds afford an exception. Owing to the peculiarity of the articulation of the head and spine, which enables them to look backward, they are without external ears. The position of the nose is admirable. If the virtues of substances were discoverable only by the taste, pungent, nauseous, and even poisonous flavors, from which we are exempted by the interposition of the nostrils, would continually annoy us. Underneath the nostrils is the palate. How important are its functions may be learned from the remark of Haller, " that there is no aliment unhealthy which has an agreeable taste.*" The sense of touch is diffused over the entire surface of the body, but its powers are concentrated in the fingers, which are the instruments of touch. Infants ascertain the tangible properties of bodies by the lips.

The eye is a roundish body, destined to let in light upon the optic nerve, which comes direct from the cerebrum, and reaches the orbit by the foramen opticum. Having fairly entered, it expands into a nervous tunic (*retina*), which is cup-shaped, and contains the humours of the eye. The light, in its progress to the retina, is refracted by the humours, which are thus disposed. The *vitreous*, like transparent jelly, fills the nervous cup, and, as it is itself excavated in front, it holds the *crystalline*, a humor of less bulk, more solid, and in figure double convex. Before it floats the *aqueous humor*, which is confined in its situation by the other investments of the eye, and is only wanting in animals whose element is water. To commence the description of these tunics from within, the choroid is the first of them. It

* Haller's First Lines, p. 220.

covers the retina, and having reached the front of the eye, lets fall a curtain before the crystalline, called *iris*, which is retained in its situation, in all vertebral animals except fishes, by the *ciliary* ligament. Internally the colour of the choroid is various. In man, it is brown; in herbivorous animals, a bluish green; and in beasts of prey, white or yellow. This part of the choroid is called the tapetum, which does not exist in birds and fishes. The choroid is coated with a black paint-like matter (pigmentum nigrum), which is wanting in Albinos. There is an aperture (*pupil*) in the middle of the iris, which contracts and enlarges, in order that an uniform quantity of light may be admitted to the seat of vision. This aperture, which in the fœtus is closed by the *membrana pupillaris*, is circular in man, oblong in the horizontal direction, in herbivorous animals, and vertical in beasts of prey. The outermost coat of the eye (*sclerotica*) is as hard as horn, and is impervious to light, except in the forepart of the eye, where it puts out a window, called *cornea*. In birds, the front of the sclerotica is surrounded by a circular lamina of bone, and the same structure obtains in the cameleon and many lizards. The skin of the face gives a covering to the front of the eye, white as milk, as far as the sclerotica extends, but where it covers the cornea transparent. In one species of rat, however, (*mus typhlus*), the *conjunctiva* is actually hairy, like the rest of the skin, and the eye is consequently useless.

The comparison of the cornea to a window, induces us to advert to certain contrivances, analogous to the furniture of a window. The iris resembles a window-curtain, and its use is similar; it does not, indeed, ascend and descend, but recedes from, and approaches the centre, according to the degree of light, and hence the size of the pupil varies every moment. Besides the shutters, to which the eyelids are analogous, windows, in some situations, are furnished with penthouses. The eyebrows (*supercilia*) are of the same use to the eyes; and as the eavings of a thatched cottage dash off the rain, the superciliary hairs secure the eyes from the sweat which trickles down the forehead. One contrivance is peculiar to the eye. A gland (*lacrymal*), is hidden in the outer corner of the orbit, which upon occasion inundates the surface of the eye; and, what is still more beautiful, a waste-pipe (*ductus nasalis*) is provided in the opposite corner, for the reception of the superfluous tears, which through this channel are conveyed to the nostrils. Many animals have a membrane (*nictitans*), for the purpose of wiping the eye, which being in some degree transparent in birds, enables the eagle to gaze upon the sun. These again have a contrivance (*marsupium*), to increase and lessen the convexity of the cornea; thus lengthening and shortening the power of vision at their pleasure. Fishes and serpents have none of these appendages. Insects have numerous microscopic eyes, and because the neck is but slightly moveable, the eyes of the crustacea are fixed on moveable pedicles. Several of the cold-blooded invertebral animals are incapable of sight altogether.

The *Ear* is adapted for the reception of sound, and is naturally divided into two parts, external and internal. The form of the *concha*, or external ear, is well known, and is admirably constructed for the collection of sounds from every quarter. It is the portal of the auditory passage (*meatus auditorius*), through which sound is conveyed to the *membrana* tympani; the termination of the external ear. The tympanum, or drum, is covered by this membrane; and, as a drum is furnished with a hole for the admission of air, the tympanum in this particular is not defective. In the throat is the termination of a canal (*Eustachian trumpet*), which communicates with the drum, and admits the air into its cavity. Within the tympanum is a chain of little bones, *malleus*, *incus*, *os orbiculare*, and *stapes*, which, being excellent conductors of sound, convey the impression made upon the membrana tympani to the labyrinth or internal ear. Birds and fishes, and most reptiles, have only one ossiculum auditûs. The bones of the ear in man, and the mammalia, have four muscles, three to the malleus and one to the stapes; but in the cuttle-fish the ossiculum is loose in the sac, which corresponds to the auditory passage in other animals. The entrance of the *labyrinth* is by two holes (*fenestra ovalis* and *rotunda*), which admit sound into a spiral canal, resembling a snail-shell (*cochlea*). Through this tortuous passage the sound winds, and increased in strength by reverberation, reaches the *semicircular canals*, in which are expanded the auditory nerves, (*portio mollis* of the 7th pair); and being full of water, the force of the impression is broken, and the nerve uninjured. Instead of a cochlea, in fishes and reptiles there is a membranous sac, which communicates with the semicircular canals. We have told you, that the auditory nerve is the portio mollis of the 7th pair in the mammalia; in fishes it is a branch of the 5th pair; a strong analogy, by the way, in favour of Mr. Charles Bell's theory of the nerves. It is worthy of remark, that the four-footed mammalia alone possess external ears. They are wanting, however, in those which live under-ground, as the *mole*, or are amphibious, as the *seal*. In the latter, the auditory passage is furnished with a valve. Suited to their element, which is one of the best conductors of sound, fishes have neither external ears, nor a tympanum; and the same privations are observed in serpents.

The other *senses* are of a simpler structure. The circumstance most remarkable in the nostrils is their depth in the horizontal direction; they extend even to the throat. To increase the extent of surface, there are four turbinated bones; two on each side the septum narium. The sense of smell resides in the pituitary membrane, which covers all these parts, and receives its powers from the first pair of nerves and a branch of the 5th, which in fishes is as large as the olfactory itself. In the cetacea the first pair is actually wanting. The floor of the nostrils is the roof of the palate, which, with the tongue, constitutes the organ of *taste*. These parts also receive their powers from the 5th pair of nerves. Examine the tongue closely, and you will find it covered with innumerable papillæ, and as each little eminence is the nidus of a nervous filament, it is erected by the contact of sapid bodies, and its powers exalted. In many animals, it is doubtful whether the tongue is an organ of taste. Thus, in fishes it is cartilaginous, and covered with teeth; and with respect to birds, it is only so in parrots, and a few others. In most birds it is strengthened by a bone. The tongue of the cameleon displays a curious mechanism. It is contained in a sheath, at the lower part of the mouth; and has its extremity covered with a glutinous secretion. The animal is enabled to dart it from the mouth to the extent of six inches, and in this manner catches insects, of which its food consists. The *palpi* are supposed to be the organ of taste in insects. The structure of the skin, as a cooler of the body, has been described already. Haller observes, "the sense of *touch* enables us to distinguish chiefly the roughness of bodies, and has been possessed to so exquisite a degree by some persons, that they have been known to distinguish coloured surfaces by the touch alone. We perceive heat, when external bodies are warmer than our fingers, and weight likewise, when they gravitate more in comparison with their bulk than usual. Humidity we judge of by the presence of adhering water; softness, by the yielding of the object; hardness, by the yielding of the fingers; figure, by the hard limits circumscribing them; distance, by an inaccurate calculation derived from experience, to which the length of the arm serves as a measure. Touch corrects the errors of the other senses, although it sometimes errs itself; and the other senses, independent of touch, furnish animals with just perceptions."* This sense exists only in three classes of the animal kingdom; viz. in most of the mammalia, some birds, where it resides in the bill, as in ducks and geese; or in the feet, as in the sparrow and

* Haller's First Lines, chap. xii.

the eagle; and in insects, which feel by means of their antennæ. It is the opinion of some naturalists, that this sense resides in the cirri, which surround the mouths of fishes, and in the snout. The instrument of touch is not alike in the mammalia. The elephant uses the proboscis for this purpose, and hoofed animals, like infants, feel by the lips. In the human subject, and the quadrumina, the tips of the fingers are the organs of touch, and are protected by the nails. This sense is so delicate in the bat, that it can find its way without interruption in the most difficult situations, even when deprived of sight and the other senses.

3. Happily for man, the functions of the sensorium end not here. Consciousness and will elevate him from the low scale of vegetable life, and connect him with the visible creation. By their agency, impressions made upon the senses become perceptions of the mind, and, whether these are agreeable or painful, volitions are excited. *Memory* also enables him to recollect former decisions of the senses; so that he does not a second time handle fire, or inspire water. Civilization developes nobler powers. The contrivances for the safety of the community, and

the business of legislation, call for the exercise of *reason;* and *imagination* adds to the arts, which adorn existence, until the world has become "a theatre of wonders."* The passions co-operate with the intellectual powers. In man, in a state of barbarism, when volitions awakened by the senses are not controuled by reason, *desire* and *aversion* take possession of the heart. If the predominant passion is desire, the uncertainty of success engenders *fear*, which, when continued, becomes *anxiety*. *Hope* alone prevents its extension to *despair*. Disappointment gives rise to *rage* and *fury*, which gradually subside into *vexation* and *sorrow*. When, however, it is occasioned by the success of a rival, *revenge* usurps the heart, and is only calmed by the death of the offender; but the circumstances of death, and the exhaustion, which rapidly succeeds powerful emotions, call up *remorse* and *pity*. On the other hand, the attainment of his desires awakens *joy* and *exultation*, his heart is big with emotions of gratitude, the savage offers up oblations to his gods; his neighbours partake with him the sacred festival; he feels a

* Hall's Sermons, p. 76.

disposition to forgive his enemies, and charity to all men; nay, the very dog that slumbers on his hearth is made to partake his transports. — The same passions animate and depress civilized man; but, as in society many of his wants are artificial, new passions are developed. Avarice, ambition, and the lust of glory, are the plagues by which the destroying angel desolates the universe. But let us turn to the virtuous emotions. Conjugal, parental, and filial affections render our homes delightful; friendship and charity enlarge the social bond; loyalty and patriotism secure its existence; and devotion adds to the happiness which earth affords the prospects of heaven. It is unnecessary to enter into the instincts of animals, that subject being exhausted in your immortal work on Entomology.

The ancients imagined, that the diaphragm was the seat of the passions, and hence the nerves, which supply this muscle, are called *phrenic* nerves. They are common to all animals which have a diaphragm; and originate in the spinal marrow being formed by the nerves of the neck.

4. Man is not yet complete. Another func-

tion of the sensorium remains to be described. The will must be furnished with instruments, or we should realize the fables of the poet, and be virtually radicated like trees; our wills fast bound as in a dream. We have voluntary powers: feet to enable us to reach the objects we desire, or carry us from destruction; and hands and arms to grasp and retain them. These important instruments are composed of bone and muscle; a part of anatomy we have reserved for the second division of our work. The *spinal* nerves are the sources of voluntary power. Of these the cervical compose the brachial plexusses, which supply the arms, and of which the divisions are thus arranged by Mr. Shaw. There are three sent to the shoulder, viz. supra-scapular, infra-scapular, and articular. Three to the skin; the external and internal cutaneous, and the cutaneous of Wrisberg. Three to the muscles, which are the radial or median, the ulnar and the muscular spiral. The *dorsal* nerves are seen in the intercostal spaces, where they inosculate with the great sympathetics; and the *lumbar* nerves are distributed to the muscles of the loins and belly. There are also five *sacral* nerves, which supply the pelvis, and uniting with the lumbar furnish the lower limbs. Of the nerves of the thigh and leg the distribution is very simple; for there are only a few branches, which go to the skin, and three great nerves to supply the muscles. The cutaneous nerves are the branches of the saphæna, major and minor, and the muscular are the anterior crural, the obturator and the ischiatic. It may be observed by way of conclusion, that in nothing do the vertebral animals resemble man more than in the distribution of the nerves.

It now only remains for us to lay before you all that is experimentally known of nervous power. The older physiologists supposed that the nerves contained a subtle fluid; but this opinion, with its successor, æther, have long since been "quietly inurned;" and certain recent attempts to accomplish their resurrection have not been successful. It is easier to ascertain what nervous power is not, than what it is. Accordingly, it has been demonstrated by the experiments of Haller, and more recently by the very conclusive ones of Wilson Philip, that the irritability of the heart, and of the vascular and muscular systems, is distinct from the influence which these parts derive from the nerves. It is inherent in organized substances, and is probably derived from the life these parts receive from the blood. They who deny the vitality of the blood, should explain to us how life is preserved in eggs and seeds. Dr. Wilson Philip has also ascertained by experiment, that the secretions and animal heat are the effects of nervous power; and as he has been enabled to imitate these processes by the application of galvanism, he concludes, that the influence supplied by the nerves is galvanic. Analogy is certainly in favour of this conclusion. The secretions are evidently chemical productions, although of a kind which human chemistry is unable to imitate, and the recent progress of this science has shewn us that all chemical changes are effected by galvanism. And with respect to the muscles, the nervous power which is conveyed to the limbs, has been imitated by the application of the same principle. The experiments of Dr. Ure on the body of a malefactor are sufficiently notorious, and imitated life so successfully, as to induce a belief in the minds of the spectators, that if the great vessels had not been divided the dead would have been revived. The same power has restored paralytic limbs; and in one case a hopeless cripple was cured by the electricity of heaven.* It is a curious fact, that many animals, as the torpedo and the electric eel (*gymnotus electricus*), abound with electricity. Whether the blood derives it from the air, and conveys it to the brain, and whether the heat and light of the sun have any share in its production, is, at present, mere conjecture: "Aery nothings, which have not yet a local habitation and a name."

Farewell.

* Medical and Physical Journal, vol. xix. p. 119.

LETTER IV.

ON GENERATION.

DEAR SIR,

NUTRITION, the circulation of the blood, surprising as they are rendered by so many beautiful contrivances; and the operations of the nervous system, which baffle the researches of our philosophy, excite far less wonder than the function of generation. This power pervades all animated beings; it is not denied even to the vegetable tribes, which being stationary, are often indebted to the winds for the fecundation of their germs; and may be considered as the corner stone, the pillar, which upholds the temple of nature. The mode in which generation is effected, varies in the different tribes of animals. In some of the invertebral (*zoophytes*) the young animal grows on the body of the parent, like the shoot of a tree; and, in the cold-blooded vertebral animals, the ova are fecundated without the body. "Hermaphrodite animals," Cuvier observes, "such as the bivalve shell-fish, generate singly; in others a reciprocal copulation takes place, each of the two individuals performing the functions of male and female; as in snails and other mollusca."* Vertebral animals, and insects, have the sexes separate, and the process is effected by copulation. The results are as various as the processes, and the fruits are either gemmiparous, as in zoophytes, and articulated worms; oviparous, as in birds; ovoviparous, as in reptiles; or vivaparous, as in the mammalia, and the human subject. In the description of the other functions, you would remark, that the performance of those, which depend upon the will of the animal, is secured by two most active principles. Pleasure, for example, attends the gratification of hunger and thirst, while abstinence is punished by the infliction of pain. For moral reasons pain affords no licence for incontinence; but the function of generation is so interwoven with instinct, appetite, and passion, that the perpetuity of the animal creation is effectually secured.

* Cuvier's Comp. Anatomy, p. 44.

Below the abdomen is a bony cavity, which has the appearance of a bason; and indeed is called *pelvis*. It contains the organs of generation, and is framed of three bones; laterally the two haunch-bones (*ossa innominata*), and behind, a wedge-like bone, the sacrum, upon which stands the column of the spine. The little appendage to the sacrum, which in animals is lengthened into a tail, is called the os coccygis. A slight inspection of the pelvis will convince you, that the greater is the burden sustained by the sacrum, the firmer must be the union of these bones. With the exception of the cetacea, all mammiferous animals have a pelvis; and even in these animals there are two loose bones at the bottom of the abdomen, which may be regarded as the rudiments of a pelvis.

In our description of the kidnies, and the bladder, the urethra was represented as a canal appended to the pubis, for the evacuation of the contents of the bladder. It has also, in the male, another function. A little dissection will shew you, that this membranous canal, to within two inches of the bladder, is surrounded with a spongy sort of matter (*corpus spongiosum*), and is strengthened laterally by two crura of a cavernous texture (*corpora cavernosa*); which two strong ligaments, and a pair of muscles (*erectores penis*), fasten to the fore-part of the pelvis. These spongy and cavernous bodies being cellular, admit of great distention. The vesical end of the urethra is surrounded by a solid substance, the prostate gland, which exists in most animals, and the other extremity constitutes the glans, which is covered by a fold of integument. The lower termination of the corpus spongiosum is rounded off into a bulb, and is surrounded by a pair of muscles (*acceleratores urinæ.*) In some animals, the cetacea, for example, the penis consists of a single corpus cavernosum, without any septum, and in others the organ is strengthened by a bone. Instead of a penis, most birds have in the cloaca two small papillæ, in which the seminal ducts terminate. Reptiles have generally a double penis: but fishes neither have, nor indeed require any external organs of generation. The penis is mostly single in insects.

Two oval bodies, the testes, are contained in a bag (*scrotum*), below the urethra in man, and in most of the mammalia; and furnish the seminal fluid of the male. These organs in the cetacea, and in fishes, and birds, are lodged in the abdomen, and the same structure obtains in animals that live underground, as the mole, or roll themselves up on the approach of danger, as the hedgehog. In insects the testes are outside the body. When the capsules of the testis are removed, its internal structure appears; a coil of vessels is exposed resembling the cocoon of a silkworm. One division, the *tubuli seminiferi*, consists of vessels several yards long, and occupies the fore-part of the testis; while their terminations, the *vasa efferentia*, lie coiled up in a cell behind, which is called the epididymis. Branches of the abdominal aorta, the *spermatics*, supply the testes with blood. In their descent the nerves accompany them, and a plexus of veins. Along with the vessels and nerves, also, is the excretory duct (*vas deferens*); and these being all inclosed in a membranous investment, and embraced by a muscle (*cremaster*), constitute the spermatic chord, by which each testis is appended to the body. The vas deferens is the termination of the vasa efferentia, and conveys the semen to certain receptacles (*vesiculæ seminales*), at the bottom of the bladder, which communicate with the urethra. In the vesiculæ the semen is diluted with their secretions, and prepared for its expulsion in coitu. These reservoirs are found in most mammiferous animals, except the cetacea, but in birds the excretory ducts terminate in the urethra. In the fœtus the testis lies beneath the kidney, behind the peritonæum, which affords it its first investment (the *albuginea*). The exterior covering is formed by the peritonæal bag, which receives it in its descent, and is called the *tunica vaginalis.* A peculiarity in the testes of birds is too curious to be omitted here. These organs differ greatly in size, at different seasons of the year. Thus, in the common sparrow, according to Mr. Hunter, the testicles are ordinarily about the size of pin-heads, but during the season of propagation, acquire the bulk of pistol-balls.

At the end of the *canalis uteri*, in the female, is the uterus, or womb. Before impregnation it is about the size of a pear, hollow, having the fundus upwards, and its orifice within the canalis uteri. Like the heart, the uterus of mammiferous animals is muscular, and is covered by a reflection of the peritonæum; the doublings of which, on each side, form two sets of ligaments, one pair of which keep the organ suspended in situ. Within the other, called the broad ligaments, and at some distance from the womb, are two egg-shaped little bodies, the *ovaria*, which, by means of two tubes, inclosed in the doublings of the ligaments (*fallopian tubes*), communicate with the cavity of the uterus. These bodies are found in the females of all animals, where the male possesses testes. In the ovaria are found the ova, the rudiments of a future being; and these in coitu are extruded by the grasp of certain fringes (*fimbriæ*), which overhang the ovaria. The separation of an ovum leaves a cicatrix, first observed by Le Graff, which is called a *corpus luteum*. The fallopian tube being muscular, urges the ovum into the uterus, where it daily increases; and the womb enlarges with it, until the full term of pregnancy is expired. Mammiferous animals have a uterus with two cornua; but in birds there is only one ovarium and oviduct. After the period of laying, the ovaries of birds are almost obliterated, and in some the sexual characters are actually changed: thus the hen-peafowl has occasionally assumed the manners and plumage of the cock. Reptiles and fishes have a double uterus, and two ovaries; and in insects there is one oviduct, which communicates with tubes analogous to the ovaria, where the ova are found like strings of beads. Most mollusca are hermaphrodites; and, as might be expected, zoophytes contain no generative organs, nor indeed have any distinction of sex.

The organs in both sexes, in the human subject, are unfit for the generative function until the age of puberty. At this period, in the male, in addition to a more perfect developement of the sexual organs, the larynx is completed, and the voice assumes a graver tone. The beard covers the lower portion of the face, and the whole character is changed. In the other sex, changes no less remarkable appear. The perfection of the sexual system is denoted by a new process, the menstrual. The breasts swell, and, as in the male, a corresponding impress is made upon the female mind. But the desire of love is concealed by modesty, an instinct, which is now for the first time perfectly developed. The union of the sexes in the brute creation is the result of a periodical æstrum, or state of excitement. Nothing similar to this takes place in the human subject. What then is the difference between the *æstrum* of animals, and the *eros* of mankind? The one is a blind instinct, and uncontroulable. The other is a desire, subordinate to the will, which is purified, and exalted by the operations of the mind into the strongest of the passions. It has been remarked, that the mind naturally prefers those qualities in which it is defective, and hence it is, that the dispositions and qualities of the sexes are strongly contrasted. Conscious of superior strength and courage, the male is captivated by the softness, and timidity of the female. Gifted with sensibility and imagination, she, again, is awed by the higher powers of reason and judgment, which are more perfectly developed in the male. The contrast might be carried further, but enough has been said to show that the sexes are framed for each other; and of the passion of love, the inmate of every human bosom, and the theme of every poet, it is surely unnecessary to observe farther than that it is an illusion of the mind, which exaggerates every quality in the beloved object, and excites an intense desire of possession. The strength of this desire may be measured by the effects of disappointment. Shakspeare has done it to the life.

> " She never told her love,
> But let concealment, like a worm i' th' bud,
> Feed on her damask cheek : she pin'd in thought;
> And with a green and yellow melancholy,
> She sat like Patience on a monument
> Smiling at grief."

Jealousy is admirably pourtrayed in Othello; and the despair of Werter has awakened, and will for ever awaken the sympathies of every reader of taste and feeling. Under limitations provided by the Author of nature, for the perpetuation of the species, promiscuous lust being cursed with unfruitfulness; and imposed by all human societies, from the earliest ages of the world, the passion is gratified; and the result is the production of a being of the same kind.

It is unnecessary to drag from the oblivion to which they have been properly consigned, the older theories of generation. They are all equally fanciful and absurd. Nor shall we disturb the repose of the still more fantastic, although modern hypotheses of Buffon, Darwin, and Lamarck, which, in a letter to me, you so finely ridiculed, when you observed, that " besides Dr. Paley's remark, as to the Jews retaining their prepuses, if their theories were true, the caste of blacksmiths in India, which has been hammering for these thousand years or more, should, by this time, have arms as thick as mill-posts, from the propagated muscular increment of as many ages; and so of the other castes. The taylors should have no legs at all by this time." Never, surely, were theories so lamely supported by facts! It has been shewn to you, that the male animal furnishes the semen, and the female the ova or rudiments; but whether or not the contact of these substances is necessary for the production of the fœtus, is a question which is still disputed. On the authority of some fallacious experiments, Dr. Haighton gives a decided negative to the question. He has shewn, that when the ovaria are separated from the vagina in animals, copulation is followed by the exclusion of an ovum, as is proved by the formation of a corpus luteum. The argument, however, is not conclusive. The experiments only prove that there is a sympathy between the two extremities of the uterine system; for although certain changes appeared in the ovaria, no young animals were found in utero. Dr. John Burns also advocates the sympathetic theory of generation, on grounds still less tenable. Impregnation, he has shewn by several examples, takes place in the human subject when the hymen has not been ruptured. But as this membrane is not imperforate, the proof is incomplete. To overcome the difficulty, he has cited a case from Ruysch, where there was impregnation and an imperforate hymen. On referring to Ruysch, however, the reader will find that there was an aperture in the hymen, large enough to admit a probe.* Haller, on the other hand, declares it is certain that the male fluid has filled the tubes themselves, after recent impregnation, both in women and other animals; and it is well known that contact takes place in the frog and toad, and in fishes, where the ova are fecundated as fast as they are extruded from the body. It is worthy of remark, that in ponds, where there are no males, fishes will rather perish than part with their spawn! But this theory has received the strongest confirmation from the experiments of Dr. Blundell. Rabbits were the subjects of

* Ruyschii, Obs. p. 22.

these experiments. Now the rabbit has two tubular uteri, which communicate with the vagina by two distinct orifices, and are completely independent of each other. When the womb, on one side only, was separated from the vagina, young animals were found in the other, to which the semen had access. This occurred constantly. In order to vary the experiments, and obviate every source of fallacy, the uteri, in several instances, were both separated from the vagina; and the effect was invariably barrenness. The tubes indeed were excited, and they really transferred the rudiments to the wombs, but the products were merely watery accumulations; abortive attempts at generation, analogous, perhaps, to the wind-eggs of unimpregnated pullets.*

We see then that both parents are instrumental in the production of their offspring, and the theories of Hervey, Lewenhoek, and others, which pretend that the father is the sole parent of the fœtus, the uterus, according to these authors, being merely a nidus for its reception, must yield to the light of recent experiment.

* Med. Chir. Trans. vol. x. part ii. p. 200.

The only question that remains to be considered is, why the offspring should resemble both parents? The effect of the imagination of the mother upon the features and complexion of the child in utero, is an ancient opinion, which has been abandoned by the moderns, apparently without reason. The opinion, however, still prevails with the vulgar, and the success of Jacob's experiment, as recorded in Genesis *, shews it to have some foundation. It may also be remarked, that many of the facts relating to nævi materni have not been overturned. Whatever share this power may have in the process of generation, the theory that assigns an equal share to both parents in the production of the ovum removes every difficulty, and the very question that we have started affords independent evidence of its truth.

As soon as impregnation has taken place, new actions are excited in the uterus. Its internal surface begins the manufacture of a membrane (*decidua*), a sort of napkin for the reception of the ovum. As it lines the whole interior of the womb, it must block up the

* Genesis, chap. xxx.

uterine aperture of the Fallopian tube. It does so, and very fortunately. Were it otherwise, the ovum, which is no bigger than a pea, would no sooner enter the uterus than it would escape from its cervix. When the ovum has reached the entrance of the womb, the membrane yields before it, and dilates as it enlarges; not indeed by extension, but by the addition of new matter, until it is eventually reflected over the ovum. The uterine portion retains the name of *decidua*, and the other is called the *decidua reflexa.* The ovum consists of the fœtus and its involucra. Of these the outer covering (*chorion*), is at first shaggy, and vascular, but afterwards becomes smooth; except the placental portion, which consists indeed of a congeries of vessels and cells, and attaches the ovum to the surface of the uterus. With the vessels of the womb these vessels inosculate, and this constitutes the medium of communication between the mother and her offspring. Within the ovum, vessels pass from the placenta to the navel of the fœtus, and being covered by a reflection of the inner membrane (*amnion*), to be next described, constitute the umbilical chord, or navel string. The amnion is a smooth delicate membrane lining the chorion, and secretes a quantity of water (*liquor amnii*), for the fœtus to float in; a beautiful and effectual contrivance to secure the embryo from external injury. The connection of the membranes of the ovum with the pregnant uterus, in mammiferous animals, is threefold. In some, as in the sow and the mare, the whole external surface of the ovum adheres to the cavity of the uterus; in others again, the union is effected by means of a simple placenta, as in the digitated animals, and quadrumina. In the *bisulca*, as the cow, the placenta consists of numerous cotyledons, which are produced by the surface of the womb; and inosculate with the vessels of the chorion. Thus the uterine and fœtal portions of the placenta are distinct from each other, and the latter only is expelled in parturition. Between the chorion and amnion, in most pregnant quadrupeds, and in the cetacea, is a membrane (*the allantois*), which does not exist in the human subject. The quadrumina have no allantois, but their embryos contain a part which resembles it, the *tunica erythroides*, the use of which is unknown.

There are certain peculiarities in the fœtus worthy the attention of all who admire the productions of nature. The umbilical vein communicating with the vena portæ, part of the blood derived from the parent is conveyed to the liver of the fœtus, and the remainder flows direct to the vena cava by a channel (*ductus venosus*), which is obliterated in after life. The lungs of the fœtus being collapsed, and not yet called into action, the blood, when it reaches the right side of the heart, does not perform the lesser circulation. A small portion, indeed, passes to the lungs, but the greater part flows direct to the left auricle, through the *foramen ovale*, an aperture between the auricles, which in after life is obliterated; and to the aorta by a canal (*canalis arteriosus*), which is found between this vessel and the right ventricle. Having reached the aorta, the blood performs the greater circulation, and returns to the parent by the umbilical arteries, which communicate with the iliac arteries of the fœtus. These peculiarities, together with the great bulk of the thymus gland, and the disproportionate size of the liver, constitute the difference between the fœtus in utero, and the new-born child.

At the expiration of forty weeks, the growth of the fœtus is completed, and it is ripe for another stage of existence. The uterus contracts upon its contents, and the embryon with its involucra are expelled. As these contractions in the human female are attended with pain, the process is called *labor*. After the expulsion of the fœtus, the uterus still contracting, expels the placenta with the membranes, or *secundines*, as they are called; and at the same time closes the mouths of the bleeding vessels. The contraction of the uterus, which, after delivery, is reduced to the size of a ball, is a merciful contrivance for the safety of the mother. Were it otherwise, and the womb continued as large as it was before the birth of the child, every parturient woman would die of hæmorrhage. A provision is now made for the helpless infant. Conducted by an unerring instinct, it seeks the breast of its mother, from whence it derives its sustenance as from a fountain, until the developement of the teeth leads it forth in quest of more substantial food.

"Egit amor dapis atque pugnæ."

We have now completed the first part of our design, which will serve as a resting-place for many of our readers; and having presented you with the jewels contained in the casket, it now only remains for us to describe the casket itself. To quit metaphor, the mechanical department of anatomy is quite as interesting as the physiological. To you, my dear Sir, who are an admirer of the fine arts, as well as a lover of science, it is unnecessary to say more to induce you to turn over leaf; and we may remind the general reader, that a learned heathen was converted by the inspection of the skeleton.

Farewell.

PART THE SECOND.

ON THE BONES AND MUSCLES.

LETTER V.

ON THE SKELETON.

DEAR SIR,

BEFORE you can obtain a knowledge of the instruments, by which the various movements of the body are effected, you must listen to a description of the *Skeleton*; which not only contains the viscera, but determines the form and proportions of the frame. In the letters on the contents of the several cavities, their bony parietes were described generally. This circumstance will materially shorten the descriptions of the head and trunk, which will be confined to an enumeration of the points therein omitted, and which are necessary to the study of the muscles.

The additional circumstances to be noticed in the cranium, are its division into eight bones. The forehead consists of the frontal bone (*os frontis*); the two *parietal* bones compose the sides of the head, and the hind head is formed of the *os occipitis.* The lower margin of the frontal bone is moulded into arches for the orbits, and there are two elevations above them, which contain the *frontal sinusses.* Immediately above each orbit is a hole (*foramen supra orbitarium*) for the transmission of the first branch of the fifth pair of nerves. In the occipital bone, at the base, is the *foramen magnum*, for the passage of the spinal marrow; and on each side of it two eminences, by which it is articulated to the spine. Birds, without exception, have but one articular eminence in the os occipitis, which enables them to sleep with the head beneath the wing. The upper half of the occiput is separated from the base by a ridge, for the insertion of the muscles of the neck. Underneath the *ossa parietalia*, on each side, are the bones of the temples, which, as you perceive, contain the auditory passages, and by their union with the cheek bones form the handles on each side the head, (*juga*). Below the auditory passage is the *mastoid process*, and underneath it a sharp one called *styloid.* The mastoid process forms a part of the os temporis in man, and the monkey only; in all other mammiferous animals it belongs to the os occipitis. Between the orbitar plates of the os frontis, and at the basis of the skull, is a bone (*os ethmoides*), which composes the roof of the nostrils, and except in fishes and reptiles, is perforated with numerous holes. All these bones, save the temporal, are united by serrated edges or sutures; and are locked together, at the basis of the skull, by a bone in the shape of a bat with expanded wings, *the sphenoid*, which is divided in the mammalia. These sutures are common to most mammiferous animals, but the skulls of birds and fishes appear to consist of a continuous bone.

As there are many holes at the basis of the cranium, for the transmission of the nerves, and as these perforations are, for the most part, in pairs; we shall enumerate them in the order they observe. In a former letter we observed that the basis of the cranium was divided into three hollows, one above another. In the first you perceive the *cribriform lamella* of the æthmoid bone, for the passage of the olfactories, and the two *foramina optica*, through which pass the optic nerves to the eyes. The second hollow gives out all the smaller nerves belonging to the muscles of the eye, and the great nerves of the upper and lower jaws. The auditory nerves, also, here find an exit to the ears. The perforations, which are symmetrical, are named *lacerum*, *rotundum*, *ovale*, and *spinosum*. From the third division escape the par vagum, the lingual nerves, and the spinal marrow; and the perforations are *foramen lacerum* in *basi cranii*, to distinguish it from the other, the *condyloid foramen*, and the *foramen magnum*. The foramina in the cranium of birds differ in many respects from those of the mammalia. There are but two for the transmission of the olfactory nerves; the sphæno orbital fissure does not exist, and the *rotundum* and *ovale* are supplied by a single hole. There is no foramen lacerum arterius; the posterior one is very small, and the meatus auditorius is a mere perforation. The horse has no foramen ovale, and in many animals the anterior and posterior foramen lacerum are united.

The face is composed of several bones, the most considerable of which are the upper and lower jaws. Between the superior maxillæ and the temples are the cheek bones (*ossa malæ*); and in the upper and inner margins of the former, are the bones of the nose, which are appended also to the os frontis. The monkey has only one os nasi. The union of these with the frontal, æthmoid, and sphænoid bones, compose the orbits, in the inner corners of which are the *ossa ungues*, neither of which is bigger than the finger nail, and are wanting in the elephant. In the upper jaw, beneath each orbit, is the *foramen infraorbitarium*, for the passage of the second branch of the fifth pair of nerves. Behind the alveolar processes, the superior maxillæ send out two plates, which uniting with the two *palatine* bones, compose the roof of the mouth, and also the floor of the nostrils. The upper jaw being hollow, the cavity, which communicates with the nostrils is called *antrum maxillare*. The nostrils are separated by a process of the æthmoid bone, and a bone which resembles a ploughshare, (*vomer*). On each side of the septum narium are three *turbinated* bones, obviously designed for the extension of the pituitary membrane, and an increase of the sense of smell. The upper jaw of mammiferous animals is distinguished by the intervention of a bone, called the *os intermaxillare*. With the temporal bone the lower jaw is articulated, and on a level with the articulation is a process (*coronoid*), for the insertion of the temporal muscle. On each side the chin is the *foramen mentale*, from which issues the third branch of the fifth pair of nerves. There are two bones of the face in birds, to which there is nothing analogous in the mammalia; one (*os articulare*) interposes between the temple and the condyle of the lower jaw, with both of which it forms a joint; and the other (*os interarticulare*, is a slender bone attached to it. The effect of this mechanism is to open the upper as well as the lower jaw; and a similar structure obtains in fishes and reptiles. In the crocodile, however, the lower jaw is articulated to the occiput; and hence has arisen the idea that the upper jaw of this animal is moveable.

The column of the *spine* supports the head, and rests upon the pelvis, and in man is composed of twenty four *vertebræ*; seven of which belong to the neck, twelve to the back, and five to the loins. The first of the cervical vertebræ is called *atlas*, and is articulated by a hinge-joint to the occiput; the second, *dentata*, from a tooth-like process, by which it is mortised to the first. It is this peculiar mechanism which enables the head to move from side to side. All the vertebræ have bodies, by which they are attached to each other; and as the intervening cement is an elastic matter, the spine is perfectly flexible. Each vertebra has four articulating processes; two transverse processes to which, in the back the ribs are lashed; and between them a spinous projection, from which is derived the name of the spinal column.

The manner in which the vertebræ are connected is worthy of attention. While the bodies of the vertebræ are united in continuous planes, the articular processes of one vertebra overlap those below; so that, of any three, the middle one is locked in, in such a manner, as to render its luxation impossible. "It will give way, neither backward nor forward, nor on either side."* In the back, the spine is still farther secured by the articulation of the ribs, each rib resting upon two vertebræ. Lest the superior pliancy of the neck should endanger it, its spines are fortified by a strong ligament, the *ligamentum nuchæ;* which in man is so weak, that its existence has been denied. It is the largest of all in the elephant, and is converted into bone in the mole. We have, in a former

* Paley's Nat. Theology, p. 104.

letter, noticed the perforations of the spine, for the transmission of the nerves. They are formed by notches, of which there are four in each vertebra. When the vertebræ are in contact, these notches coming in apposition form holes. But the most important perforation is the ring for the passage of the spinal marrow. A remarkable deviation from the form of the spine occurs in serpents. The anterior part of the vertebra is rounded into a tubercle, and the posterior part into a corresponding cavity; so that each vertebra is connected to those next it by a sort of knee-joint. This mode of articulation explains the motion of reptiles, which is from side to side; and not up and down, as is represented by painters. The dorsal spine in birds is inflexible.

You will remember the general description of the thorax, in the letter on the circulation of the blood. The sternum is not unlike a poniard, and is pointed by a cartilage called *ensiform*. The seven superior ribs are attached to it, by the intervention of as many cartilages. To the top of the sternum the collar bones are articulated; the bones which sustain the shoulder-blades in situ. The circumstances worthy of attention in the ribs, are their semicircular form, their angular processes, and the oblique manner in which they are articulated to the spine. It is obvious, that the cartilages of the ribs increase their flexibility. The crocodile has an abdominal sternum for the support of the viscera; frogs have a sternum, but no ribs; while serpents have ribs, but no sternum; and fishes have no thorax.

Of the *Pelvis* we must give you a description more in detail. The haunch bone (*os innominatum*) for the convenience of the memory may be divided into three portions; the *ilium* above, the *ischium* below, and in front the *pubis*. This division may be considered a natural one, as in the fœtus these bones are separate, and are held together by cartilage. The *ilium* sustains the bowels, and is hollowed out for the purpose. It is bounded by a crest which terminates before, in a slight projection, called the *anterior spine*, to distinguish it from a similar eminence behind. Underneath it is the *ischium*, to which the thigh bone is articulated. The bottom of the ischium (*tuber ischii*) is the bone on which we sit. Above, it is hollowed out into a cup (*acetabulum*) for the head of the former, and in front it terminates in the pubis, by two processes, which meeting the corresponding rami of the pubis, leave a large round hole, (*foramen obturatorium*). Of the *ossa pubis* it is sufficient to remark, that they constitute the front of the pelvis, and their union is called the *symphysis*, underneath which is the pubic arch. It is remarkable that these bones are not united in birds, except in the ostrich, which is incapable of flight. The sacrum resembles, and is in fact a wedge, which sustains the spine, and holds the bones of the pelvis together. It looks like a continuation of the spine, and is in the same line in the mammalia. It is remarkable for two rows of holes, for the passage of the nerves, and a little appendage called *os coccygis*, which in many animals is lengthened into a tail. The union of the sacrum with the ilia, leaves two immense notches behind (*ischiatic*), which are converted into *foramina* by the sacro-sciatic ligaments. In baboons the sacrum consists of three bones; it is evident, therefore, that Galen's description of it was not derived from human anatomy.

We now come to the limbs, which are literally the handmaids of the body, and shall commence with the description of the *pectoral* member; which consists of the *shoulder*, *arm*, *fore-arm*, and *hand*. "These four component parts of the upper extremity can be shown to exist in all mammalia, however dissimilar they may appear. The wings of the bat, osteologically considered, are hands, and in the fins of the dolphin, porpoise, and whale, which are placed behind the head, we find all the bones of the anterior extremity. The same may be said of the fore-feet of the sea-otter, seal, walrus, and manati, which are intermediate between the two; and what is still more surprizing, the bones of the wings of birds resemble those of the fore-feet of the mammalia." * As might be expected, the organs of motion in the invertebral animals are altogether dissimilar.

The arm-bone (*humerus*) is appended to the chest, in such a manner as not to interfere with its important functions. This is effected by the location of two bones, the blade-bone (*scapula*) behind, and the collar-bone (*clavicle*) before. The *scapula* is concave within, and accommodated to the convexity of the ribs. From its upper corner arises a process (*acromion*), for the protection of the head of the humerus.

* Laurence's Natural History of Man, p 48.

Underneath it the scapula is moulded into a slight hollow (the *glenoid* cavity), and within, the joint is protected by another process of the scapula, called *coracoid*, from its fancied resemblance to the beak of a crow; between this last and the acromion is a strong ligament (triangulare); so that the head of the humerus is lodged in a deep socket, and its motions are unshackled. A small bone, like an Italian *S* (the clavicle), being secured to the acromion and the sternum by four strong ligaments, the shoulder cannot fall forward. This bone exists in all animals which use the pectoral members, whether for the purposes of climbing, digging, swimming, or flying; and is wanting in those which employ the fore-feet merely for the purpose of progression.* The shoulder of birds is composed of three bones, the clavicle, scapula, and forkbone, of which last a rudiment only is found in the cassowary and the ostrich; and there are two clavicles in the frog and toad.

To obviate the inconvenience of a long inflexible limb, the pectoral member is divided by the elbow into two divisions; the arm, and fore-

* Laurence on Blumenbach, p. 89.

arm. The arm consists of a single bone (*humerus*), the head of which is spherical, as we have seen; below it are two *tuberosities*, separated by a groove; the outer one the *greater*, the inner one the *less*. The articulation of the arm with the forearm being a hinge, the structure of the lower end of the humerus is peculiar. The bone towards the end is expanded, and somewhat flattened, and is accommodated for the reception of two bones; for the forearm consists of two. Just above the elbow, before and behind, are excavations, to render the flexion and extension of the forearm as perfect as possible. In quadrupeds, in which the metacarpus is extremely long, the humerus is proportionably short; and it is articulated both to the scapula and clavicle, in the mole; and also in birds, and the turtle.

The forearm is not only capable of flexion and extension, but it has the power of turning the hand prone and supine; except in ruminant animals and birds, where the radius and ulna are in a state of permanent pronation. As far as the articulation of the elbow is concerned, the ulna is the principal bone of the forearm. Accordingly its articular surface is expanded, and engrosses two-thirds of the end of the humerus, to which it is secured by the capsular and lateral ligaments. It is also hollowed out in front, in such a manner as to leave a protuberance (*olecranon*) behind, which checks into the posterior excavation of the humerus; and thus prevents the backward flexion of the forearm. A similar mechanism in front renders the flexion of the forearm complete. Below the head of the ulna is a small process (*coronoid*), for the insertion of a muscle. The ulna tapers off at the opposite extremity almost to a point (*styloid process*), and is but slightly articulated to the wrist.

In the radius this is all reversed. It is broadly joined to the wrist, and but slightly articulated to the humerus; and hence the upper end is narrow, the lower broad. Rising all round like the discs of a wheel at each end, it moves in corresponding grooves in the ulna, in the acts of pronation and supination. A little below the upper end of the radius is a tubercle, and here you may observe the *coronary* ligament and its two accessories, which attach it to the humerus. The joint of the wrist being a free kind of hinge, the extremities of the radius and ulna, are hollowed for its reception, and secured to it by two *lateral* ligaments besides the capsular.

The hand consists of the wrist (*carpus*), the *metacarpus*, and the fingers. It is not very obvious why the carpus is composed of eight little bones — but so it is. These are placed in two rows. The first, forming the wrist, are the *scaphoides*, *lunare*, *cuneiforme*, *pisiforme*. The second, consisting of those which receive the metacarpal bones, are the *trapezium*, the *trapezoides*, *magnum*, *unciforme*. These bones are united by cartilages, and the arch they compose is secured by a tendinous expansion (*fascia palmaris*), which covers the hollow of the hand. Under this arch play the nutrient arteries of the fingers, and the *palmar fascia* secures them effectually from pressure. The monkey has one metacarpal bone more than man, and the *os pisiforme* is so large as to serve the purpose of a heel. For the articulation of the thumb and fingers, and to lengthen the hand, the five metacarpal bones are fastened to the wrist; but in ruminant animals, and the horse, the metacarpus is united into one bone (the *cannon*). Of the fingers much need not be said. There are never fewer than three, nor more than five in mammiferous animals. The structure of the last phalanges, in cats, enables them to raise their claws, and keep them from the ground. It is worthy of remark, that the union of the metacarpal bone of the thumb with the wrist is moveable, which enables the hand to grasp a sphere as well as a cylinder. Man is distinguished from the monkey tribe by the length of the thumb, which is justly described by Albinus as a second hand, "Manus parva majori adjutrix." * In carnivorous animals the thumb is parallel to the other toes.

Like the pectoral, the pelvic member is the same in all mammiferous animals, and is divided by an articulation (the *knee*), into two parts. The thigh, like the arm, also consists of one bone; and as its articulation with the pelvis is a ball and socket joint, it revolves on its own axis. The rotation of the thigh being effected by muscles, which are placed between its upper extremity and the pelvis, the end of the shaft is roughened into a process (the *trochanter major*), from which arises the round

* De Sceleto, p. 465.

head of the bone at an obtuse angle with the shaft. The intervening space constitutes the neck of the femur, just below which is another process, less than the other (the *trochanter minor*). The hip joint is held *in situ* by a cord-like ligament, the *orbicular*, and the strong purse which surrounds the neck of the bone, and encircles the socket; a piece of anatomy not unknown to Homer. In describing the wound of Æneas, he says,

> "On the hip
> He smote him, where the thigh-bone's slippery knob
> Rolls in its cavity, the socket named:
> It crush'd the socket with its rugged points,
> Tore the tough tendons wide, and stripp'd the skin." *

The cylindrical shaft of the femur is roughened behind into *lineæ asperæ*, and as it approaches the knee it becomes flatter, and is excavated in front for the play of the *patella*. The lower end of the femur is worked off into two condyles, the ends of which are rounded for its articulation with the *tibia*. The femur is so short in ruminant animals, and in the horse,

* Homeri Ilias, lib. v. l. 305

that the part which corresponds to the leg of the human subject, is vulgarly called the thigh.

The knee-joint is merely a hinge, which admits of extension, and of flexion backward; and the joint is formed of the femur and the broad end of the tibia. The outer bone, or fibula, which is wanting in ruminant animals, and the horse, is merely a splint for the strengthening of the leg and ankle; the latter of which it affects by reaching lower than the surface of the tibia, to which it is attached. The union of these bones, at the bottom, forms a deep hollow for the reception of the *tarsus*, to which they are secured by three strong ligaments besides the capsular. So strong, indeed, is the ankle-joint, that it cannot be luxated outward without a fracture of the fibula. The front of the knee-joint is protected by a roundish bone (*patella*), which is fastened to the end of the tibia by a ligament; and is attached to the thigh by muscles. The joint of the knee is very strong. In addition to the capsular ligament, which is common to all the joints, internally it is held by two cord-like ligaments (*crucial*), laterly by two strong flat ones, and behind by cross bands. The *ligamentum mucosum* forms a soft cushion for the end of the femur, and the *semilunar* cartilages deepen the head of the tibia. In front, the patella and its ligament afford it ample security.

The tarsus is an arch, which, in the human subject, sustains the weight of the body, and is consequently very strong. The key-stone of the arch is the *astragalus*, which rests upon the heel (*os calcis*), as a pediment in one direction, and the rest of the tarsal bones in the other. The monkey has not the prominence of the os calcis, which forms the heel; and hence these animals walk on the sides of the feet. We shall enumerate the tarsal bones in the order they observe in their natural situation. Before the *astragalus* is a considerable bone (*os naviculare*), to which, and to the fore-end of the os calcis, four small bones are attached; the *os cuboides* from without, and the three *cuneiform* bones. This row of little bones, like the carpus, compose a lesser arch across the instep, and for a similar purpose. Like the palm of the hand, the sole of the foot is protected by a strong tendinous expansion, which forms a natural sandal. The five toes are articulated to five metatarsal bones, which, lengthening the foot, strengthen the gait; and their junction with the tarsus, being slightly flexible, enables the foot as it were to grasp the ground on which it treads.

Farewell.

LETTER VI.

ON THE MUSCLES OF THE HEAD, NECK, AND TRUNK.

DEAR SIR,

WE shall commence our account of the muscular system, with a description of the powers, by which are expressed the *passions* of the mind; and those by which the business of *mastication*, *deglutition*, and *respiration*, are effected. These important purposes give a superior attraction to the present letter, the subjects of which are equally interesting to the artist and the physiologist. The lover of nature too, will have reason to admire the wise œconomy of the Creator, in observing the paucity and flexibility of the means, by which so many great ends are obtained.

1. The emotions of the mind are legible in the features of the face. Now there are two operations of the mind, *attention* and *reflection*;

and these conditions of the sentient principle are denoted by the muscular apparatus of the forehead and eyes, which are in a state of activity, while the rest of the facial muscles are quiescent. The muscles of the forehead are the *frontales*, and the *corrugatores supercilii*. The first pair originating in the lower margin of the frontal bone, cover the forehead, and are lost in the scalp. They obviously wrinkle the brows.* The second are small slips of fibres, peculiar to man, which arise from the middle of the orbitar margins of the same bone; and crossing the root of the nose, are inserted into the skin above it. When in action, they produce the peculiar expression of the countenance called frowning; and their habitual use occasions the overhanging of the eyebrows so striking in studious men.

In a former letter the eyelids were compared to the shutters of a window. The muscle which closes them is a circular one (*orbicularis palpebrarum*). It encircles the lids, and is inserted

* The occipital portion of this muscle is crossed by the two *occipital arteries*, after they have emerged from behind the mastoid processes, and is therefore interesting to the surgeon.

by a small tendon into the inner corner of the orbit. This little tendon is interesting to the surgeon, because it covers the *lacrymal sac;* the bag which collects the tears, and pours them into the nostril. The upper lid is opened by a lever muscle (*levator palpebræ*), which originating in the bottom of the orbit, is inserted into the inside of the cartilage (*tarsus*), the material of the lid. Six muscles execute the various motions of the eyeball; *four recti,* and *two obliqui.* One of the latter is also called *trochlearis.* The four straight muscles take their rise, not from the bottom of the orbit, but from the side near the inner corner; so that the two outer ones are considerably larger than their antagonists within. These muscles embrace the eyeball; fix it in the act of attention, or move it from side to side. The reason why the *superior oblique* is called *trochlearis* is, because it crosses a sort of pulley, formed in a groove at the upper margin of the orbit. It arises from the bottom of the socket, and is inserted into the back part of the eyeball. In reflection, and devotional meditation, the action of the trochlearis is very conspicuous. The eye appears to look inward upon the soul, and the white of it alone is visible. Its antagonist, the *inferior oblique*, is a short muscle, which also originates in the bottom of the orbit, and is fixed to the under surface of the eyeball. All other mammiferous animals, except monkies, have an additional muscle (*choanoid*); and in birds and fishes the superior oblique does not pass through a pulley, as in man. "In animals, where the motions of the neck are wanting, or imperfect, "we oberve," says Dr. Barclay, "the eyes on moveable pedicles, projecting from the surface; as in crabs and lobsters. In some, again, where the eyes are destitute of motion, their number is increased, as in the *libellulæ*, and many winged insects." *

These operations of the mind, being succeeded by *desire* or *aversion*, may be regarded as the parents of the passions; which may be said to play around the lips. All the pleasurable feelings, as love, joy, exultation, and transport, are expressed by the muscles, which elevate the corners of the mouth, and expand the countenance. They are inserted into a circular muscle (*orbicularis oris*), which closes the mouth,

* Barclay on Muscular Motion, p. 475.

and serves as a *point d'avpui* for the muscles, which unceasingly move around it. It is unnecessary to describe them individually, as they all originate from the upper jaw and cheek; in the order in which we shall enumerate them, beginning from within. Their names are,

Levator labii superioris et alæ nasi,
——— *labii superioris,*
——— *anguli oris,*
zygomaticus major and minor

The two last cling to the cheek-bone, and by elevating the cheeks close the eyes somewhat.* In laughter, the orbicular muscles of the eyes appear to be thrown into sympathetic action, and hence the eyes flash fire, and sometimes a tear escapes. The antagonists of these muscles, viz. those which depress the corners of the mouth, are significant of the painful emotions, as fear and despair, hatred, rage, and revenge; the effects of which are to concentrate the fea-

* The zygomaticus is important in a surgical point of view, denoting the course of the *facial artery* and vein, which, after they have emerged from beneath the *submaxillary* gland, became superficial near the angle of the lower jaw.

tures of the face, and lengthen the visage. They are called, from their office, *depressor anguli oris*, and *depressor labii inferioris*. Both arise from the inferior margin of the lower jaw; and the former is inserted into the corner of the mouth, the latter into the under lip. Birds have none of these muscles, and they are altogether different in other animals.

As the nostrils may be considered instruments subservient to the process of respiration, the muscles which move their *alæ*, do not come within the classification we have made of the muscles expressive of the emotions of the mind. In the stronger passions, however, they are sometimes thrown into sympathetic action. We see this in the expression of contempt, which, in addition to the marks of hatred, is denoted by a rising of the upper lip and nostril on one side. The muscles of the nose consist of a single pair, which cover the alæ of the nostril. The cheek is composed of a thin muscle (*buccinator*), capable of great expansion. It is unnecessary to describe the muscles of the ears, which in man are but the semblances of muscles; and, except in a state of nature, are incapable of motion. In quadrupeds, however, they are very numerous, and move the ear in every direction.

2. Before we enter into the subject of *mastication* and *deglutition*, a general description of the throat must be premised. The most prominent part consists of the *larynx* and *trachea*, an account of which was given in a former letter. Above the larynx, to which it is united by intervening cartilage, and hidden by the double chin, is the thought-bone (*os hyoides*), which is attached to the styloid processes, and resembles a horse-shoe with the cawkins downward.* To this bone the tongue is rooted, and from it arises the valve (*epiglottis*), by which the glottis, or mouth of the larynx, is protected during deglutition. Some small muscles (*arytænoidæi*), have the power of expanding and diminishing the glottis, and by this means the voice is modulated. Behind the larynx and trachea is the gullet (*œsophagus*), and its funnel-shaped entrance, the *pharynx*, which also were described in a former letter. The skin of the throat is strengthened internally by a layer of

* The angle of the *os hyoides* is crossed by the *lingual* artery and *nerve*, and a little below it is the origin of the upper *thyroidæal*.

muscular fibres, (the *platysma myoides,*) extending from the jaw to the breast. In animals it lines the skin universally, and is called the fleshy pannicle. In the hedgehog it is highly curious and complicated, and enables the animal to roll itself up like a ball. The ruffling of the feathers in the neck of the dove, and other birds, is effected by this muscle. *

Mastication consists of the elevation and depression of the lower jaw, and its lateral and circular motions, around one condyle as a fixed point. These movements are effected by the *masseters, pterygoid*, and *temporal muscles*, and their antagonists, the muscles beneath the chin. Of the *temporal* muscle much need not be said. It covers the temple and side of the head, and passing beneath the *jugum*, is inserted tendinous, into the coronoid process of the lower jaw. The *massetur* is placed between the jugum and the angle of the jaw; and the *pterygoid* are deep-seated muscles, attached to the sphænoid bone, and the jaw internally. † The muscles beneath

* It is worthy the attention of the surgeon, as without a knowledge of the direction of its fibres, he cannot even open the *external jugular vein* with effect.

† The *temporal* artery mounting before the ear, on the temporal muscle, divides into two branches; and the *trans-*

the chin are three-deep on each side, and are found in the order we shall enumerate them. Their names are,

Digastricus,
Geniohyoidœus,
Mylohyoidœus.

The first of them is a double muscle, with a tendon in the middle. One portion arises from the mastoid process of the temporal bone, and the other from the chin. The tendon is attached to the os hyoides. The names of the other two denote their situation; one arising from the chin, the other from the inside of the basis of the lower jaw; and both are inserted into the thought-bone.

The temporal muscles close the mouth, but unless the larynx were rendered a fixed point, the muscles last described would be unable to depress the jaw. This leads us to the description of a set of muscles, the office of which has

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versalis faciei, another branch of the external carotid, crosses the masseter. Below it is the *parotid* duct, in a line with the tip of the ear, and a branch of the *portio dura*, the respiratory nerve of Mr. Charles Bell. The termination of the duct in the mouth, is opposite the space between the second and third *molares* of the upper jaw.

been overlooked by anatomists, but which is obviously that of rendering the larynx and thought-bone immoveable. From each corner of the os hyoides, a slender cord-like muscle, having, like the *digastricus*, a tendon in the middle, goes off at an obtuse angle with the trachea, and is fastened to the coracoid process of the shoulder-blade. This pair of muscles are called *omohyoidœi*, which are hidden by the large superficial muscles of the neck. Within this angle are certain auxiliary muscles, which being secured to the chest, materially contribute to the fixation of the larynx. They are named from their situation,

Sterno-hyoidœi,
Sterno-thyroidœi.

When in action these six muscles as effectually fix the larynx, and os hyoides, as the strings of a tent ensure the steadiness of its pole. Between the thyroid and cricoid cartilages, on each side the larynx, and the os hyoides, are two additional short muscles, named from their situation. These co-operate with the muscles last described, and are also used in the various motions of the larynx.

In mastication, as we have shewn, the lower jaw is moveable, while the larynx is a fixed point; the reverse obtains in deglutition. During this process, a provision was to be made for the closing of the glottis, which is thus effected. The jaw being fixed by the temporals, the contraction of their antagonists, the muscles beneath the chin, and the stylo hyoidœi elevates the os hyoides and larynx; and in this manner the glottis is brought in close contact with the epiglottis. But for this provision, every morsel might pass into the trachea, and produce suffocation. The tongue, which is the instrument by which the food is cast beyond the fauces, is composed of the *lingualis* muscle; and is moved by certain deep-seated muscles — *styloglossi*, *hyoglossi*, and *geniohyoglossus*, which take their rise from the styloid processes of the temporal bones, the os hyoides and chin, and are attached to the roots and sides of the tongue. The mode in which the pharynx and æsophagus complete the process of deglutition, was mentioned in the letter on nutrition. The pair of muscles which dilate and raise the pharynx, are the stylo-pharyngæi. They arise, each from the styloid process, and are inserted into the sides of the pharynx. The constrictors of this organ are three pairs of muscles which are situated between the os hyoides and pharynx, and between the latter organ and the base of the cranium.

The posterior boundary of the mouth is formed by a fleshy and moveable curtain, the soft palate, which terminates in the middle, in a conical-shaped body (the *uvula*); a piece of anatomy peculiar to man, and the monkey tribe. On each side of the uvula, the palate descends in two folds, which contain two glands (the *tonsils*), one on each side the throat.* In the act of swallowing, certain muscles *circumflexus palati*, *tensor palati*, *azygos uvulæ*, and others, close the fauces, and draw up the soft palate, by which means the posterior entrance of the nostrils is closed; and in this manner the regurgitation of fluids from the pharynx into the nostrils and mouth, in the act of deglutition, is prevented.

3. The process of respiration comprehends the principal movements of the trunk. When the body is at rest, these motions are scarcely visible; but after running or wrestling, the heaving of the chest and flanks is very conspicuous. Respir-

* The surgeon should bear in mind, that the *internal carotid* is on the inside of the tonsil.

ation consists of two actions; *inspiration*, or the act of drawing in the air, and *expiration*, or its expulsion from the chest. In the former, the ribs are elevated, and the diaphragm depressed; in the latter, the ribs are restored to their natural situation, and the midriff encroaches upon the thoracic cavity. Respiration in ordinary circumstances is an involuntary action; but whenever the air is impure, or the rapidity of the circulation renders frequent inspiration necessary, the muscles of the neck and shoulders are thrown into sympathetic action, and respiration is then obedient to the will. The concurrence of these muscles is strikingly apparent in a paroxysm of asthma.

The muscles employed in *inspiration* may be divided into those which elevate the ribs, and those which depress the belly. To the former belong the *intercostales*, which are assisted occasionally by the

Levatores costarum and
Serratus superior.

The latter effect is produced solely by the diaphragm. The *intercostals* consist of two rows of small muscles, which fill up the spaces between the ribs; and the *levatores costarum* arise from the transverse spines of the dorsal vertebræ, and are inserted into the angles of the ribs. These are deep-seated, and are concealed by the superficial muscles. The *superior serratus* originates partly from the spines of the neck, and partly from those of the upper dorsal vertebræ. It descends in an oblique direction, and is attached to the upper ribs behind. The *diaphragm* constitutes the muscular septum, which separates the chest and belly in mammiferous animals, and is concave downward and convex upward. Anatomists divide it into the greater and lesser muscle. The former arising from the ensiform cartilage, and the cartilages of all the ribs; and the latter from several of the lumbar vertebræ. There are perforations in the diaphragm, for the passage of the æsophagus, thoracic duct, and the nerves and great vessels of the body. The centre of the diaphragm being tendinous, the contraction of its muscular fibres necessarily enlarges the cavity of the chest.

Expiration is produced principally by the repose of the muscles just described, the ribs descending, and the midriff resuming its natural situation; and, according to Dr .Carson, by the elasticity of the lungs. There is also a muscle intended to depress the ribs, *serratus inferior*, which may be considered the antagonist of the superior serratus. This muscle ascends from the spines of the lower dorsal and the upper lumbar vertebræ, and is inserted by digitations, which give it a serrated appearance, into four of the inferior ribs. When, however, respiration is quickened, the *abdominal muscles* are thrown into action. Their rapid motions are very perceptible in the heaving flanks of the wearied coarser. To the painter, the superficial muscles of the belly are highly interesting. The first of them is the *obliquus descendens*, which arises by eight fleshy digitations from the inferior ribs, intermixing with those of the serratus, and from the fascia, of the loins, and descending obliquely, is inserted into the crest of the ilium; it then becomes tendinous, and is farther attached to a ligament (*Poupart's*) which runs from the spine of the ilium to the symphisis pubis *, and to the whole length of the

* At the pubic end, Poupart's ligament splits into two distinct portions. The upper column is inserted into the symphysis, and the lower into the spine and crest of the pubis; and this constitutes the *abdominal ring*, from whence issues the spermatic chord in the male, and the ligamentum teres of the female. For an exact account of the abdominal sheath, consult Lawrence on Hernia, p. 155.

linea alba, a tendinous line between the pubis and ensiform cartilage. A line almost parallel with the linea alba, which marks the tendinous origin of the external oblique, is called *linea semilunaris*. Directly under the tendon of the external oblique, is a straight muscle (*rectus abdominis*,) divided by three tendons into four portions. It is attached to the ensiform cartilage and the symphisis pubis. This pair of muscles does not exist in birds. Their removal exposes two deep-seated, the *obliquus ascendens* and the *transversalis*. The former ascends from the ilium and loins, and part of Poupart's ligament, and crossing the belly, is inserted into the ribs and linea alba. The latter arising from the cartilages of the seven lower ribs, the spine of the ilium, and internally the transverse processes of the lumbar vertebræ also reaches the linea alba. It is obvious that the joint action of these muscles must diminish the cavity of the belly, and encroach upon the chest. Besides being subservient to respiration, they are the principal agents by which the contents of the uterus, bladder, and intestines are expelled. *

* The *external iliac artery* and vein are situated under Poupart's ligament, and are covered by the posterior

4. With a concise account of the muscles, which produce the movements of the head, neck, and trunk, we shall close the present letter. In the description of the skeleton, we mentioned the articulation of the head with the atlas, and the *tenon* and *mortice*-like union of the first and second vertebræ. This peculiar mechanism affords a key to the several motions of the head, which is capable of nodding; and moving from side to side, a large segment of a circle.

In nodding and bowing, a pair of large muscles is principally concerned. Their names, *sterno-cleido-mastoidæi*, declare their situation. These two beautiful muscles, on the sides of the neck, the muscles of the double chin, which assist, and the larynx between them, constitute its prominent features, and are a study for the artist; and are still more interesting to the surgeon, as the *carotid* artery lies on each side the trachea. * Some deep-seated muscles, in

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surface of the peritoneum, and the other investments of the abdomen. It gives off the *epigastric artery*, and the *circumflexa* ilii. For the exact course of the former, see Lawrence on Hernia, p. 166.

* On the outside of the artery is the internal *jugular vein*, between which is the *nervus vagus*. These parts are inclosed in a sheath of condensed cellular substance;

front of the cervical vertebræ (*recti*), co-operate with the sterno-cleido-mastoidæi. Their insertions into the base of the os occipitis readily explains their action. Two pairs of muscles, the *splenii* and *complexi*, elevate the head, and realize the description of the poet —

> " Os homini sublime dedit, cælumque tueri jussit
> Et erectos ad sidera tollere vultus."

The *splenii* are placed between the dorsal vertebræ and the occipital ridge, and adhere to the neck like splints. In quadrupeds they are inserted into the ligamentum nuchæ, but birds have no splenii. Between the splenii are the *complexi*, partly concealed by the former. Co-operating with these also, are some small deep-seated muscles, which seem to form a part of them; and not being very distinguishable, it is unnecessary to describe them in detail.

The muscles just enumerated are in pairs; their joint actions produce the motions already mentioned, and when they act separately, the head is enabled to rotate from side to side.

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underneath which, and close upon the spine, is the great *sympathetic* nerve. Upon the surface of the sheath play the twigs of the *nervus descendens noni.*

Thus when one *sterno-cleido-mastoidæus* acts, the head is moved laterally, and the concurrence of the *splenii* extends its rotatory motion, which, when they act alternately, is from side to side. It is said of Moses, when he had slain the Egyptian, " and he looked this way and that way, and saw no man : a lively picture of fear and suspicion; and a forcible example of the advantage of anatomy to the painter. When the neck is bent laterally, the sterno-cleido mastoidæus is assisted by some deep-seated muscles, on the sides of the neck; the *scaleni*, which arise from the transverse processes of the vertebræ of the neck, and are inserted into the first and second ribs. *

The pelvis being a fixed point, the trunk is bent forward by the contraction of the recti abdominis, assisted probably by the psoas muscles, which will be described hereafter; and the back is restored to a perpendicular, partly by

* As the *subclavian* artery emerges between the scaleni, the situation of these muscles should be studied by the surgeon. On the acromial edge] of the sterno-cleido-mastoidæus, indeed, the artery lies upon the first rib, and admits of being secured by ligature. The great vein is seen before the artery; behind which are the cervical nerves.

its elasticity, and partly by the operation of two masses of muscle, on each side its spinous processes. Each mass consists of the *longissimus dorsi*, *sacro-lumbalis*, and *cervicalis descendens*. These muscles are wanting in birds, whose necks alone are movable. The motion of the tail in animals and birds is effected by peculiar muscles; and the spinal muscles of fishes are totally different from those of the other classes. The lateral movements of the trunk are effected chiefly by the oblique muscles of the belly, and the *quadratus lumborum*, which are not found in birds and bats. Each *quadratus* occupies the space between the last rib, and posterior part of the crest of the ilium, and are conspicuously exerted in the see-saw gait of a sailor.

Farewell.

LETTER VII.

ON THE MUSCLES OF THE PECTORAL MEMBER.

DEAR SIR,

FOR the convenience of the memory, we shall divide this letter into four sections; the first comprehending the motions of the *scapula* upon the trunk, the second those of the *humerus* upon the shoulder-blade. The movements of the fore-arm upon the humerus, and of the *radius* upon the *ulna*, will constitute the third; and the last will consist of the muscles of the *hand* and *fingers*.

1. The motions of the scapula upon the trunk are two-fold: it is capable of being elevated, as in the act of shrugging up the shoulders, and of forward progression, as in rowing, and playing at quoits. In the act of shrugging, the shoulder is elevated by the *levator scapulæ*, a muscle which arises from the upper vertebræ of the neck, and is inserted into the superior corner of the scapula; and by the *cucullaris*, a

lozenge-like muscle, which, with its fellow, covers the shoulders like a shawl. This muscle derives its origin from the whole of the transverse ridge of the occiput, from the spines of the cervical vertebræ, along with the ligamentum nuchæ, and from all the vertebræ of the back; its fibres converge, and adhere to the spinous and acromion processes of the scapula. It is the upper portion of the muscle which co-operates with the levator scapulæ. The descent of the scapula is effected by the lower portion of the *cucullaris*, and by the *rhomboideus major* and *minor*. These muscles originate on the dorsal spine, opposite the base of the scapula, into which they are inserted.

When the discator throws his shoulder forward, the scapula is impelled by the great *serratus*, and by the lesser *pectoral;* muscles which belong to the fore part of the chest. The *pectoralis minor* takes its rise from the third, fourth, and fifth ribs; its fibres converge, and reach the *coracoid* process of the scapula. The nine upper ribs are the origins of the *serratus major*. The inferior digitations are therefore concealed by the lesser pectoral. It is a flat and fleshy muscle, and is inserted into the whole basis of the scapula from within. The shoulder recoils by the joint actions of the *rhomboidei*, and the middle portion of the *cucullaris*. In quadrupeds without a clavicle, the two serrati are of great magnitude, and support the trunk; and as they are equally extensive in the monkey, it is plain that nature intended this animal to walk on all fours! Carnivorous animals and the horse have no pectoralis minor.

2. Enough has been said already on the necessity of a fixed point, for the effective action of a muscle; but the scapula and humerus are both movable. We have described the *serratus* and lesser *pectoral*, on the one hand; and the *rhomboidei* and *cucullaris*, on the other. These muscles antagonize, and by their joint action fix the shoulder-blade to the thorax; which, being effected, nothing disturbs the free play of the muscles, that extend from the scapula to the humerus. The arm is capable of moving in all directions: —

1. Upward, and from side to side.
2. Downward, backward, and forward.

The artist must be struck with the fine swell of the *deltoid*, the mass of flesh commonly called the cap of the shoulder. This muscle is attached to the whole edge of the *acromion process*, to a considerable portion of the *scapular spine* behind, and to the *collar*-bone before. Its fibres converge, and becoming tendinous, end in the outside of the humerus, near its middle. When the scapula is fixed, the action of the deltoid elevates the humerus, while the clavicular fibres move it forward, and the scapular behind. The clavicular portion is aided by the *pectoralis major*, which arises from the whole length of the sternum, and from the cartilages of the fifth and sixth ribs. Its fibres converging, it is inserted into the humerus, under the insertion of the deltoid. The deltoid has another auxiliary in the *supra-spinatus*, a small muscle which occupies the hollow above the scapular spine; and, being inserted into the greater tuberosity of the os humeri, is hidden by the cucullaris. Birds have three large pectorals, which enable them to flap their wings with astonishing force.

Two masses of muscle favour the descent of the humerus, and its backward and forward motion. In front the *pectoralis major*; and the *teres major* and *minor*, together with the *latissimus dorsi* behind. The *greater pectoral* has been described already. The *teres major* and *minor* originate in the lower angle of the scapula. The *lesser* is inserted into the outer tuberosity near the head of the humerus; the *greater* into the inside of the bone a little below. The contraction of these muscles necessarily depresses the humerus; but they are aided by an immense muscle of the back and loins, — the *latissimus dorsi*. This muscle arises tendinous from the lower dorsal vertebræ, below the insertion of the cucullaris; from all the lumbar vertebræ; from the posterior spine of the ilium, and from a short rib or two; its fibres ascend, converge, and having reached the arm, its tendon is inserted by the side of the teres major. It is proper to observe, that this is not the only function of this muscle. When the humeri are fixed, as in climbing, the *latissimi* elevate the trunk.*

The arm is rotated inward by the *subscapularis*, a muscle which occupies the under and concave surface of the scapula, and is inserted into the lesser tuberosity of the humerus, and

* The tendons of the pectoralis major and latissimus dorsi mark the origin of the *subscapular*, the principal branch of the axillary artery. The *external thoracics*, &c. observe no regular distribution.

the teres major. Its outward rotation is effected by the *teres minor*, aided by the *infra-spinatus*; a muscle which fills the space below the spine of the scapula, and adheres to the greater tuberosity of the humerus, just below the teres minor. In the bat there is no teres minor.

3. The lower end of the humerus forming, with the ulna, a hinge-joint, the motions of the fore-arm are limited to *flexion*, and *extension*. Two masses of muscle, one in front, and the other behind the humerus, are destined to execute these motions.

The *flexors* are the { coraco-brachialis, biceps flexor cubiti, and brachialis internus.

The *extensors* compose one large muscle, the *triceps extensor cubiti*. The olecranon process of the ulna limits the backward motion of the ulna to simple extension, and this accounts for the relative disproportion between the flexor and extensor muscles.

The *coraco brachialis* is a small muscle on the inside of the arm. It arises from the coracoid process of the scapula, along with the short head of the *biceps*; and keeps company with it half way down the humerus, when it attaches itself to the surfaces of the bone.* The short head of the biceps here unites with the long one, which arises tendinous from the glenoid cavity of the scapula, and runs along a channel, between the tuberosities of the humerus. Their union is the commencement of a large muscle, which covers the fore part of the humerus. About the elbow-joint it forms a tendon that sinks between the bones of the fore-arm, and is inserted into the lesser tubercle of the radius. The *biceps* is always visible, and forms a striking feature in paintings and statues, and directs the surgeon to the course of the brachial artery.† The *brachialis internus* is almost invisible, being concealed by the biceps. It cleaves to the bone from its origin, about the middle of the arm, to the coronoid process of the ulna, where it ends.

* The *axillary artery* keeps close to the edge of this muscle, before which is the vein, and a little above it the brachial plexus of nerves.

† This artery runs along its inner edge, along with its venæ comites, and the radial nerve. All which parts are enclosed in a sheath of condensed cellular substance. At the bend of the elbow the artery passes under a *fascia* which extends from the aponeurosis of the fore-arm to the tendon of the biceps.

The frog has neither a biceps nor a brachialis internus.

The antagonist of these muscles is the *triceps extensor cubiti.* The first head is found on the inferior margin of the scapula, very near the glenoid cavity; the other two on the back part of the humerus. It is a large flat muscle, covers the arm behind, and is inserted by a flat tendon into the olecranon process of the ulna. The bat is the only animal which has but one flexor, and one extensor of the fore-arm.

4. From a consideration of the osteology, it is evident that the hand is capable of four motions:

Pronation, and supination;
Flexion, and extension.

The pronators of the hand are two muscles on the fore-part of the arm; the first of them is the *pronator radii teres,* which, arising from the inner condyle of the humerus, crosses the fore-arm obliquely, and is inserted into the middle of the radius. This muscle is very strong in the fore-arms of horse-breakers. The other is the *pronator quadratus,* a small flat muscle which lies between the radius and ulna near the wrist, and is quite invisible. Ruminant animals, as might be expected, have no pronators; the rabbit, however, has the pronator teres. Supination is likewise effected by two muscles, which are the antagonists of the pronators, and are placed on the opposite side of the fore-arm. The *supinator radii longus* springs from the outer condyle of the humerus, and is inserted into the radius, near the styloid process. It is a large muscle, and forms the fine swell at the outside of the fore-arm, and is interesting to the surgeon, as it denotes the situation of the radial artery in the upper part of the fore-arm. The supinator longus is wanting in the dog and cat; and ruminant animals and birds are incapable of supination. The second *supinator* lies buried underneath the extensor muscles, between the ulna and radius, near the elbow. The wrist may be bent without any motion of the fingers, and the fingers admit of flexion, without a corresponding motion of the wrist.

The flexors of the wrist are — { flexor carpi radialis, flexor carpi ulnaris;

and

the flexors of the fingers are — { flexor digitorum sublimis, flexor digitorum profundus.

Of course, when both sets of muscles act, the hand and fingers move together. The *flexor carpi radialis* is a muscle, the tendon of which is very visible, on the radial side of the fore-arm. Its origin is by the side of the pronator teres, and being now and then accompanied by a small muscle, with a long tendon, no thicker than a fiddle-string (palmaris longus), is inserted into the os scaphoides. On the other side of the fore-arm is the *flexor carpi ulnaris*, which, arising from the inner condyle of the humerus, courses along the ulna, and is fixed to the os pisiforme.* The student who knows the positions of the flexors of the wrist, will easily remember those of the fingers, which are placed between them, the one upon the other. The uppermost muscle is the *flexor sublimis perforatus;* it arises from the inner condyle, and splitting into four tendons, creeps under the annular ligament, and palmar fascia.† Each

* The tendons of these two flexors direct the surgeon to the *radial* and *ulnar* arteries, of which the former is accompanied by a branch of the *muscular-spiral*, and the latter by the *ulnar* nerve.

† The body of the muscle conceals the upper portion of the ulnar artery.

tendon goes to the last joint but one of the four fingers, and they are bound down by tendinous sheaths. These sheaths and perforations are peculiar to vertebral animals, and increase the power of the muscles without augmenting the bulk of the extremities. The *flexor profundus* lies underneath; its four tendons pass through the perforations of the tendons of the sublimis, and terminate in the last joints of the fingers.* These flexors are assisted by certain minute muscles, which appear alongside the tendons of the perforatus, and are inserted into them near the middle of the fingers. The thumb also admits of flexion, and is bent by the *flexor longus pollicis*, a deep and hidden muscle, the tendon of which sinks beneath the ball of the thumb, and may be traced to the last joint, and by the minute flexors which compose the ball of the thumb. The monkey has no flexor longus pollicis.

* The *radial* nerve is found between these tendons in the wrist; and upon them, in the hand, is the continuation of the ulnar artery (*arcus superficialis*), covered by the palmar fascia.

The *extensors* of the *wrist*, *fingers* and *thumb* may thus be classified: —

Extensors of the wrist:	Ext. carpi radialis longior.
	———————— brevior.
	——carpi ulnaris.
Extensors of the fingers:	Ext. communis digitorum.
	Indicator.
Extensors of the thumb:	Ext. primus pollicis.
	—— secundus ——.
	—— tertius ———.

Immediately below the great supinator arises the *extensor carpi radialis longior*; its fleshy belly runs parallel with the muscular portion of the supinator, ends where it ends; and the tendons keep company until they reach the wrist. The tendon of the extensor then passes underneath the annular ligament, and terminates at the root of the fore-finger. Lower still, and in a line with the *tendon* of the great extensor, is the fleshy belly of the *extensor brevior*. It also creeps under the annular ligament, and reaches the metacarpal bone of the middle finger. The last extensor of the wrist, the *extensor carpi ulnaris*, is on the ulnar side of the fore-arm;

it courses along the back of the ulna, and is inserted tendinous into the os unciforme.

The extensors of the fingers are situated between the extensors of the wrist. The *extensor communis* originates between them: its four tendons, having passed the wrist-joint, terminate in the very ends of the fingers; a slip of muscle (*auricularis*) accompanies its digital tendon to the little finger. A muscle called the *indicator*, and a very trivial one, is also seen by the side of the tendon of the extensor, and is inserted into the root of the fore-finger.

Although it has but one great flexor muscle, the thumb has three *extensors*: — *primus*, *secundus*, and *tertius*. * They are seen peeping from under the extensor communis digitorum, and proceed to the last joint of the thumb, except in ruminant animals, and the horse. Independently of these motions of the fingers, the thumb and little finger have muscles which enable the hand to grasp a spherical body. The instruments of these interesting movements com-

* This last muscle is interesting to the surgeon, as it marks the continuation of the *radial* artery, before it sinks into the hollow of the hand, to form the deep-seated *palmar arch*.

pose two masses; the ball of the thumb, and the mass on the outside of the hand. The former consists of the

Abductor pollicis,
Opponens pollicis,
Flexor brevis, and their

antagonist, the *adductor pollicis*, which lies between the metacarpal bone of the fore-finger and the bone of the thumb. The mass at the root of the little finger is composed of the

Abductor minimi digiti,
Flexor brevis minimi digiti,

and a small cutaneous muscle, the *palmaris brevis*, which crosses the upper part of the mass. The forms of these masses of muscle are sufficiently conspicuous in the hand.

Farewell.

LETTER VIII.

ON THE MUSCLES OF THE PELVIC MEMBER.

DEAR SIR,

In order to render the complex and interesting subject of this demonstration as clear as possible, we shall first enumerate the movements of each division of the pelvic member; then describe the muscles employed in these motions, and, lastly, explain the movements as they are combined in the ultimate purposes of standing, walking, running, and leaping.

The motions of the thigh upon the pelvis are, *flexion*, *extension*, and *rotation outward*. Two muscles which descend from the loins to the upper part of the femur bend the thigh upon the pelvis: these are the *psoas magnus*, and the *iliacus* internus. They are assisted by two others, the pectinalis and the triceps, which will be described as rotators of the pelvis. The psoas, called magnus, because a lesser muscle (*psoas parvus*) sometimes accompanies it, takes its rise from the transverse processes of the lumbar vertebræ, passes through the pelvis, and in its passage, uniting with the iliacus internus, a muscle which occupies the hollow of the ilium; they form a common tendon, which is inserted into the trochanter minor.* Neither of these muscles is found in bats; and birds and frogs have no psoas. The thigh is extended by the mass of muscle which forms the buttock, the *glutæi*. The *glutæus medius* and *minimus* originate entirely from the dorsum of the ilium, and are covered by the *glutæus maximus*, which arises from the whole length of the sacrum, from the spine and dorsum of the ilium, and is inserted along with the other two into the trochanter major. Another important office of the glutæi is to fix the pelvis on the thighs, and thus maintain the erect position of the trunk; a reason is thus afforded for the want of buttocks in the *simiæ*.

A cluster of small muscles, placed horizontally

* Upon these muscles, and midway between the anterior superior spine of the ilium and the symphysis pubis, rest the *femoral artery* and *vein;* the vein inside. They are enclosed in a sheath of condensed cellular substance, on the outside of which is the *anterior crural nerve*.

between the hind part of the pelvis and the trochanter major, rotate the thigh, thus turning out the toes. The first in the series is the *pyriformis*, which has its origin just within the sacrum, passes through the great sciatic notch, and terminates in the root of the great trochanter.* The *gemelli* succeed; one of them arises from the spine, the other from the tuber ischii, and both are inserted into the trochanter. Between the gemelli is the *obturator externus*, which, leaving the obturator foramen, reaches also the trochanter major. The *quadratus femoris* is the last of the series: it takes its rise from the tuber ischii, below the origin of the gemelli, and is inserted into the femur below the trochanter. When the pelvis is fixed, the contraction of these muscles brings the great trochanter nearer the sacro-iliac portion of the pelvis; and in this manner the thigh is rotated

* The largest branch of the *internal* iliac, the *glutæal artery*, emerges from the upper part of the *sciatic* notch, above the *pyriformis* muscle, and runs along the edge of the glutæus medius. Immediately below the same muscle issues the *ischiadic*, and the great *sacro-sciatic* nerve. The *pudendal* re-enters the pelvis, and courses along the tuber ischii, and ramus of the pubis. For the anatomy of the *perinæum*, consult John Bell's Principles of Surgery, vol. ii. part 1.

outward. These muscles, as well as the *glutæus medius*, are of great size in the horse, and enable this animal to strike backward with astonishing force. They are wanting altogether in the bat, and in birds and frogs.

The connection of the femur with the pelvis is an arthrodia, or ball and socket joint; and when the thigh is fixed, the pelvis revolves upon it, as upon a pivot, describing in the horizontal direction a large segment of a circle: this is effected by the *pectinalis* and the *triceps*, a function of these muscles which has been overlooked; and they have been regarded as simple flexors of the thigh. The *pectinalis* is a broad muscle which arises from that portion of the pubis which forms the brim of the pelvis, and is inserted a little below the trochanter minor. Below the pectinalis, the *triceps* originates in three heads; from the descending ramus of the pubis, and from the obturator foramen, which it entirely conceals: it is inserted into the whole length of the linea aspera of the thigh-bone, beginning just below the trochanter minor. In the part occupied by the pectinalis, in birds, arises a slender muscle, which is prolonged to the knee. Its tendon passes over, and then under the leg, to the heel, when it is attached to the flexors of the toes: hence the flexion of the knee and heel mechanically bends the toes; and it is by means of this structure, that the bird is supported, when roosting, without any muscular action.

We have next to describe the motions of the leg upon the thigh; and, as the knee is a hinge-joint, they are limited to *flexion* and *extension*. The flexors are situated upon the back of the thigh, and are called the hamstring muscles*: to which may be added the *gracilis* and *sartorius*. The *biceps* composes the outer hamstring. One head arises from the tuber ischii, and the other from the *linea aspera* of the femur: it is inserted by a strong and well marked tendon into the head of the fibula. In quadrupeds and the monkey, the muscle corresponding to the biceps is single-headed. Two muscles compose the inner hamstring; the *semitendinosus* and *semimembranosus*, which extend from the tuberosity of the ischium to the inside of the head of the

* Between these tendons, and close to the bone, is the *poplitæal* artery, the continuation of the femoral. It is covered by a mass of fat, upon which repose the *posterior crural* nerves. These important parts are further protected by a strong fascia, which stretches from one hamstring to the other.

tibia The *gracilis* descends from the symphysis pubis to the inside of the tibia, and is found immediately behind the inner hamstring. The *sartorius* is a sort of swathing-band to bind down the muscles of the thigh; originating in the anterior superior spine of the ilium, it crosses the thigh obliquely, and is inserted into the tibia by the side of the gracilis. * In quadrupeds, and even in the simiæ, the flexors are inserted low in the tibia, which preserves their knees in a state of permanent semiflexion. Hence the straightness of the knee is characteristic of the human species. The leg is extended by muscles on the fore-part of the thigh; the two *vasti*, the *cruræus*, and the *rectus*. The anterior superior spine of the ilium is the point from which arises the *rectus*; while the two *vasti* cling to the linea aspera, on each side the femur, and between them is the *cruræus*. These three muscles are inserted into the *patella*. The *rectus* and *cruræus* are attached to the top of the patella, but the vasti adhere to its sides. The

* The *femoral* artery, along with the nervus saphenus, sinks beneath the sartorius, in the middle of the thigh, in order to reach the ham, and is braced down by a fascia which connects this muscle to the fascia lata of the thigh.

fine swell on the outside of the thigh is formed by the vastus *externus*; and the vastus *internus* composes a cushion of flesh above the inside of the knee. The muscles of the thigh are enclosed in a membranous sheath (fascia lata), which is provided with a particular muscle (ilio-fascialis), the fibres of which are covered by the fascia.

The movements of the foot are effected by the muscles of the leg: they are limited to *flexion* and *extension*. The muscles which form the calf of the leg, one of the characteristics of the human form, bend the foot, or rather elevate the heel: they are the *gastrocnemius*, and the *solæus*. The *gastrocnemius* arises, by two short heads, from the condyles of the femur, which, speedily uniting, compose a mass of flesh that coalesces with the *solæus*. This muscle may be considered as a part of the gastrocnemius. It arises from the back surfaces of the tibia and fibula, and ends in the Achilles tendon, which is attached to the heel. Cut away these larger muscles, and the flexors of the foot and toes are exposed; for the toes admit of flexion without any corresponding motion of the foot, as the foot may be moved independently of the toes. The first in the series, beginning on the tibial side of the leg, is the *tibialis posticus*, a muscle which is not found in animals that have cannon bones, or in birds: the *flexor digitorum* succeeds.* These muscles descend from the top of the tibia behind; become tendinous as they approach the inner ankle, and reach the sole of the foot, where the one adheres, while the other proceeds in four divisions to the four smaller toes. The *flexor pollicis*, a large muscle with a strong tendon, comes next; it sinks into the sole between the junction of the astragalus and os calcis, and terminates in the great toe. The last of the flexors is the *peroneus longus*, which courses along the fibula, and passes behind the outer ankle to reach the sole. The tendons of these flexors, and the short muscles lying close upon the sole, viz.

Abductor pollicis pedis,
Flexor brevis pollicis pedis,

* The tendons of these muscles direct the surgeon to the posterior tibial artery, which, in the lower half of the leg, together with the *nerve* and *venæ comites*, is almost superficial. These important parts are braced down by a *fascia*, which crosses from the tendo Achillis to the posterior edge of the tibia.

Abductor pollicis pedis,
Abductor minimi digiti,
Flexor brevis minimi digiti et
Flexor brevis digitorum,
Massa carnea vel musculus accessorius,
Lumbricales pedis,
Transversales pedis et
Interossei,

are protected by the *plantar fascia*, which covers the foot from the heel to the toe, and also secures the arteries of the sole. The foot is extended by the muscles on the fore-part of the leg, in the hollow between the tibia and fibula. The *tibialis anticus* is the first in order. It arises from the top of the tibia, and becoming tendinous, crosses the fore-part of the leg and foot, and in the sole adheres to the internal cuneiform bone. The next is the *extensor longus pollicis;* it accompanies the tibiälis anticus, and the two tendons proceed side by side to the ankle, where they separate; the tibialis passing over to the sole, and the extensor proceeding to the great toe. * In the monkey there is an

* Between these muscles, and close upon the interosseous ligament are the *anterior tibial artery*, and the *ner-*

additional muscle, the *abductor pollicis*. The *extensor communis digitorum* is hardly visible; its tendons, however, appear by the side of the other extensor tendons, and creep under the *annular ligament* to reach the four lesser toes. To the extremities of the tendons of the extensor communis, are attached the tendons of a small muscle on the outside of the foot, the *extensor brevis digitorum*.

It now only remains for us to describe the ultimate purposes of the muscles of the pelvic member. *Standing* is effected solely by the extensors of the lower limbs, which accounts for the greater fatigue it occasions than walking, in which the flexors and extensors are in alternate action. In *walking*, the foot, leg, and thigh of one side are rendered inflexible and fixed to the earth; and the pelvis turning horizontally round the head of the thigh-bone, the other limb is carried forward. This in turn is fixed, and the other advances in the same manner. The limb is rendered inflexible, and held to the earth by the action of the extensors,

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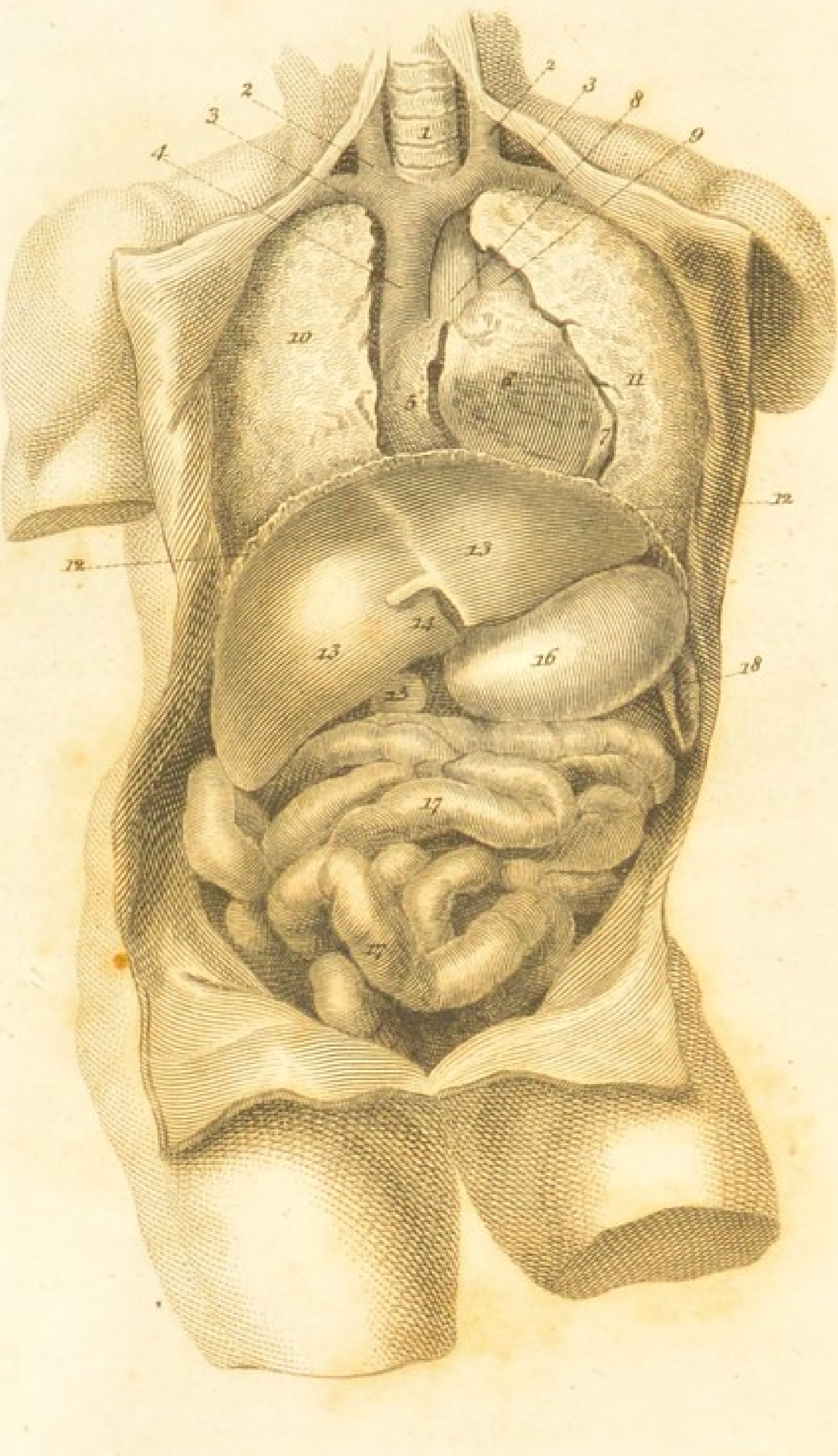
vus peronæus; as it approaches the foot the artery is found between the tendon of the latter muscle and the extensor communis digitorum.

while the advancing member is lifted from the ground by the flexors of the thigh and leg. The revolution of the pelvis is effected, as you have seen already, by the pectinalis and the triceps. The extent of this horizontal motion is a small segment of a large circle. When the pelvis is large, as in women, the circle is increased, and the gait more ambling. The foot and knee of the moving member would be turned inwardly by the rotation of the pelvis, were it not for the rotators of the thigh, the pyriformis, gemelli, and obturator externus; the use of which muscles is acquired by habit. Infants turning the toes inwardly, and from an over-rolling of the pelvis, cross their legs and fall; and adults, who turn in the toes, walk insecurely. *Running* is merely a succession of short leaps. In *leaping*, the body rises from the earth by the action of the extensors of the lower limbs, after an unusual degree of flexion. The body is projected, and would continue in that state but for the counteracting power of gravity.

" Jamque opus exegi."

My task is done, and if I have not, like the Roman poet, reared a monument to my own reputation, more durable than brass, I have at least erected an altar to the Almighty Maker of the universe. The materials are far more excellent than the marbles of Pentelicus or Paros; and though the workmanship be rude, the stones ill-hewn, and worse disposed, the building will stand; and, like the altar of the patriarch, hold an oblation grateful to the Deity, and useful to my friends. I may say, indeed, with Galen, "that in explaining these things, I consider myself as composing a solemn hymn to the Author of our bodily frame; and in this I think there is more true piety than in offering to Him hecatombs of oxen, and burnt-offerings of the most costly perfumes; for I first endeavour to know Him myself, and afterwards shew Him to others, to inform them how great is His wisdom, His goodness, and His mercy."

Farewell.



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EXPLANATION OF PLATE I.

Thorax.

1. The trachea.
2. —— internal jugular vein.
3. —— subclavian vein.
4. —— upper vena cava.
5. —— right auricle of the heart.
6. ———— ventricle of ditto.
7. Part of the left ventricle.
8. The aorta.
9. —— pulmonary artery.
10. —— right lobe of the lungs.
11. —— left lobe.

Abdomen.

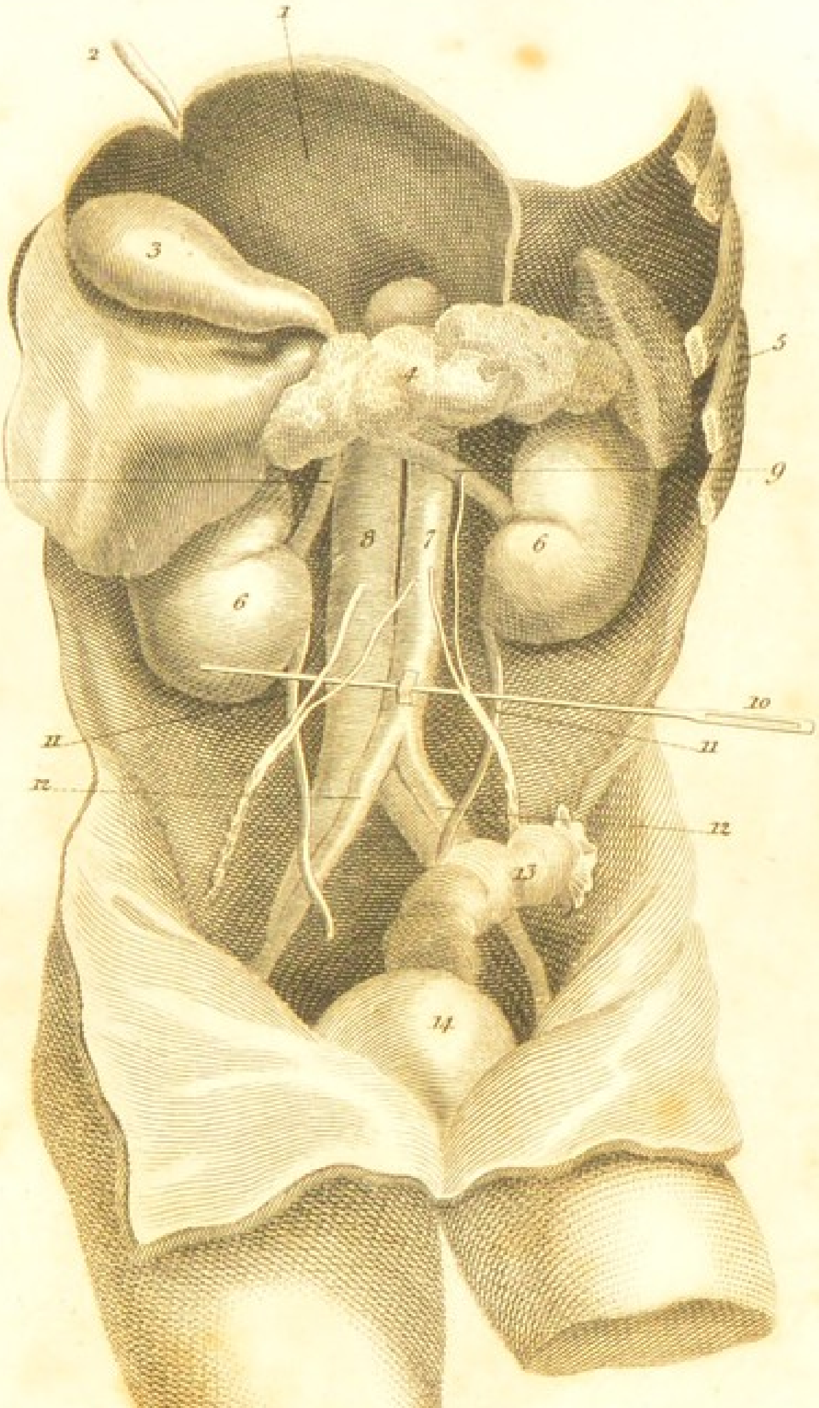
12. The diaphragm.
13. —— liver.
14. —— round ligament of the liver.
15. —— gall bladder.
16. —— stomach.
17. —— small intestine.
18. —— spleen.

EXPLANATION OF PLATE II.

1. The under surface of the liver.
2. —— round ligament.
3. —— gall bladder.
4. —— pancreas.
5. —— spleen.
6. —— kidnies.
7. Aorta (abdominal.)
8. Vena cava ascendens.
9. Emulgent vein.
10. Spermatic arteries.
11. The ureters.
12. —— illiac vessels.
13. Rectum.
14. Bladder.

EXPLANATION OF PLATE III.

A. The right ventricle.
B. ———— auricle.
C. —— Vena cava.
D. —— Pulmonary artery.
E. —— Arch of the aorta-e-aorta.



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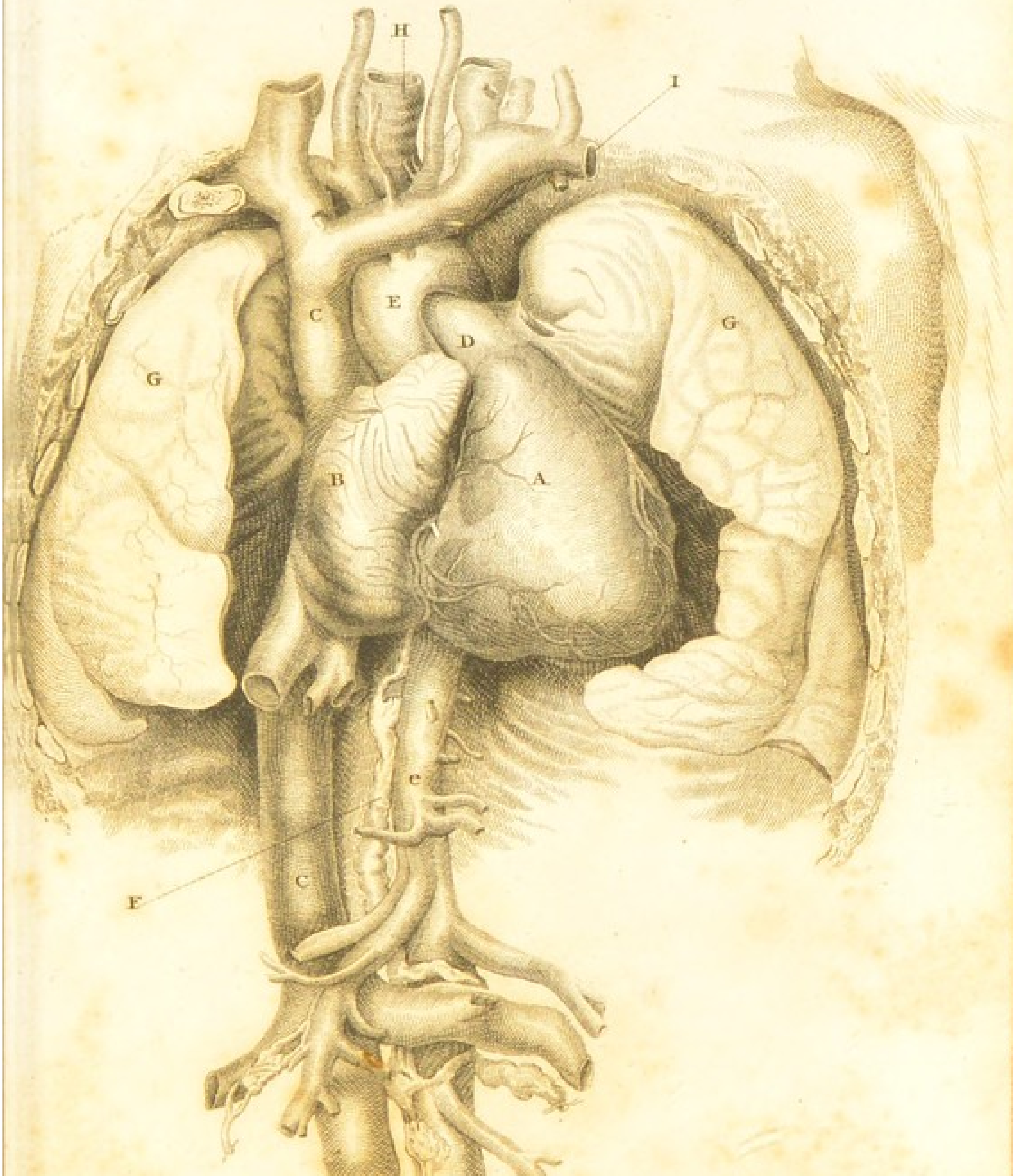

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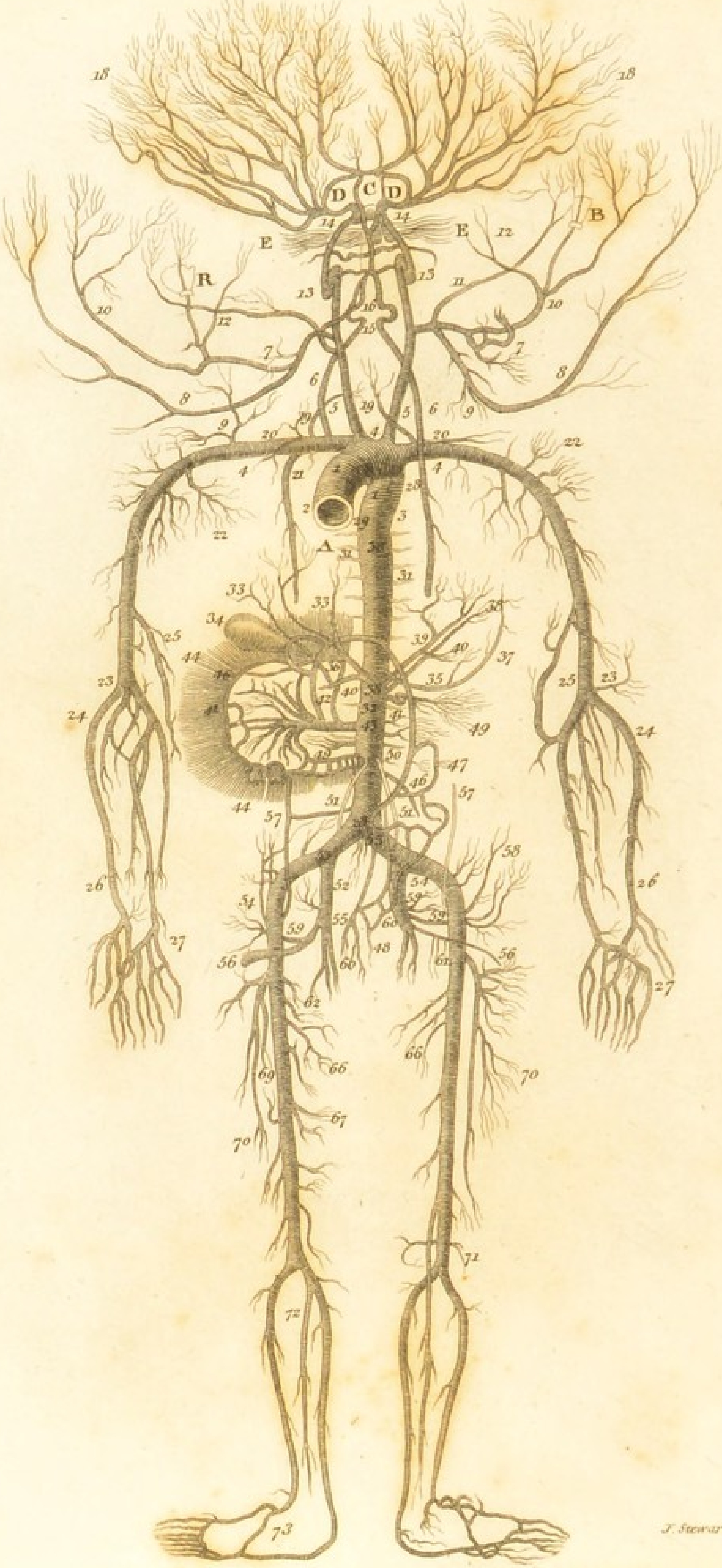

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F. The Thoracic duct.
G. G. —— Lungs.
H. —— Trachea.
I. —— left subclavian vein.

EXPLANATION OF PLATE IV.

1. Aorta ascendens.
A. Three semilunar valves.
2. Trunk of the coronary artery.
3. Aorta descendens.
4. Subclavian artery.
5. 5. Carotid arteries.
6. 6. Vertebral arteries.
7. 7. Arteries that go to the lower part of the face, tongue, &c.
8. 8. Temporal arteries.
10. 10. Trunks which go to the foramina narium, &c.
11. 11. Occipital arteries.
12. 12. Arteries which go to the fauces, &c.
B. B. A small portion of the basis of the skull.
13. 13. Contorsions of the carotid arteries, before they pass the brain.

EXPLANATION OF PLATE V.

a. a. Vena cava.
b. Descending trunk of the cava.
c. c. Ascending trunk of the cava.
d. d. Subclavian veins.
e. Vena azygos.
f. Intercostal veins.
g. Mammary veins.
i. i. Internal jugulars.
l. l. External jugulars.
m. Right axillary vein.
n. Cephalic vein.
o. Basilic.
q. Phrenic.
s. s. Emulgents.
w. w. Iliac branches.
x. Internal iliacs.
1. Vena sacra.
2. Spermatic veins.
3. Epigastric.
4. Saphena.

Plate V.

Veins

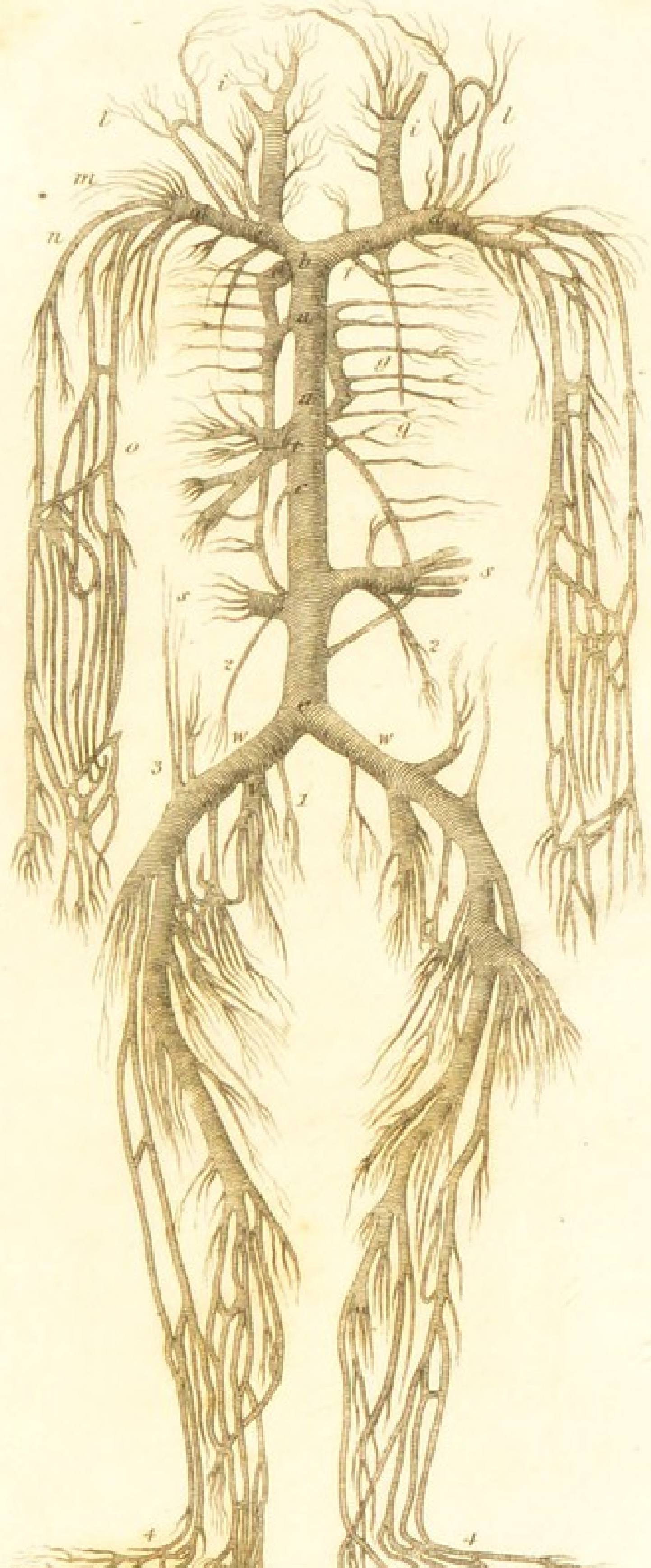

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Fig. 1.

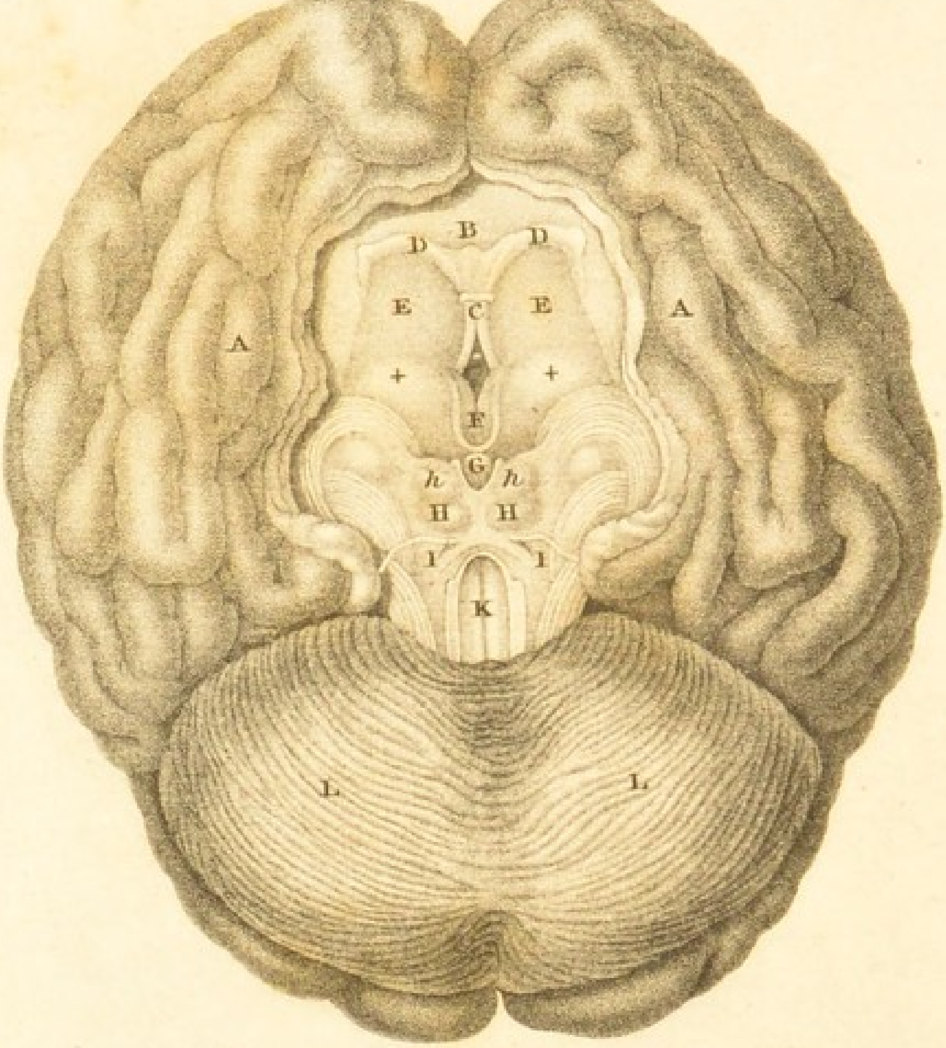
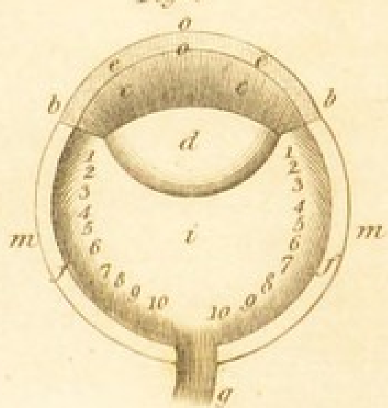


Fig. 2.



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EXPLANATION OF PLATE VI.

Fig. 1.

A. A.	The cerebrum.
B.	Margin of corpus callosum.
C.	Fornix.
D. D.	Crura of the fornix.
E. E.	Corpora striata.
× ×	Thalami nerv. opticorum.
F.	Third ventricle.
G.	Pineal gland.
h. h. / H. H.	Corpora quadrigemina.
I. I.	Origins of the pathetic nerves.
K.	The fourth ventricle.
L. L.	Cerebellum.

Fig. 2.

b. e. b.	The cornea.
e. e.	— Iris o pupil.
c. c.	— Aqueous humor.
d.	— Crystalline humor.
f. f.	— Choroid coat.
g.	— Optic nerve.
I.	— Vitreous humor.
m. m.	— Sclerotic coat.
1, 2, 3, 4, 5, &c.	— Retina.

EXPLANATION OF PLATE VII.

Fig. 1.

A. A. A. A.	The fore and hinder lobes of the cerebrum.
B. B.	The Cerebellum.
C. C.	Medulla oblongata.
D. D.	Olfactory nerves, or 1st pair.
E. E.	Optic nerves, or 2d pair.
F. F.	Motores oculi, or 3d pair.
G. G.	Trochlearis, or 4th pair.
H. H.	Trigemini, or 5th pair.
I. I.	Abducentes, or 6th pair.
K. k.	The auditory, or 7th pair.
L. l. l. l.	— par vagum, or 8th pair.
M. M.	Nervus accessorius.
N. N.	The lingual, or 9th pair.
o. o.	Eminentiæ candicantis.
P. P.	Trunk of the carotid artery.
S.	Pons Varolii, or tuber. annulare.
T. T.	The vertebral arteries.
X.	— Infundibulum.

Fig. 2.

A. Incus.
B. Stapes.
C. Muscle of the Stapes.

Fig. 3.

A. Malleus.
C. Muscle of the Malleus (external.)
E. Internal muscle.

Fig. 1.

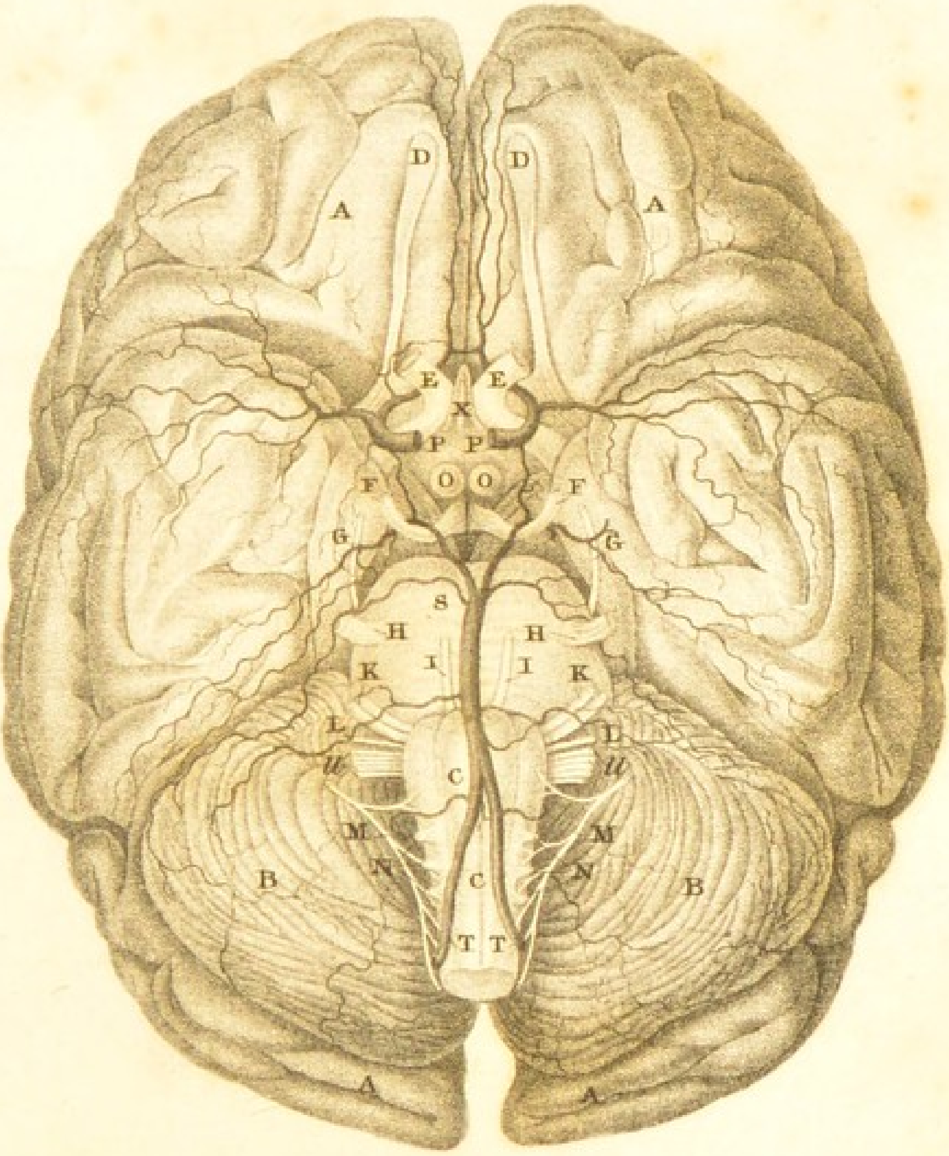

Fig. 2.

Fig. 3.

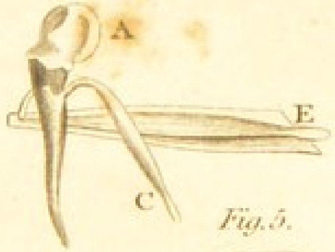

Fig. 4.

Fig. 5.

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Fig. 1.

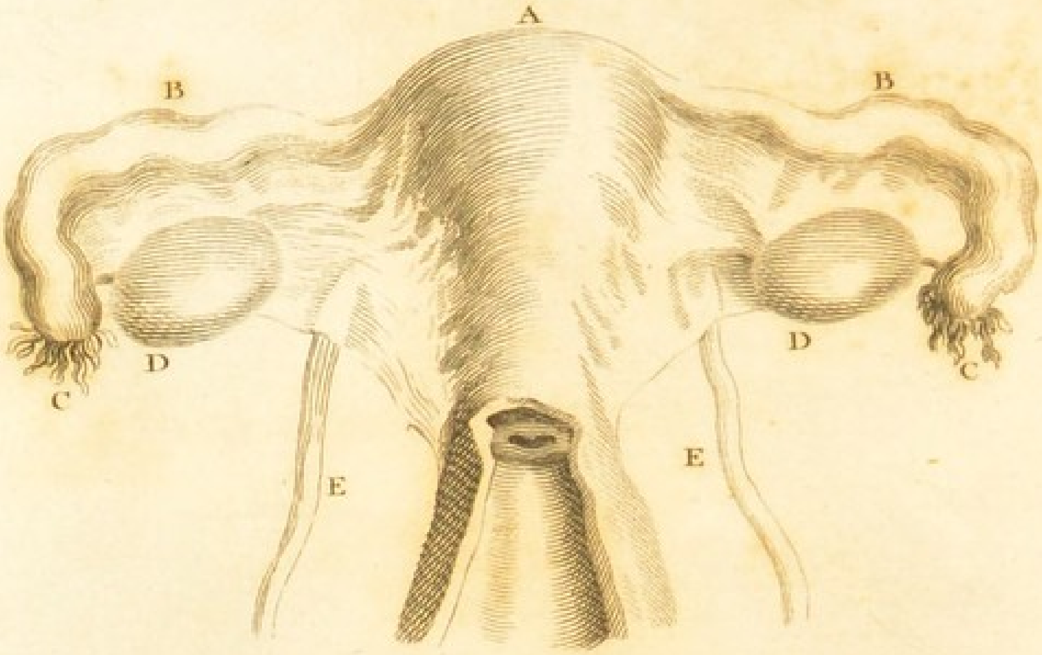

Fig. 2.

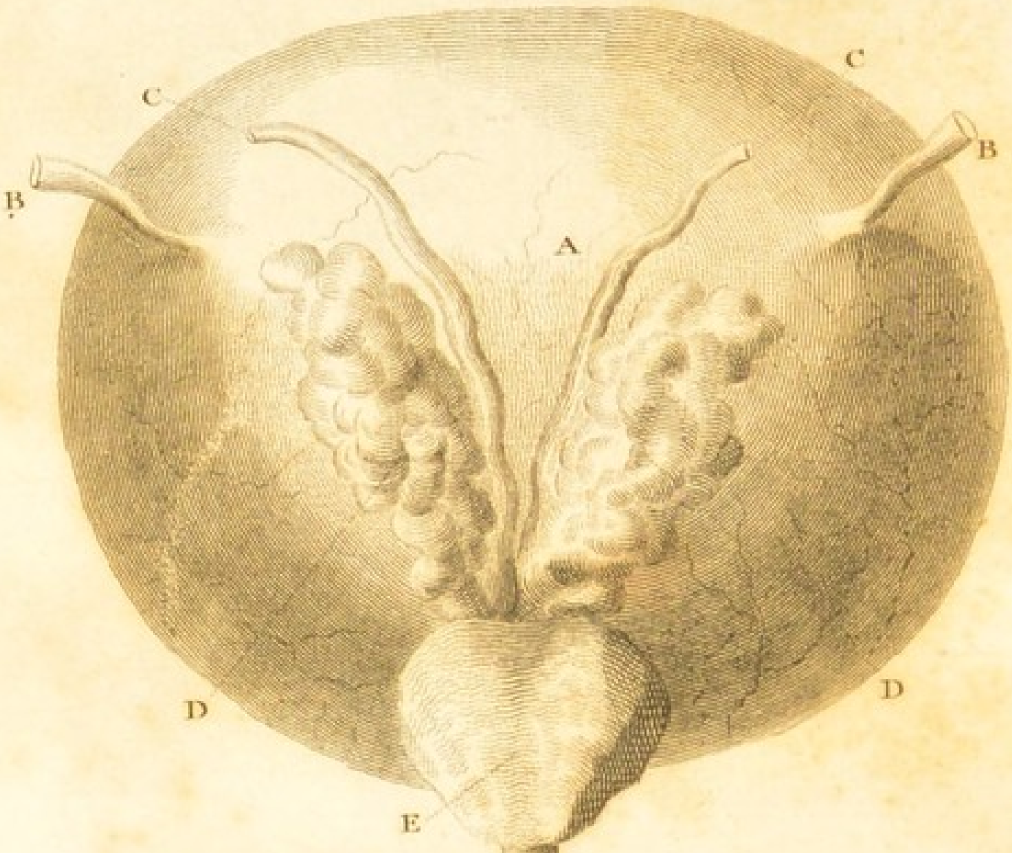

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Fig. 4.	Fig. 5.
A. The vestibulum, or cochlea.	The cochlea.
B. Semicircular canals.	

EXPLANATION OF PLATE VIII.

Fig. 1. — The Uterus and its appendages.

A. The Uterus.
B.B. —— Fallopia tubes.
C.C. —— Timbriæ.
D. D. —— Ovaria.
E. E. —— round ligaments.

Fig. 2. — The base of the Bladder.

A. The Bladder.
B. B. —— Ureters.
C. C. —— Vasa deferentia.
D. D. —— Vesiculæ.
E. —— Prostate gland.
F. —— Urethra.

EXPLANATION OF PLATE IX.

Bones of the Head and Neck.

1. Os frontis.
2. — parietale.
3. — temporis.
4. — malæ.
5. Os maxillare sup.
6. — maxillare inf.
7. The seven cervical vertebræ.

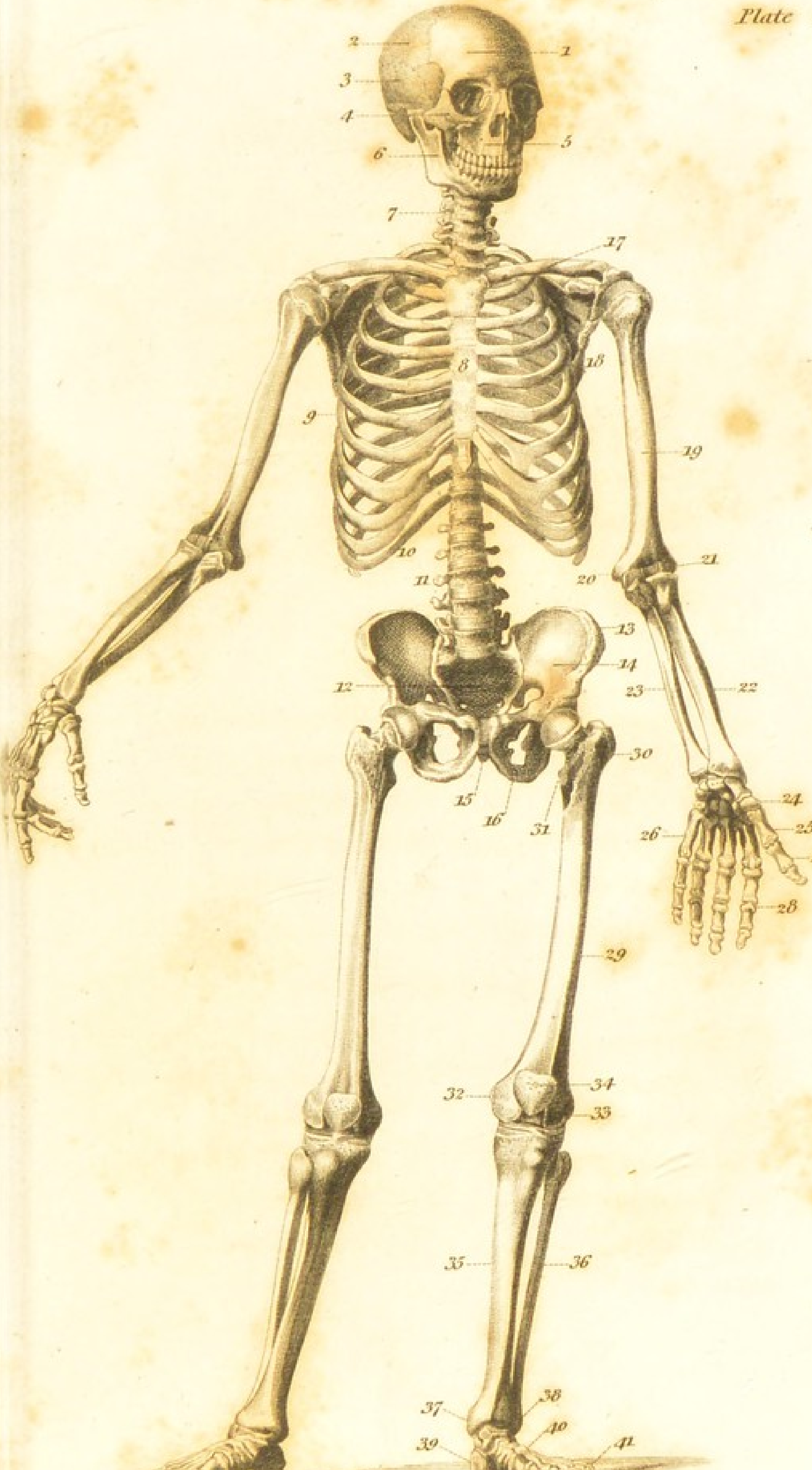
Trunk.

8. Sternum.
9. The last true rib.
10. The last false rib.
11. The five lumbar vertebræ.
12. Os sacrum.
13. Os innominatum, *consisting of*
14. Os ilium.
15. — pubis.
16. — ischium.

Upper Extremity.

17. Clavicle.
18. Scapula.
19. Os humeri.
20. Internal condyle.
21. External condyle.
22. Radius.
23. Ulna.
24. Carpus.
25. Metacarpal bone of the thumb.
26. Ditto of the fingers.
27. The thumb.
28. —— fingers.

Plate IX.



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Lower Extremity.

29. Os femoris.
30. Trochanter major.
31. ———— minor.
32. Internal condyle.
33. External ditto.
34. Patella.
35. Tibia.
36. Fibula.
37. Internal ankle.
38. External ditto.
39. Os calcis.
40. Metatarsus.
41. The toes.

EXPLANATION OF PLATE X.

Back View of the Head and Neck.

1. Os parietale.
2. — occipitis.
3. — Malæ.
4. Maxilla inferior.
5. Cervical vertebræ.

The Trunk.

6. The last true rib.
7. ——— false rib.
8. Lumbar vertebræ.
9. Sacrum.
10. Os coccygis.
11. Os innominatum, *divided into*
12. Os ilium.
13. — pubes.
14. — ischium.

Upper Extremity.

15. Clavicle.
16. Scapula.
17. Os humeri.
18. Internal condyle.
19. External ditto.
20. Radius.
21. Ulna.
22. Carpus.
23. Metacarpal bone of the thumb.
24. Metacarpus.
25. Thumb.
26. Fingers.

Plate X.

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Lower Extremity.

27. Os femoris.
28. Trochanter major.
29. ———— minor.
30. Internal condyle.
31. External ditto.
32. Tibia.
33. Fibula.
34. Inner ankle.
35. Outer ditto.
36. Tarsus.
37. Metatarsus.
38. Toes.

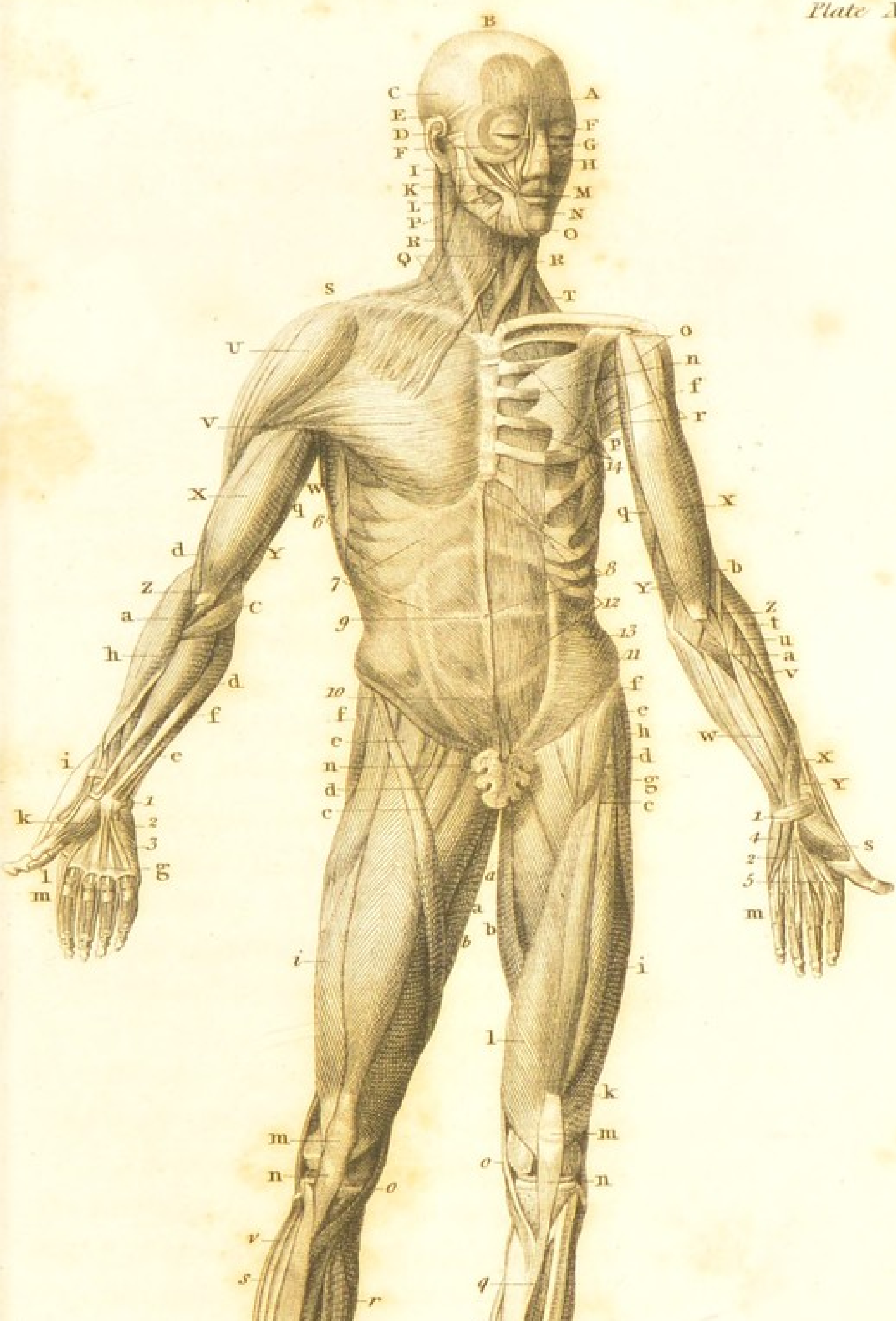
PLATE XI.

Fig. I.—The muscles immediately under the common teguments, on the posterior part of the body, are represented in the right side; and on the left side the muscles are seen, which come in view when the exterior ones are taken away.

Head.—A. A. Occipito-frontalis. B. Attollens aurem. C. Part of the orbicularis palpebrarum. D. Masseter. E. Pterygoidæus internus.

Trunk. Right Side.—F. F. F. Trapezius seu cucularis. G. G. G. G. Latissimus dorsi. H. Part of the obliquus externus abdominis.

Trunk. Left Side.—I. Splenius. K. Part of the complexus. L. Levator scapulæ. M. Rhomboidei. N. N. Serratus posticus inferior. O. Part of the longissimus dorsi. P. Part of the sacro-lumbalis. Q. Part of the semi-spinalis dorsi. R. Part of the serratus anticus major. S. Part of the obliquus internus abdominis.



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Superior Extremitv. Right Side.—T. Deltoides. U. Triceps extensor cubiti. V. Supinator longus. W. W. Extensores carpi radialis longior et brevior. X. X. Extensor carpi ulnaris. Y. Y. Extensor digitorum communis. Z. Abductor indicis. 1. 2. 3. Extensores pollicis,

Superior Extremity. Left Side.—a. Supra spinatus. b. Infra spinatus. c. Teres minor. d. Teres major. e. Triceps extensor, cubiti. f. f. Extensores carpi radialis. g. Supinator brevis. h. Indicator. 1. 2. 3. Extensores pollicis. i. Abductor minimi digiti. k. Interrossei.

Inferior Extremity. Right Side.—l. Glutæus maximus. m. Part of the glutæus medius. n. Tensor vaginæ femoris. o. Gracilis. p. p. Abductor femoris magnus. q. Part of the vastus internus. r. Semi-membranosus. s. Semi-tendinosus. t. Long head of the biceps flexor cruris. u. u. Gastrocnemius externus seu gemellus. v. Tendo achillis. w. Solæus seu gastrocnemius internus. x. x. Peronæus longus et brevis. y. Tendons of the flexor longus digitorum pedis; and under them, * flexor brevis digitorum pedis. z. Abductor minimi digiti pedis.

Inferior Extremity. Left Side.—m. n. o. p.

q. r. s. t. u. v. w. x. y. z. point the same parts as in the right side. a. Pyriformis. b. b. Gemini. c. c. Obturator internus. d. Quadratus femoris. e. Coccygæus. f. The short head of the biceps, flexor cruris. g. g. Plantaris. h. Poplitæus. i. Flexor longus pollicis pedis.

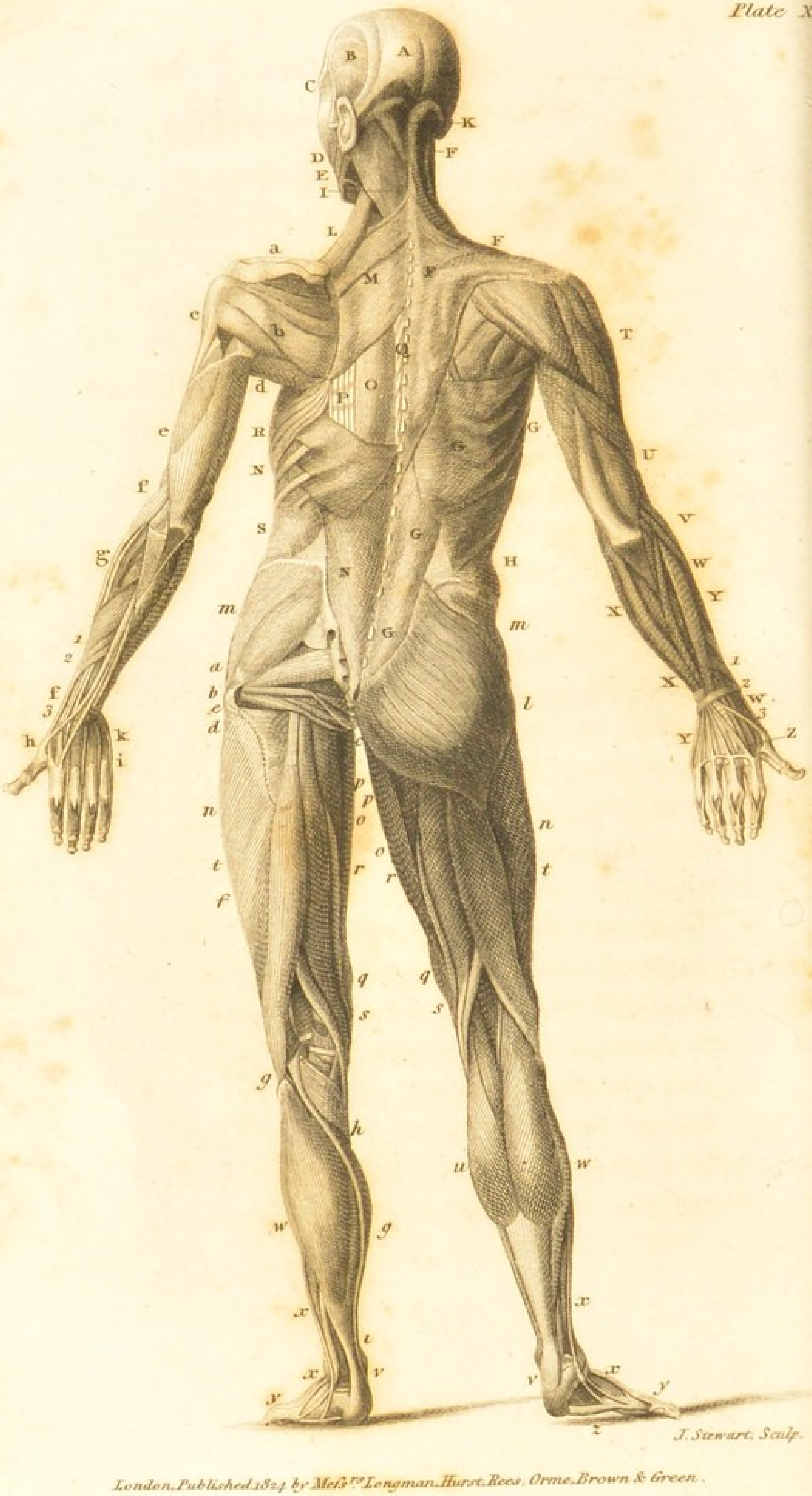

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PLATE XII.

Fig. I. — The muscles immediately under the common teguments, on the anterior part of the body, are represented on the right side, and on the left side the muscles are seen which come in view when the exterior ones are taken away.

A. The frontal muscle. B. The tendinous aponeurosis, which joins it to the occipital ; hence both are named, occipito-frontalis. C. Attollens aurem. D. The ear. E. Anterior auris. F. F. Orbicularis palpebrarum. G. Levator labii superioris, alæque nasi. H. Levator anguli oris. I. Zygomaticus minor. K. Zygomaticus major. L. Masseter. M. Orbicularis oris. N. Depressor labii inferioris. O. Depressor anguli oris. P. Buccinator. Q. Q. Platysma myoides. R. R. Sterno-cleido-mastoideus. S. Part of the trapezius. T. Part of the scaleni.

Superior Extremity. — U. Deltoides. V. Pectoralis major. W. Part of the latissimus dorsi.

X. X. Biceps flexor cubiti. Y. Y. Part of the brachialis externus. Z. Z. The beginning of the tendinous aponeurosis (from the biceps) which is spread over the muscles of the fore arm. a. a. Its strong tendon inserted into the tubercle of the radius. b. b. Part of the brachialis internus. c. Pronator radii teres. d. Flexor carpi radialis. e. Part of the flexor carpi ulnaris. f. Palmaris longus. g. Aponeurois palmaris. 3. Palmaris brevis. 1. Ligamentum carpi annulare. 2. 2. Abductor minimi digiti. h. Supinator radii longus. i. The tendons of the thumb. k. Abductor pollicis. l. Flexor longus pollicis. m. m. The tendons of the flexor sublimis perforatus, profundus, perforatus, and lumbricales. The sheaths are entire in the right hand: in the left cut open to show the tendons of the flexor profundus perforating the sublimis.

Muscles not referred to in the left superior extremity.— n. Pectoralis minor seu serratus anticus minor. o. The two heads of (x. x.) the biceps. p. Coraco-brachialis. q. q. The long head of the triceps extensor cubiti. r. r. Teres major. s. s. Subscapularis. t. t. Extensores radiales. u. Supinator brevis. v. The cut extremity of the pronator teres. w. Flexor sublimis perforatus. x. Part of the flexor profundus. y. Flexor pollicis longus. z. Part of the flexor pollicis brevis. 4. Abductor minimi digiti. 5. The four lumbricales.

TRUNK. — 6. Serrated extremities of the serratus anticus major. 7. 7. Obliquus externus abdominis. 8. 8. The linea alba. 9. The umbilicus. 10. Pyramidalis. 11. 11. The spermatic cord. 12. 12. Rectus abdominis. 13. Obliquus internus. 14. 14. &c. Intercostal muscles.

INFERIOR EXTREMITIES. — a. a. The gracilis. b. b. Part of the triceps. c. c. Pectinalis. d. d. Psoas magnus. e. e. Iliacus internus. f. Part of the glutæus medius. g. Part of the glutæus minimus. h. Cut extremity of the rectus cruris. i. i. Vastus externus. k. Tendon of the rectus cruris. l. l. Vastus internus. * Sartorius mascle. ** Fleshy origin of the tensor vaginæ femoris, or membranosus. Its tendinous aponeurosis covers (i.) the vastus externus on the right side. m. m. Patella. n. n. Ligament, or tendon from it to the tibia. o. Rectus cruris. p. Cruræus. q. q. The tibia. r. r. Part of the gemellus, or gastrocnemius externus. s. s. s. Part of the solæus, or gastrocnemius internus.

t. Tibialis anticus. u. Tibialis posticus. v. v. Peronæi muscles. w. w. Extensor longus digitorum pedis. x. x. Extensor longus pollicis pedis. y. Abductor pollicis pedis.

THE END.

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Printed by A. & R. Spottiswoode,
New-Street-Square.